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Efficacy of the Dorsal Application of Kinesio Tape for Carpal Tunnel Syndrome

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Efficacy of the Dorsal Application of Kinesio Tape for Carpal Tunnel Syndrome

by

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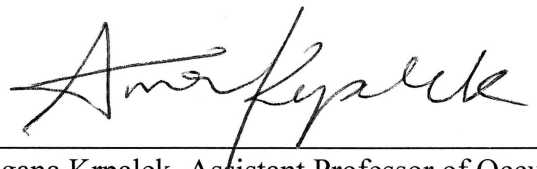
Each person whose signature appears below certifies that this dissertation in his/her opinion is adequate, in scope and quality, as a dissertation for the degree Doctor of Philosophy.



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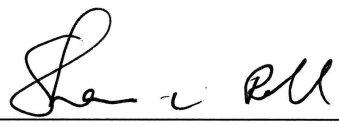

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CONTENT

FIGURES

Figure Page

Chapter 2

TABLES

Table Page

Chapter 2

Chapter 3

ABSTRACT OF THE DISSERTATION

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Upper extremity musculoskeletal disorders (MSD), such as Carpal Tunnel Syndrome (CTS) affect worldwide working populations. CTS symptoms are problematic especially when signs and symptoms are not substantial enough to require surgical intervention. Conservative treatments have mixed effectiveness, and there is yet to be a best option for chronic low-grade CTS. Kinesio tape is an emerging modality, the dorsal application may provide biomechanical support while allowing functional movement.

Thus, the objective of this study was to determine if the dorsal application of Kinesio tape applied to the wrist extensors for individuals with carpal tunnel syndrome makes a difference in occupational performance of pain and function as measured by the Numeric Pain Rating Scale (NPRS), Visual Analog Scale (VAS), Boston Carpal Tunnel Questionnaire (BCTQ), functional grip and pinch measurements as compared to the commonly accepted lumbrical stretching exercises and nightly use of general cockup splint. Additionally, this study sought to explore the perspectives of participants wearing Kinesio tape to understand if Kinesio tape contributed to changes in occupational performance, and if so, how.

A single blind randomized controlled trial with a limited phenomenological study

embedded within was conducted. A significant reduction in median NPRS pain scores of forearm and wrist in Kinesio tape group ($p = 0.006$, and $p = 0.005$ respectively), but not the splint group ($p = 0.11$, $p = 0.17$), and sham group ($p = 0.43$, $p = 0.30$) with a minimal clinically important difference (MCID) of 1.0. MCID for VAS was 1.64. Kinesio tape and sham group had significant improvement in function, but not the splint group. Kinesio tape group improved in pain and function compared to splint group.

Investigation of individuals' experiences with the dorsal application of Kinesio tape for CTS management revealed three emerging themes: Kinesio tape was positively perceived to be effective on decreasing pain, increasing self-efficacy, and improving daily functional performance on tasks previously avoided or abandoned.

Results of this study suggest that Kinesio tape is a positively perceived intervention for decreasing pain and increasing function for individuals with CTS. Based on the findings of this study, further consideration of the dorsal application of Kinesio tape as an alternative conservative intervention for CTS appears warranted.

CHAPTER ONE

INTRODUCTION

Efficacy of the Dorsal Application of Kinesio Tape for Carpal Tunnel Syndrome

Musculoskeletal disorders (MSD) include a range of inflammatory and degenerative conditions from overexertion of muscles during an activity or repetitive motions resulting in an injury to muscles, joints, ligaments, tendons, cartilage, or nerves and manifests via pain, discomfort, or tingling (Lysaght, Donnelly, & Luong, 2010; Punnett & Wegman, 2004; United States Bureau of Labor, 2015b). Although not uniquely caused by work, upper extremity (UE) MSDs affect worldwide working populations with evidence indicating 20% - 30% of workers experience symptoms (Luckhaupt et al., 2013, Murray et al., 2012, 2013; Punnett & Wegman 2004). An UE MSD impairs an individual's ability to work and complete daily self-care tasks involving both gross and fine motor movements (United States Bureau of Labor Statistics, 2015a). In addition, MSD creates an economic burden on society in both direct cost to the health care system and indirect cost through loss of work and productivity (American Public Health Association [APHA], 2011). In the United States alone, UE MSDs are one of the most common diagnosis, following low back injury, for absenteeism and accounted in 2015 for 34% of all work-related injuries (United States Bureau of Labor, 2015a). That statistic could be higher but a lack of universal terminology of UE MSD allows reporting of injuries under separate classifications such as cumulative trauma disorders, repetitive stress injuries, overuse syndrome, and carpal tunnel syndrome (CTS) (Huisstede, Bierma-Zeinstra, Koes, & Verhaar, 2006). Even with the current lack of reporting uniformity the most common reported MSD of the UE is CTS (United States Bureau of Labor, 2015b).

The U.S. Bureau of Labor Statistics (2015) report an incident rate of 22 million individuals with CTS. The median number of days missed from work due to the UE MSD CTS has fluctuated between 21 – 32 days per incidence without a discernable trend from 1997 to 2010 and over $15 – 18 billion dollars spent annually in health care related costs (Pollack & Watkins-Castillo, 2014; US Department of Labor, 2015b). In the past 10 years though there has been a 5% increase in proportion to the population needing care for MSD, yet less than 2% of the National Institute for Health budget is allocated to researching solutions (US Bone & Joint Initiative, 2014; Weinstein, 2016).

Carpal Tunnel Syndrome

CTS is the most common local entrapment neuropathy of the UE (Ali, Battecha, & Mansour, 2013). Considered a disabling repetitive stress injury, CTS results in altered neurological function in the distribution of the median nerve. The median nerve originates off the brachial plexus and is a major peripheral nerve running the length of the UE (Newington, Harris, & Walker-Bone, 2015). The carpal tunnel is found in the proximal palmar wrist and is created by carpal bone boundaries of the pisiform, hook of the hamate, tuberosities of the scaphoid and trapezium (Newington et al., 2015). The flexor retinaculum attaches to the carpal bones creating a canal in which nine flexor tendons run through. The median nerve also runs through the carpal tunnel from the forearm to the wrist proving sensory innervation to the palmar surface of the thumb, index, middle, and radial half of ring finger and motor supply to the thenar (thumb) muscle group (Newington et al., 2015).

Compression of the median nerve and narrowing of the lumen of the tunnel may lead to impaired median nerve conduction, paresthesia, and pain in the area of the median nerve distribution in the hand and wrist (Ali, et al., 2013). Symptoms may include burning, tingling, numbness in the first three fingers, pain in the forearm, decreased sensation, and weakness of the hand and wrist. Early morning or nocturnal pain and numbness is a distinguishing symptom and persistent constriction can lead to advanced symptoms such as weakness and wasting of the thenar muscles (Newington et al., 2015). Though CTS is considered a repetitive stress injury, the etiology of this MSD is multifactorial and includes classification of both non-work-related MSD and work-related MSD (WRMSD).

Non-work Related

CTS is a multifactorial syndrome and evidence has been found to link physical, individual, and psychosocial elements as contributing causal factors. Though non-work-related MSD prevalence of CTS has been reported to increase with age, gender also seems to affect the incidence according to Newington et al. (2015). Three females to one male experience CTS symptoms annually, 1.5 per 1000 compared to 0.5 per 1000 respectively (Newington et al., 2015; Thomsen, Gerr, & Atroshi, 2008). Historically the demographics of individuals with CTS included women aged 45 – 54 years; however, for women the ratio decreases with age while incidences in men appear to increase with age (Newington et al. 2015).

Epidemiological factors such as body mass index, obesity, and co-morbidities of diabetes and even pregnancy have been hypothesized as contributing factors to CTS,

(Ozgen et al. (2011); however, evidence of the correlational decrease in signs and symptoms with weight-loss or pharmacological interventions are incomplete. Consideration returns then to occupation and work-related positions and repetitive stress.

Work-related

The etiology of work-related MSD CTS is hypothesized to be caused from an increased pressure of the carpal tunnel, prolonged exposure to hand-arm vibrations, a combination of repetitive hand use and the use of hand force, and in recent years has expanded to include the repetitive use of computers and similar devices (Ali et al., 2013). Chronic repetitive use of the fingers and wrist may generate a shearing between the carpal tunnel, the median nerve, and the flexor tendons, which results in a restricted hyperplasia and fibrosis of the tenosynovitis of the flexor tendons and the median nerve in the tunnel (Ali et al., 2013). Individuals such as those who are employed in manufacturing, service industry, office work, and nursing have a significant chance of being diagnosed with CTS (Walker et al., 2000). Coggon et al. (2013) found that individuals who use computers four hours a day experience a high incidence of CTS. Goldfarb (2016) expanded these findings and found those who use computers for 12-hours a day over an eight -year span are primarily at-risk. Such findings would put students at the highest risk for CTS. The previous demographics of individuals commonly diagnosed with CTS, females 45 – 64 years old, may need to now include students who use computers greater than 12-hours per day (Goldfarb, 2016; United States Department of Labor, 2015). The mechanics and position of the wrist and hand with small hand-held devices need to be considered.

While the diagnosis of CTS is confirmed through electromyography; however, medical personnel including occupational therapists assess CTS based on signs and symptoms. Health care professionals including occupational therapists commonly assess for CTS by administering the Phalen's Test and Tinel's Test. Evidence suggests Phalen's Test and Tinel's Test to be valid with high specificity and reliability (Denham, Wilhite, McGrady, & Booth, 2015). Denham and colleagues (2015) report specificity of the Phalen's Test was 80% with confirmed diagnosis of CTS and the sensitivity of the Phalen Test and electromyography is between 68% to 85% and 73% to 89%. Kotevoglu and Gulbahce-Saglam (2005) found a correlation of ($r = 0.80$, $p < 0.001$) for the Phalen Test using diagnostic ultrasound and Tinel's Test correlation factor of ($r = 0.70$, $p < 0.001$).

Significance for Occupational Therapy

Occupational therapists historically have had a role in treating UE MSD including CTS by addressing occupational performance and impairment of functional tasks (Roll, 2017). Occupational performance is identified as the intersection of the person, the environment, and the occupations which support tasks, activities, and roles that define that person as an individual (Baum & Law, 1997). In essence, occupational performance is an individual's ability to participate in activities that are meaningful to them. Individuals who feel a sense of control over their environments and are able to successfully address obstacles derive satisfaction from their roles, which is the hall mark of occupational therapy's contribution to the medical community (Burke, 1977).

Occupational therapists can increase quality of life by increasing occupational performance working holistically with individuals with CTS to find effective

methodologies to meet individual's needs for relative mastery. Individuals with an UE MSD such as CTS can lose the ability to engage in self-care, work, homemaking, and leisure and become unable to demonstrate a positive interaction and mastery within the environment. When occupational performance issues are not addressed, individuals are left to fend for themselves in resolving problems that can compromise function and health (Baum & Law, 1997). Such an example is highlighted by the work of Bates and Mason (2014) who found individuals with CTS used coping strategies, which included avoiding activities deemed difficult, adjusting occupational roles, or simply pushed through signs and symptoms. Occupational therapy assists individuals in maximizing the fit between what an individual wants to do, needs to do, and the capacity to do it (Baum & Law, 1997).

According to the Occupational Therapy (OT) Practice Framework ([Framework-III], American Occupational Therapy Association [AOTA], 2014), it is within occupational therapy's domain to address musculoskeletal disorders as it impairs body function. In studies undertaken to establish the benefits of occupation-based interventions in hand therapy, Colaianni and Provident (2010) found that occupation-based hand therapy interventions increased client motivation, satisfaction and adherence, and promoted a faster functional recovery due to the relevance of the activities to the individual's daily life and interests. Such activities also addressed psychological factors such as fear, pain and confidence. Furthermore, Jack and Estes (2010) identified that a holistic, client-centered and occupation-based approach to the treatment of hand injuries resulted in improved patient outcomes through facilitating adaptation and improved performance of functional activities.

Interventions

Current intervention strategies for CTS are abundant but can be categorized largely as surgical and non-surgical; however, in a systematic review Roll and Hardison (2017) found no standardized protocol or guidelines exists for the management and treatment of CTS. Williams, Westmorland, Schmuck, and MacDermid (2004) reported insufficient evidence exists to identify effective workplace rehabilitation interventions for the UE MSD CTS.

Surgical Intervention

Though surgical intervention results for CTS are mostly positive, Nanavati, Walker-Bone, Stanworth, and Williams (2013) report 29% of population have difficulty completing activities of daily living following surgery and 28% report a return of symptoms 28 days or more post-surgery. In a prospective study by Hobby, Venkatesh, and Motjur (2005) found conflicting evidence of the effectiveness of carpal tunnel release in older patients, with persistent numbness and loss of dexterity following surgery. Qiyun and MacDermid (2011) found no statistical difference between surgical and non-surgical intervention at three months, some benefit at six and twelve months; however, complications and side effects were more common following surgical intervention for CTS. In a meta-analysis, Huisstede et al. (2010) found moderate evidence in favor of surgical intervention compared with splinting, but no RCT has been found to determine the best strategy and timing for surgical intervention particularly for individuals with mild to moderate CTS.

Svernlöv, Nylander, and Adolfsson (2011) reported 30% of individuals who underwent surgery for CTS considered their symptoms unchanged by surgery and 12% considered symptoms to be worse post-surgery. Ehler et al. (2014) examined the relationship between the age of patients and the speed of adjustment of nerve conduction. Results concluded that individuals of a certain age, primarily between the ages of 60 and 94, were less likely to experience favorable outcomes from surgical intervention but males are more likely than females to benefit from surgical intervention (Ehler et al., 2014). However, Tan, Lai, and Tay (2017) in a follow up study of outcomes for carpal tunnel release found males had poorer outcomes than females and individuals under 55 years of age had poorer outcomes than those over 55-years of age.

When comparing surgical intervention to manual physical therapy, Fernández-de-las Peñas et al. (2015) found that the two interventions had comparable results with regard to changes in pain and function long-term; however, the physical therapy group had greater improvements in function, pinch-tip grip, and reduction of symptoms of CTS at one month, concluding that the physical therapy group had a more favorable outcome short term. Short-term improvements allow an individual to restore activities of daily living and meaningful occupations earlier in recovery. These results warrant further evidence on short-term interventions for CTS as alternatives to surgery.

Non-surgical Interventions

Conservative non-surgical interventions for CTS include, but are not limited to: Ultrasound, steroid injections, exercise therapy, and splinting but lack established uniform protocol or guidelines (Amini, 2011; Roll, 2017). Ultrasound is one of the few

passive modalities still accepted as part of effective intervention for CTS but 20 applications are needed and possible biophysical effects are unknown (Amini, 2011, Page, O'Connor, Pitt, & Massy-Westropp, 2013). In a systematic review, Amini (2011) concluded that exercise interventions alone to be generally ineffective and steroid injections limited in duration of effectiveness. The most commonly accepted non-surgical interventions for CTS include the combination of splinting the wrist in neutral, exercises, and ultrasound of which 20 sessions are required (Amini, 2011; Roll, 2016). However, Sim, Gunasagaran, Goh, and Ahmad (2018) compared splinting alone with combination of splinting, nerve/tendon glide exercises, and ultrasound without additional benefit noted using multiple interventions together.

Splinting

The most commonly prescribed intervention for CTS is splinting; however, outcomes vary based on protocol. Patient compliance and adherence is a universal complaint and only mediocre effectiveness is found (Amini, 2011; Walker et al., 2000). Roll and Hardison (2016) in a systematic review report splinting type, position, and guidelines remain unstandardized and concur high incidences of non-compliance by patients. So, why do orthotics persist as an intervention for CTS?

Weiss, Gordon, Bloom, So, and Rempel (1995) used an electrogoniometer to analyze the wrist angle and a device to read the pressure within the carpal tunnel. Participants moved the wrist through all planes of motion and data identified a wrist in neutral had the lowest pressure within the carpal tunnel (Weiss et al., 1995). A low internal carpal tunnel pressure at neutral indicated less stress on the median nerve which

could help alleviate some of the symptoms associated with CTS. Burke et al. (1994) sought to identify the optimal angle needed for a splint to reduce symptoms in those with CTS. Researchers compared the wrist in a neutral position against the wrist in 20° of extension using a cock-up splint. Results indicated the wrist in a neutral provided greater symptom relief (Burke et al., 1991).

Recently Nadar, Dashti, and Cherian (2013) found that finger position influenced properties of the median nerve, with significant palmar bowing of the flexor retinaculum for finger extension and a flattening of the median nerve during the isometric squeeze grip as it translocated down into the wrist. Thus, the median nerve became compressed when the fingers were in a flexed or grip position. This evidence is also supported by Bulut et al., (2015) who found when the wrist was positioned in neutral and metacarpophalanges were supported, subjects experienced the best outcomes. However, this evidence has yet to be translated into clinical practice.

The evidence for the effectiveness of splinting either full-time or night, combined with lumbrical stretching exercise for the treatment of CTS has demonstrated both short-term and long-term effects (Baker et al., 2012). Baker et al. (2012) and Manente et al. (2012) in one study found a combination of lumbrical stretching and general cock-up splint for CTS provided symptom relief up to 24 weeks, longer than any combination of conservative intervention. None of the accepted protocols take into consideration the new evidence that the wrist positioned in neutral and metacarpophalanges supported provides the best outcomes for individuals with CTS and leaves the issue of splint noncompliance unaddressed (Bulut et al., 2015). Though evidence supports the

effectiveness of orthosis, Roll (2017) identified the challenge in describing protocols and wearing patterns for MSD conditions such as CTS.

Qiyun and MacDermid (2011) declare both surgical and non-surgical methods produce similar outcomes. The surgical method resulted in a higher risk of complications while the conservative method's effectiveness plateaued after three months with varied efficacy, lack of homogeneity in protocols, and prolonged treatment times in the clinic (Qiyun & MacDermid, 2011). Six years later Roll (2017) found no standardized protocol for the management and treatment of CTS. Governmental regulation and cost containment needs are pushing for increased and early worksite interventions for individuals with CTS (Lysaght, Donnelly, & Luong, 2010). Takata, Wade, and Roll (2017) also identify the need for therapists to increase functional activity-based interventions providing interventions that are effective and impact quality of life, behavioral, and psychosocial outcomes.

Taping

Light elastic tape has been in the sports arena for years, and gained popularity when the company Kinesio donated the tape to the 2008 Olympic athletes. Developed in 1979 by Kenzo Kase, a doctor of Chiropractic medicine, Kinesio tape exhibits its efficacy through activation of neurological and circulatory (Kase, Hashimoto, & Okane, 1998, Kase, 2003). There has been an attempt to transition Kinesio tape from the athletic arena into the rehabilitation arena and a noticeable increase in evidence-based studies to determine its effective properties.

Kinesio taping is said to be guided by four principles (Kase et al., 1998). The first principle of Kinesio tape, according to Kase et al. (1998) is that the tape supports muscles, which leads to a reduction of muscle fatigue and injury; thus, increasing range of motion, and improving muscle contraction in weakened muscles. The second principle is that Kinesio tape helps to increase flow of body fluids by removing congestion, improving the circulation of blood and lymphatic fluid, and calming inflammation (Kase et al., 1998). The third principle of Kinesio tape is that it potentially activates an endogenous analgesic system, resulting in a reduction of pain. The fourth principle is that Kinesio taping corrects joint problems by adjusting misaligned joints. This allows an individual to move freely while providing proprioceptive input to cue the body to reposition (Kase et al., 1998). According to Kase and colleagues (1998) Kinesio tape is able to provide musculoskeletal correction based on application, often referred to as the "rebound effect". The tape will contract to its base of application increasing the convolutions and input to the muscle, thereby repositioning the joints.

Kinesio tape is applied to the epidermis of the skin and, by compression released on the nociceptors (pain receptors), provides input through the subcutaneous tissue layer to the body's proprioceptive system (Kase et al., 1998). The hypodermic input influences pain, edema, and discomfort by microscopically lifting the skin. This lifting effect forms convolutions in the skin, thus increasing interstitial space and allowing for a decrease in inflammation, while enabling a more effective flow of blood and lymphatic fluid in and out of the target area (Kase et al., 1998).

Made of cotton fibers, is latex-free, Kinesio tape allows body moisture to be absorbed and wicked away. When compared with traditional nonsurgical interventions,

including splinting, Kinesio tape provides a lasting effect due to its adhesive and water-resistant properties, allowing it to stay in place for several days before reapplication (Thelen, Dauber, & Stoneman, 2008). Brateanu (2009) elaborated on its ability to be worn three to five days without reapplication and evidence of common applications for patellar pain syndrome, low back pain, and shoulder instability. Fourteen peer-reviewed studies between 2004 and 2014 provide evidence of the effectiveness of Kinesio tape in terms of lower extremity pain and edema (Brown, O'Brien, & Taylor, 2014). Brown, O'Brien, and Taylor (2014) found consistent scores in the Visual Analogue Scale (6 studies) and improved range of motion (3 studies) with the use of Kinesio tape.

Ali et al. (2013) compared traditional physical therapy interventions of wrist strengthening and stretches for wrist muscles and ligaments with and without Kinesio tape for four weeks in patients with CTS. Results demonstrated a significant decrease in pain level and median sensory distal latency (MSDL) for individuals who completed the traditional physical therapy intervention of the wrist and received Kinesio tape compared to the individuals who received traditional physical therapy interventions without Kinesio tape (Ali et al., 2013).

Eraslan, Baltaci, Yuce, and Erbilici (2016) in a randomized controlled trial found statistically significant results for the use of Kinesio tape in decreasing pain intensity for patients with moderate CTS as compared to conventional physiotherapy and rigid taping. The Kinesio tape was more effective in reducing pain intensity when taped around the wrist with 25% to 50% tension in the center of the tape over the dorsal carpal tunnel in participants with moderate CTS (Eraslan et al., 2016). In contrast, Kocjan (2016) investigated the effect of Kinesio tape on pain level, hand functional status, and ROM of

the carpal joint with application on the flexor surface and found no significant difference between pre- and post-treatment values; however, scores on functional assessments were slightly improved. Kulcu et al. (2016) also in a randomized controlled trial with Kinesio tape applied to the flexor surface of the hand and forearm for both the intervention and the sham group, compared to a control group with a custom volar orthotic device and found improvement in grip strength for the orthotic group and improved function by the groups with Kinesio tape. Similarly, Guner, Altan, and Kasapoglu Aksoy (2018) in a randomized controlled trial found Kinesio tape applied to the flexor surface, with low-power laser treatment an effective and reliable intervention on pain and function for individuals with CTS. According to Lemos, Pereira, Protássio, Lucas, and Matheus (2015), there is a correlation between muscle function and the application of Kinesio tape when applied with moderate tension on the flexor surface of the forearm. However, if Kinesio tape is used to support or facilitate muscles based on application, as well as provide musculoskeletal re-positioning, and influence sub-acute pain, then using it on the flexor surface would seemingly only increase compression on the median nerve by pulling the wrist and fingers into flexion or grip position. To the best of our knowledge no study exists with methodology to support Kinesio tape on the dorsal surface. It is possible to consider the application of Kinesio tape on the dorsal surface of the forearm to facilitate the wrist extensors, thereby positioning the wrist in neutral, which is the optimal position of the wrist to release compression on the median nerve (Weis, Gordon, Bloom, So & Rempel, 1995). The application of Kinesio tape over the extensor surface of the first and fifth metacarpals may help facilitate extension opening the carpal tunnel

while allowing individuals to participate in occupations of work, self-care, activities of daily living, and removing issues of compliance and adherence.

Statistical evidence for the effectiveness of Kinesio tape on pain and/or function remain inconsistent. Moreover, although CTS is the third most studied diagnosis for distal UE rehabilitation less than five percent of studies have explored patient experiences using qualitative methods (Takata et al., 2017). Such studies are needed to better answer clinical questions regarding successful intervention options, the impact of self-efficacy on performance, and adapted responses to environmental tasks. In the absence of recent evidence regarding perceptions of interventions for CTS outside of surgical interventions, and no evidence regarding perceptions of Kinesio tape as a treatment option, there is a need to further explore and understand individuals' experiences when using Kinesio tape. Learning the perspectives of individuals using Kinesio tape for CTS may provide insight regarding functional performance, sense of self-efficacy, and likelihood of follow through with the intervention.

Theoretical Framework

Occupational therapists recognize that it is important to consider all aspects of the domain which affect an individual's engagement and performance in occupations. The Biomechanical frame of reference, the most common of all framework in rehabilitation, focuses on physical deficits emphasizing strengthening, endurance and range of motion through prevention, restoration, compensation, and stabilization of body structures. Occupations in a Biomechanical frame of reference focus on exercise and is often used in UE rehabilitation. It is a bottom-up approach focusing on one component rather than

considering all components. The Biomechanical frame of reference is appropriate when collecting quantitative data, such as grip and pinch strength.

The Theory of Occupational Adaptation provides a holistic approach to intervention without losing the kinematics emphasis, especially for UE impairments. The Theory of Occupational Adaptation developed in 1992 by Schkade and Schultz is a holistic model that not only takes into account the individual and his or her environment, but the interaction of the two. According to Cole and Tufano (2008), when clients have a desire for mastery, they have innate adaptive response to their environment. Healthy adaptation occurs when the individual demonstrates adeptness that is demanded by the environment. Problems occur when individuals cannot meet the demands to adapt and can be measured through qualitative data such as pain and occupational performance.

Jack and Estes (2010) found interventions that were client-focused and promoted mastery of the environment produced more successful rehabilitation. Combining the Theory of Occupational Adaptation and the Biomechanical frame of reference offers a client-centered approach integrating a focus on the physical body as well as an individual's interaction with their occupational environment. The application of an intervention such as Kinesio tape allows an individual to continue participating in meaningful occupations of work and daily activities.

Objectives of the Study

The objectives of this study were to:

1. Determine if the dorsal application of Kinesio tape applied to the wrist extensors for individuals with CTS, makes a difference in occupational performance of pain and

function as measured by the Numeric Pain Rating Scale (NPRS), Visual Analog Scale (VAS), Boston Carpal Tunnel Questionnaire (BCTQ), functional grip and pinch measurements as compared to the common accepted lumbrical stretching exercises and nightly use of general cockup splint

2. Explore perspectives of participants wearing Kinesio tape to understand if Kinesio tape contributed to changes in occupational performance, pain, function and compliance.

References

Ali, R.R., Battecha, K.H., Mansour,W.T. (2013). Influence of kinesio tape in treating carpal tunnel syndrome. *Journal of Medical Science and Clinical Research, 1*(1), 1-9. Retrieved from http://www.jmscr.igmpublication.org

American Occupational Therapy Association. (2014). Occupational therapy practice framework: Domain and process (3rd ed.). *American Journal of Occupational Therapy, 68*(Suppl. 1), S1–S48. http://dx.doi.org/10.5014/ajot.2014.682006

American Public Health Association. (2011). *Musculoskeletal disorders as a public health concern* [Policy 20114]. Retrieved from www.apha.org

Amini, D. (2011). Occupational therapy interventions for work-related injuries and conditions of the forearm, wrist, and hand: A systematic review. *American Journal of Occupational Therapy, 65*, 29-36. http://dx.doi.org/10.5014/ajot.2011.09186

Baker, N., Moehling, K., Rubinstein, E., Wollstein, R., Gustafson, N., & Baratz, M. (2012). The comparative effectiveness of combined lumbrical muscle splints and stretches on symptoms and function in carpal tunnel syndrome. *Archives of Physical Medicine and Rehabilitation, 93*(1), 1 – 10. http://dx.doi.org/10.1016/j.apmr.2011.08.013

Bates, E., & Mason, R. (2014). Coping strategies used by people with a major hand injury: A review of the literature. *British Journal of Occupational Therapy,* 77(6), 289 – 295. http://doi.org/10.4276/030802214X14018723137995

Baum, C. & Law, M. (1997). Occupational therapy practice: Focusing on occupational performance. *American Journal of Occupational Therapy, 51*(4), 277 – 289.

Bulut, G., Caglar, N., Aytekin, E., Ozgonenel, L., Tutun, S., Demir, S. (2015). Comparison of static wrist splint with static wrist and metacarpophalangeal splint in carpal tunnel syndrome. *Journal of Back & Musculoskeletal Rehabilitation, 28(*4), 761 – 767. http://dx.doi.org/10.3233/BMR-140580

Burke, D., Burke, M., Stewart, G., & Cambre, A. (1994). Splinting for carpal tunnel syndrome: In search of the optimal angle. *Archives of Physical Medicine and Rehabilitation, 75*(11), 1241– 124.

Burke, J. (1977). A clinical perspective on motivation: Pawn versus origin. *American Journal of Occupational Therapy,* 32, 254 – 258.

Brateanu, D. (2009). Kinesio Taping technique and Kinesio Tex. *Timisoara Physical Education and Rehabilitation Journal, 2*(3), 36 – 40.

Brown, T., O'Brien, L., & Taylor, R. (2014). A scoping review of the use of elastic therapeutic tape for neck and upper extremity conditions. *Journal of Hand Therapy, 27*(4) 235 – 246.

Coggon, D., Ntani, G., Palmer, K. T., Felli, V. E., Harari, R., Barrero, L. H., ... & Bonzini, M. (2013). Disabling musculoskeletal pain in working populations: Is it the job, the person, or the culture? *Pain*, *154*(6), 856-863. http://dx.doi.org/10.1016/j.pain.2013.02.008

Cole, M., & Tufano, R. (2008). Applied theories in occupational therapy: A practical approach. Thorofare, NJ: SLACK.

Colaianni, D., & Provident, I. (2010). The benefits of and challenges to the use of occupation in hand therapy. *Occupational Therapy in Health Care, 24*(2), 130 – 146. http://dx.doi.org/

10.3109/07380570903349378

Ehler, E., Kanta, M., Kune, P., Prochazka, A., Valis, M., Vysata, O., & Yadollahi, M. (2014). Age delays the recovery of distal motor latency after carpal tunnel syndrome surgery. *Acta Neurochirurgica, 156*(7), 1335-1339. http://dx.doi.org/10.1007/s00701-014-2065-1

Eraslan, L., Baltaci, G., Yuce, D., & Erbilici. A. (2016). Does taping affect the rehabilitation of patients with carpal tunnel syndrome? A randomized control trial. [Special issue]. *HAND, 11*(1), 133s-133s. http://dx.doi.org 10.1177/1558944716660555jf

Fernández-de-las Penas, C., Ortego-Satiago, R., de la Llave-Rincón, A., Marínez-Perez,A., Fahandeh-Saddi Diaz, H., Martínez-Martín, J.,... Cuadrado-Pérez, L.M. (2015). Manual physical therapy versus surgery for carpal tunnel syndrome: A randomized parallel-group trial. *Journal of Pain, 16*(11), 1087-1094. http://dx.doi.org/10.1016/j.jpain.2015.07.012

Goldfarb, C. A. (2016). The clinical practice guideline on carpal tunnel syndrome and workers' compensation. *Journal of Hand Surgery*, *41*(6), 723-725. http://dx.doi.org/10.1016/j.jhsa.2016.04.003

Geler Kulcu, D., Bursali, C., Aktas, I., Bozkurt Alp, S., Unlu Ozkan, F., Akpinar, P. (2018). Kinesiotaping as an alternative treatment method for carpal tunnel syndrome. *Turkish Journal of Medical Sciences, 46*, 1042 – 1049. http://dx.doi.org 10.3906/sag-1503-4

Guner, A., Altan, L., & Kasapoglu Aksoy, M. (2018). The effectiveness of the low-power laser and kinesiotaping in the treatment of carpal tunnel syndrome, a pilot study. *Rheumatology International, 38*, 895. http://doi.org/10.1007/s00296-018-4020-6

Hobby, J., Venkatesh, R., & Motkur, P. (2005). The effect of age and gender upon symptoms and surgical outcomes in carpal tunnel syndrome. *Journal of Hand Surgery (European Volume), 30*(6), 599 – 604. http://dx.doi.org/10.1302/0301 620X.87B2.15055

Huisstede, B. M., Bierma-Zeinstra, S. M., Koes, B. W., & Verhaar, J. A. (2006). Incidence and prevalence of upper-extremity musculoskeletal disorders. A systematic appraisal of the literature. *BioMed Central Musculoskeletal Disorders, 7*, 7. http://doi.org/10.1186/1471-2474-7-7

Huisstede, B., Randsdorp, M, Coert, J., Glerum, S., van Middelkoop, M., & Koes, B. (2010). Carpal tunnel syndrome. Part II: Effectiveness of surgical treatments – A systematic review. *Archives of Physical Medicine and Rehabilitation, 91*(7), 1005 – 1024. http://dx.doi.org/10.1016/j.apmr.2010.03.023

Jack, J. & Estes, R. (2010). Documenting progress: Hand therapy treatment shift from biomechanical to occupational adaptation. *American Journal of Occupational Therapy, 64*, 82 – 87. http://dx.doi.org/10.5014/ajot.64.1.82

Jarvinen, T., Jarvinen, M., & Kalimo, H. (2013). Regeneration of injured skeletal muscle after injury. *Muscles Ligaments, & Tendons Journal, 3*(4), 337 – 345.

Kase, K. (2003). *Illustrated kinesio taping* (4th ed.). Albuquerque, NM: Ken'i Kai Information.

Kase, K., Hashimoto, T., & Okane, T. (1998). *Kinesio perfect taping manual: Amazing*

taping therapy to eliminate pain and muscle disorders. Albuquerque, NM: Kinesio Taping Association.

Kotevoglu, N. Gulbahce-Saglam, S. (2005). Ultrasound imaging in the diagnosis of Carpal tunnel syndrome and its relevance to clinical evaluation. *Joint Bone Spine, 72*(2), 142 – 145. http:/dx.doi.org/10.1016/j.jbspin.2004.03.012

Kocjan, K. (2016). Kinesio taping in conservative treatment of mild to moderate cases of carpal tunnel syndrome. *Journal of Education, Health and Sport, 6*(9), 604 – 609. http://dx.doi.org/10.5281/zenodo.155060

Lemos, T. V., Pereira, K. C., Protássio, C. C., Lucas, L. B., & Matheus, J. C. (2015). The effect of kinesio taping on handgrip strength. *Journal of Physical Therapy Science, 27*(3), 567-570. http://dx.doi.org/10.1589/jpts.27.567

Luckhaupt, S., Dahlhamer, J., Ward, B., Sweeney, M., Sestito, J., & Calvert, G. (2013). Prevalence and work-relatedness of carpal tunnel syndrome in the working population, United States, 2010 National Health Interview Survey. *American Journal of Industrial Medicine, 56*(6), 615 – 624. http://dx.doi.org/10.1002/ajim.22048

Lue, Y., Wu Y., Liu, Y., Lin, G., & Lu, Y. (2015). Confirmatory factor analysis of the Boston Carpal Tunnel Questionnaire. *Journal of Occupational Rehabilitation, 25*, 717 – 724. http://dx.doi.org/10.1007/s10926-015-9579-0

Lysaght, R., Donnelly, C., & Luong, D. (2010). Best practices in the rehabilitation of Acute musculoskeletal disorders in workers with injuries: An integrative review And analysis of evolving trends. *Work, 35*, 319 – 333.

Manente, G., Melchionda,D., Staniscia, T., D'Archivio, C., Mazzone, V., & Macarini, L.

(2012). Changes in the carpal tunnel while wearing the Manu® soft hand brace: A sonographic study. *The Journal of Hand Surgery, 38*(1), 57 – 60. http://dx.doi.org/10.1177/1753193412446112

Murray, C., Arkinson, C., Bhalla, K., Birbeck, G., Burstein, R., Chou, D., …Murray, D.; U.S. Burden of Disease Collaborators. (2013). The state of US health, 1990 – 2010: Burden of diseases, injuries, and risk factors. *Journal of American Medical Association, 310*, 591 – 608. http://dx.doi.org/10.1001/jama.2013.13805

Murray, C., Vos, T., Lozano, R., Naghavi, M., Flaxman, A., Michaud, C., …Memish, Z. (2012). Disability-adjusted life years for 291 diseases and injuries in 21 regions, 1990 – 2010: A systematic analysis for the Global burden of Disease Study 2010. *Lancet, 380*, 2197 – 2223. http://dx.doi.org/10.1016/S0140-6736(12)61689-4

Nadar, M. S., Dashti, M. H., & Cherian, J. (2013). Finger position alters the median nerve properties within the carpal tunnel: A pre-post MRI comparison study. *Plos One, 8*(11), e79273. http://dx.doi.org/10.1371/journal.pone.0079273

Nanavati, N., Walker-Bone, K., Stanworth, H., & Williams, C. (2013). Outcomes of open carpal tunnel decompression. *New Zealand Medical Journal, 126*(1369), 60 – 67.

Newington, L., Harris, E., & Walker-Bone, K. (2015). Carpal tunnel syndrome and work. *Best Practice and Research: Clinical Rheumatology, 29*(3), 440 – 453. http://dx.doi.org/10.1016/j.berh.2015.04.026

Ozgen, M., Gungen, G., Sarsan, A., Ardiç, F., Caliskan, S., Sabir, N., . . . Baydemir, C. (2011). Determination of the position on which the median nerve compression is at the lowest in carpal tunnel syndrome and clinical effectiveness of custom splint

application. *Rheumatology International, 31*(8), 1031-1036. http://dx.doi.org/10.1007/s00296-010-1414-5

Page, M., O'Connor, D., Pitt, V., & Massey-Westropp, N. (2013). Therapeutic ultrasound for carpal tunnel syndrome. *Cochrane Database of Systematic Reviews, 2013*(3), 1 - 93. http://dx.doi.org/10.1002/14651858.CD009601.pub2

Parkhad, S., & Palve, S. (2014). Utility of nerve conduction study in early diagnosis of carpal tunnel syndrome (CTS). *National Journal of Physiology, Pharmacy & Pharmacology, 4*(1), 9-14. http://dx.doi.org/10.5455/njppp.2014.4. 130620132

Pollack, A., & Watkins-Castillo, S. (2014). *Workplace MSD Injuries. The Burden of Musculoskeletal diseases in the United States*. Retrieved from www.boneandjointburden.org

Punnett, L., & Wegman, D. (2004). Work-related musculoskeletal disorders: The epidemiologic evidence and the debate. *Journal of Electromyography and Kinesiology 14*, 13-23. http://dx.doi.org/10.1016/j.jelekin.2003.09.015

Qiyun, S., & MacDermid, J. (2011). Is surgical intervention more effective than non-surgical treatment for carpal tunnel syndrome: A systematic review. *Journal of Orthopaedic Surgery & Research, 6*(1), 17 – 25.

Robinson, L., Brown, T., & O'Brien, L. (2016). Embracing an occupational perspective: Occupation-based interventions in hand therapy practice. *Australian Occupational Therapy Journal,* 63, 293 – 296. http://dx.doi.org/10.1111/1440-1630.12268.

Roll, S. (2017). Current evidence and opportunities for expanding the role of Occupational Therapy for adults with musculoskeletal conditions. *American*

Journal of Occupational Therapy, 71, 7101170010 http://dx.doi.org/10.5014/ajot.2017.71102.

Roll, S. (2016). *Carpal tunnel syndrome: Improving intervention effectiveness*. Retrieved from www.CE-Express.com

Roll, S., & Hardison, M. (2017). Effectiveness of occupational therapy interventions for adults with musculoskeletal conditions of the forearm, wrist, and hand: A systematic review. *American Journal of Occupational Therapy*, 71(1), 7101180010p1-p12. http://dx.doi.org/10.5014/ajot.2017.023234

Schkade, J. & Schultz, S. (1992). Occupational Adaptation: Toward a holistic approach for contemporary practice Part 1. *American Journal of Occupational Therapy, 46*(9), 829 – 837. http://dx.doi.org/10.5014/ajot.46.9.829

Svernlöv, B., Nylander, G., & Adolfsson, L. (2011). Patient-reported outcome of surgical treatment of nerve entrapments in the proximal forearm. *Advances in Orthopedics,* 2011. http://dx.doi.org/10.4061/2011/727689

Takata, S., Wade, E., Roll, S. (2017). Hand therapy interventions, outcomes, and diagnoses evaluated over the last 10 years: A mapping review linking research to practice. *Journal of Hand Therapy,* 1 – 8. http://dx.doi.org/10.1016/j.jht.2017.05.018

Thelen, M. D., Dauber, J. A., & Stoneman, P. D. (2008). The clinical efficacy of kinesio tape for shoulder pain: A randomized, double-blinded, clinical trial. *Journal of Orthopaedic and Sports Physical Therapy, 38*(7),389-395. http://dx.doi.org/10.2519/jospt.2008.2791

Thomsen, J., Gerr, F., & Atroshi, I. (2008). Carpal tunnel syndrome and the use of computer mouse and keyboard: A systematic review. *BioMedical Central Musculoskeletal Disorders*, 9, 134. http://dx.doi.org/10.1186/1471-2474-9-134

Trampisch, U. S., Franke, J., Jedamzik, N., Hinrichs, T., & Platen, P. (2012). Optimal Jamar dynamometer handle position to assess maximal isometric hand grip strength in epidemiological studies. *The Journal of Hand Surgery*, *37*(11), 2368-2373. http://dx.doi.org/10.1016/j.jhsa.2012.08.014

U.S. Bone and Joint Initiative. (2014). *The burden of musculoskeletal diseases in the United States* (3rd ed.). Rosemont, IL: American Academy of Orthopaedic Surgeons. Retrieved from http:/www.boneandjointburden.org

United States Bureau of Labor Statistics. (2015). *Nonfatal occupational injuries and illnesses requiring days away from work, 2014 (USDL 15-2205)* [News release]. Retrieved from http://www.bls.gov/news.release/pdf/osh2.pdf

United States Department of Labor. (2015a). *Nonfatal occupational injuries and illnesses requiring days away from work, 2015*. Retrieved from http://www.bls.gov

United States Department of Labor. (2015b). *OSHA*. Retrieved from http://www.osha.gov

Walker, W. C., Metzler, M., Cifu, D. X., & Swartz, Z. (2000). Neutral wrist splinting in carpal tunnel syndrome: A comparison of night-only versus full-time wear instructions. *Archives of Physical Medicine and Rehabilitation, 81*(4), 424-429. http://dx.doi.org/10.1053/mr.2000.3856

Weinstein, S.L. (2016). The burden of musculoskeletal conditions. *Journal of Bone and Joint Surgery, 98*, 1331. http://dx.doi.org/10.2106/jbjs.16.00595

Weiss, N. D., Gordon, L., Bloom, T., So, Y., & Rempel, D. M. (1995). Position of the wrist associated with the lowest carpal-tunnel pressure: Implications for splint design. *Journal of Bone and Joint Surgery, American Volume, 77*(11), 1695-1699.

Williams, R., Westmorland, M., Schmuk, G., & MacDermid, J. (2004). Effectiveness of workplace rehabilitation interventions in the treatment of work-related upper extremity disorders: A systematic review. *Journal of Hand Therapy, 17*(2), 267 – 273. http://dx.doi.org/10.1197/j.jht.2004.02.012

Williamson, A., & Hoggart, B. (2005). Pain: A review of three commonly used pain rating scales. *Journal of Clinical Nursing, 14*(7), 798-804. http://dx.doi.org/10.1111/j.1365-2702.2005.01121

CHAPTER TWO

Comparative Efficacy of the Dorsal Application of Kinesio Tape and Splinting for Carpal Tunnel Syndrome: A Randomized Controlled Trial

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Abstract

Background
Carpal Tunnel Syndrome (CTS) symptoms are problematic especially when signs and symptoms are not substantial enough to require surgical intervention. Conservative treatments have mixed effectiveness, and yet are one of the best options for chronic low-grade CTS. Kinesio tape is an emerging modality, as it provides biomechanical support while allowing movement.

Purpose
To determine the efficacy of dorsal application of Kinesio tape on occupational performance as measured by pain and function in individuals with CTS; as compared to the accepted non-surgical intervention of general cockup orthosis and lumbrical stretching exercises versus sham tape.

Study Design
Single blind randomized controlled trial

Method
Forty-four participants (68 wrists) with CTS were randomized to one of three interventions: Kinesio tape group, sham group, or splint group, and completed baseline and four subsequent measurements of grip and pinch, Visual Analogue Scale (VAS), Numeric Pain Rating Scale (NPRS), Boston Carpal Tunnel Questionnaire (BCTQ), and application of intervention every three days. Daily symptom journals were completed by all, splint group recorded wearing schedule and exercises.

Results
A significant reduction in median NPRS pain scores of forearm and wrist in Kinesio tape group ($p = 0.006$, and $p = 0.005$ respectively), but not in the splint group ($p = 0.11$, and $p = 0.17$), and sham group ($p = 0.43$, and $p = 0.30$) with a minimal clinically important difference (MCID) of 1.0. MCID for VAS was 1.64. Kinesio tape and sham group had significant improvement in function, but not the splint group.

Conclusion
Kinesio tape group showed improvement in pain and function as compared to the splint group.

Key Words: Carpal Tunnel Syndrome; Kinesio tape; Conservative interventions; Functional performance

Comparative Efficacy of the Dorsal Application of Kinesio Tape and Splinting for Carpal Tunnel Syndrome: A Randomized Controlled Trial

Carpal tunnel syndrome (CTS) is a highly prevalent disorder that has numerous impacts on daily life. CTS effects 22 million individual lives in the United States alone with symptoms that include pain, numbness, burning, and weakness of the forearm, wrist, and hands.[1] These symptoms frequently lead to a loss of participation in meaningful functional self-care, work, and leisure. Moreover, early signs of CTS are often overlooked or unclear leading to delays in interventions or symptoms are not substantial enough to require immediate surgical intervention and delay skilled intervention.[2] Conservative non-surgical interventions for CTS exist, however, these interventions have mixed-evidence and lack standardized protocols leading to limited clinical guidance on the best treatment options for chronic low-grade CTS.[3]

Among conservative interventions, the use of an orthosis has the most promising evidence. Nightly use of a general cock-up orthosis and lumbrical exercises were found to provide symptom relief of the longest duration (24 weeks) as a non-surgical intervention; however, compliance and adherence are common issues.[4-7] Lack of standardized protocols for wearing schedules and types of orthotic design also contribute to the difficulties in intervention guidelines for CTS. Recent evidence indicates that finger position can influence the median nerve, as the wrist positioned in neutral with metacarpophalanges supported provides the best outcomes for individuals with CTS; but is yet to be seen in clinical practice.[3,4,8-10]

The need to find alternative non-surgical interventions that may improve client adherence and thereby reduce symptoms for the effective management of CTS has led to a range of clinical investigations. Kinesio tape is one such emerging modality with

increasing use in upper extremity (UE) rehabilitation. Kinesio tape is applied to the skin to provide biomechanical support during functional movement. In addition to support, compression released on the nociceptors (pain receptors) provides input through the subcutaneous tissue layer to the body's proprioceptive system.[11] Together, it is theorized that Kinesio tape use results in improved muscle contraction, increased circulation of blood and lymphatic fluid, activation of an endogenous analgesic system which inhibits nociceptive pain impulses, and musculoskeletal correction.[11-13] The principles of Kinesio tape are based on application utilizing a rebound effect. That is, the tape will contract to its base of application increasing the convolutions and input to the muscles for musculoskeletal correction thereby repositioning the joints.[11-13] Evidence from studies utilizing magnetic resonance imaging (MRI) also suggests that the application of Kinesio tape increases sensory and motor activity in the cerebral cortex resulting in a continuous contraction of muscle to create stable muscle tension.[14;15]

When applied to the wrist extensors the sensory and motor activity after the application of Kinesio tape, creates a stable muscle base for the hand to engage in functional activities. Lemos, Pereira, Protássio, Lucas, and Matheus[16] found a correlation between muscle function and Kinesio tape when applied with moderate tension on the flexor surface of the forearm. Kamal-Eldeen, Awooda and El-aksou[17] found the application of Kinesio tape on the wrist extensors for children with Erb's palsy allowed stable joint positioning of the wrist, which promoted involvement on functional activities.

Given its ability to support the wrist and hand, Kinesio tape may provide similar support to that of orthoses commonly used for CTS, while allowing greater functional mobility. In a single blind randomized controlled trial (RCT) with participants who had

CTS, Guner and colleagues[18] found that Kinesio taping and low-power laser were beneficial in reducing long-term symptoms (i.e., 12-weeks). In another randomized controlled trial Kinesio tape was applied to the flexor surface for CTS and reported insignificant results on pain and function.[19,20] However, if Kinesio tape is used to support or facilitate muscles based on application, as well as provide musculoskeletal re-positioning, and influence sub-acute pain, then using it on the flexor surface would seemingly increase compression on the median nerve by pulling the wrist and fingers into flexion or grip position. Perhaps then the application of Kinesio tape on the dorsal surface of the forearm, facilitating the wrist extensors; thereby, positioning the wrist in neutral may release compression on the median nerve while providing a stable base for functional activities. The application of Kinesio tape over the extensor surface of the first and fifth metacarpals may help facilitate extension opening the carpal tunnel while allowing individuals to participate in the work environment and activities of daily living, removing issues of compliance.

Purpose

Given that Kinesio tape may have a similar effect as an orthosis, we wanted to examine whether Kinesio tape would be as beneficial as an orthotic device for individuals with CTS. The purpose of the study was to determine the efficacy of a dorsal application of Kinesio tape on symptoms and functional performance in individuals with CTS, as compared to usual and accepted non-surgical intervention of general cockup orthosis and lumbrical stretching exercises or a sham application of Kinesio tape on the posterior shoulder.

Methods

We conducted a single blind randomized controlled trial with multi-methods embedded within the study. In addition to quantitative outcomes on symptoms and function reported in this manuscript, qualitative examination of patient experiences with the Kinesio tape intervention have been reported separately[21]. The study protocol was reviewed and approved by the university's institutional review board and all participants provided informed consent prior to participating. To examine the efficacy of the Kinesio tape application, a G-power analysis was conducted with a 5% significance level. A power of 80%, and a moderate effect size of 0.7, indicated that a sample size of 64 participant units (wrists) was needed.

Participants

Sixty-eight wrists (44 participants) with CTS were purposely recruited using snowball and judgmental sampling from the Southern California region. Recruitment ceased when sample size was achieved. Eligible participants were fluent in English, male or female 18-years and older who reported symptoms and clinical signs of CTS; that is, having pain, numbness, or tingling of the forearm, wrist, or hand, that worsened at night and demonstrated a positive Phalen's Test or Tinel's Test. Exclusion criteria included undergoing current treatment for CTS, a history of surgical carpal tunnel release, an allergy to adhesives, compromised skin integrity, or past history of traumatic event, surgery, or congenital impairment of the forearm, wrist, or hand. In addition, individuals with the following conditions were excluded: pregnancy, diabetes not controlled by medication, radiculopathy (e.g., cervical radiculopathy, diabetic radiculopathy), and thoracic outlet syndrome. Twenty-three participants presented with symptoms bi-

laterally, received interventions and completed outcome assessments for each hand. Participants were enrolled and all data were collected between February 2018 and October 2018.

Randomization and Blinding

Randomization was maintained by separating participants into three treatment groups by means of a simple randomization technique. A neutral third party generated the allocation sequence and randomized the three groups before the start of the study. Using an algorithm in Microsoft Excel, a master list was created. Using the randomization schedule and opaque packets, a second neutral third party created participants' packets with the specific interventions inside consecutively numbered envelopes. The neutral party retained the randomized intervention list. The intervention was only revealed to the researcher and the participants upon opening the opaque numbered envelop following full enrollment into the study. The researcher or participants were unable to be blinded to the intervention but attempted to reduce bias by the use of a neutral third party in creating and randomizing the interventions to the participants as well for data entry.

Interventions

Participants were randomized to one of three intervention groups: Kinesio tape group (KG), sham control group (CG), or splint group (SG). Participants in the KG had Kinesio tape applied to the dorsal upper extremity from proximal aspect of the forearm to the interphalangeal joint of the first digit and distal interphalangeal joint of the fifth digit (See Figure 1). We used a 10% stretch of the tape applied while the participant completed wrist flexion within available pain-free range of motion. A common athletic adhesive spray was applied to the skin surface prior to tape application. Participants were

instructed not to remove the tape, but to complete all of their typical activities. New tape was reapplied at each consecutive visit approximately three days apart across the two-week study period. Participants in the CG had a four-inch strip of Kinesio tape applied to the spine of the scapula that corresponded with the arm that had carpal tunnel syndrome. Prior to application, the tape was removed from the backing, allowed to fully retract, and was then placed on the participant with 0% stretch. Participants were instructed to inhale and exhale relaxing the shoulder girdle prior to tape application to ensure that any sustained muscle tension was released which could provide artificial stretch to the tape after application. The CG used the same wear, activity, and replacement pattern as the KG. Participants in the SG group were provided a prefabricated Mueller Sport Care one-size-fits-all adjustable maximum support orthosis with instructions to wear the orthosis while sleeping. Lumbrical stretching exercises were demonstrated, and participants were provided with an instructional handout for completing the stretches throughout the day as able. The same researcher provided all interventions and assessments across the three groups, and each participant was seen individually in order to minimize contamination across groups.

Outcome Assessments

Participants completed a demographic questionnaire at baseline, repeated measures of symptoms and occupational functioning at baseline and at each of four follow-up visits. Participants were seen five times, approximately every three days, over the course of two weeks to check or replace the intervention and obtain outcome measures. In addition to these measures, participants completed daily symptom journals while enrolled in the study to document their daily activities and symptoms. Participants

in the SG also recorded orthotic wearing and exercise times. Symptom journals were collected at each of the subsequent meetings during the intervention period. Immediately following completion of the study protocol, individuals in the KG completed face-to-face recorded semi-structured interviews lasting approximately 30-minutes to capture the experiences and perceptions of the use of Kinesio tape as a treatment option for CTS, none declined.[21]

Two general assessment tools were used to evaluate symptoms. The Numerical Pain Rating Scale (NPRS), is an 11-point objective assessment in which participants report pain levels in whole numbers in a range from 0 – 10. The NPRS is commonly used in clinical practice due to its superior sensitivity and ability to detect sex differences in pain intensity[22,23] The NPRS has high test-retest reliability in both literate and illiterate patients with Rheumatoid arthritis (r = 0.96 and 0.95, respectively), is used with multiple populations as the assessment translates well in most settings for chronic pain, and has a high construct validity (r = 0.86 to 0.95).[24,25] The Visual Analog Scale (VAS) for pain is similar to the NPRS, but measures pain on a continuous scale from 0 – 10 by requesting that individuals place a mark on a 10cm-long line. The VAS has good test-retest reliability among literate (r = 0.94) and illiterate individuals (r = 0.71), and demonstrates good construct validity.[24] Participants provided ratings on both the NPRS and VAS for current pain and worst pain they had experienced in the last 24-hours for each hand, wrist, and forearm.

Grip and pinch strength, which support occupational function were assessed using a Jamar dynamometer and pinch gauge. Following standard clinical procedures maximum grip strength was measured in three consecutive trials with each hand while

the participant sat in a chair with feet placed flat on floor, arms positioned along the side of the body, elbow flexed at 90 degrees and wrist in neutral position. Using this position, grip strength has been shown to have acceptable inter-instrument reliability, test-re-test reliability ($r > 0.80$), higher inter-rater reliability ($r = 0.98$), with concurrent validity to other assessments.[26-28] Pinch strength was similarly assessed using a pinch gauge to evaluate two-point, 3-point, and lateral punch strengths in each hand. When using standardized positioning and instructions, pinch strength assessments have high inter-rater reliability ($r = 0.97$) and test-retest reliability ($r = 0.80$).[26]

Subjective assessment of symptoms and occupational function directly related to CTS was completed using the Boston Carpal Tunnel Questionnaire (BCTQ). The BCTQ includes an 11-item measure of symptoms severity (SS) and 8-item-measure of basic functional status (FS). The BCTQ is a commonly accepted questionnaire used for assessing daytime pain, nocturnal numbness/tingling, and hand function in individuals with CTS. Lue, Wu, Liu, and Lu[29] found good face, content, and construct validity as well as test-re-test reliability ($r = 0.91$) and internal consistency ($0.80 – 0.90$) on the Symptom Severity Scale as well as high test - re-test reliability ($r = 0.93$) and internal consistency ($0.88 – 0.93$) on the Functional Status Scales.[30]

Statistical Analysis

Demographic data and outcome measures at baseline were compared using One Way Analysis of Variance (ANOVA) for continuous variables and Chi square analysis for categorical data. The normality of the continuous variables was examined using Shapiro Wilk and Kolmogorov- Smirnov tests. We used a 3 x 5 factorial ANOVA to examine changes in pain (VAS, BCTQ SS) and function (BCTQ FS) by group (KG, CG,

SG) over time (baseline, visit 2, visit 3, visit 4, visit 5), and 3 X 2 factorial ANOVA to assess changes in pinch and grip by group over time (baseline versus visit 5). For each analysis, the main effect of time evaluated whether there was a significant change among participants regardless of group, and the group by time interaction evaluated whether the magnitude of change across time differed by the type of intervention. When a significant group by time interaction was detected we conducted a one-way repeated measure ANOVA for each group separately. Post hoc comparisons were conducted using Bonferroni test. NPRS and grip data were not normally distributed. Therefore, we used Friedman test to examine changes in NPRS over time for each group separately, followed by Wilcoxon Signed Rank test to determine at which individual times the changes were significantly different. Similarly, we used Kruskal-Wallis ANOVA to examine differences in grip scores at baseline and at visit 5, followed by Mann Whitney U test to determine which groups were significantly different. Significance level was set at $p \leq 0.05$, and all data were analyzed using SPSS version 24.0 (IBM Corp.; Armonk, NY).

Results

Sixty-eight wrists (44 participants) were enrolled in the study. One subject (CG) dropped from the study secondary to complaint that the Kinesio tape was itchy. A second subject (SG) dropped from the study desiring another intervention, (Figure 2). A total of sixty-six wrists (42 participants) with a median (min, max) participant age of 29.5 (21,76) years completed the study. The majority of participants were female (n = 38, 90.5%), Caucasian (n = 22, 52.4%), right-handed (n = 39, 92.9%), and worked in an office setting (n = 22, 52.4%). Nineteen participants worked full-time (45.2%). The most frequent activities reported by participants were aerobics (n = 10, 23.8%), arts and crafts (n = 10,

23.8%), and shopping (n = 9, 21.4%). Participants were randomly assigned to KG (n = 15, 35.7%), SG (n = 15, 35.7%), and CG (n = 12, 28.6%) (Table 1).

Intervention Effects on Symptoms

NPRS. Though the distribution for NPRS was not approximately normal, there was no significant difference in median NPRS at baseline for forearm and wrist (p = 0.99 and p = 0.48, respectively). Data from the forearm indicated there was a significant reduction in median pain scores in the Kinesio tape group over time ($\chi^2_{4,.05}$ = 14.4, p = 0.01), but not in splint group ($\chi^2_{4,.05}$ = 6.4, p = 0.17), nor in the sham Group ($\chi^2_{4,.05}$ = 4.9, p = 0.30). In the Kinesio tape group forearm, post hoc comparisons were completed using Wilcoxon Signed Rank Test showed there was a significant difference in pain noted between baseline and visit five (p = 0.017). An average difference of 1.0 was found, slightly less than the minimal clinically important difference (MCID) of 1.1. Despite the overall difference not achieving clinical significance, 24% of individual participants in the Kinesio tape group reached clinical significance, 18% in the splint group, and 26% on the sham group, with 15 wrists reaching significant changes (Table 3).

Similarly, for the wrist, results of Friedman's test revealed that there was a significant reduction in pain in the Kinesio tape group ($\chi^2_{4,.05}$ = 14.9, p = 0.01) but not in the splint group ($\chi^2_{4,.05}$ = 7.5, p = 0.11) or sham group ($\chi^2_{4,05}$ = 3.8, p = 0.43). In the Kinesio tape group for the wrist, post hoc comparisons revealed there was a significant improvement in pain between baseline and visit 4 (p = 0.03), and baseline and visit 5 (p = 0.04). In the Kinesio tape group 36% reached clinical significance, 32% in the splint group, and 26% in the sham group with 21 wrists reaching significant changes.

VAS. To assess pain levels, the VAS was used with instructions for participants to indicate the worst pain levels in the last 24 hours to determine if the intervention was effective on the forearm and wrist. For VAS measurements of worst pain in the forearm, there was a significant group x time interaction ($p = 0.001$, partial$\eta^2 = 0.09$). Results of the one-way repeated measure ANOVA for each group separately revealed that participants in the KG had a significant reduction in pain over time ($F_{4,96} = 3.0$, $p = 0.03$, partial$\eta^2 = 0.10$). Bonferroni post hoc comparisons revealed that there was significant change between baseline and visit 4 ($p = 0.04$). Similarly, there was a significant reduction in pain in the splint group over time ($F_{4,96} = 4.5$, $p < 0.01$, partial$\eta^2 = 0.18$), with significant change between visit 2 and visit 4 ($p = 0.01$). For the CG there was significant reduction in pain over time ($F_{4,96} = 5.7$, $p < 0.01$, partial$\eta^2 = 0.24$), with significant change between baseline and visit 5 ($p = 0.02$). A minimal clinical difference of 1.64 was found with 40% of participants in the KG who reported decreased pain. In the SG, 54.5% reported less pain, and 73.7% of the CG improved, with 36 wrists reaching clinical importance.

The VAS data for worst pain reported in the last 24 hours in the wrist showed a significant reduction in pain over time, ($F_{4,252} = 6.5$, $p = <0.001$, partial$\eta^2 = 0.09$), however, there was no significant group by time interaction ($F_{8,252} = 0.9$, $p = 0.51$, partial$\eta^2 = 0.03$). Significant changes were seen across all groups ($p = 0.50$, partial$\eta^2 = 0.03$) and across all visits ($p = 0.001$, partial$\eta^2 = 0.8$). A MCID of 1.64 was achieved with 54.5% reaching clinical importance with 48% in the KG improving, 63% in the SG, and 79% in the CG. Forty-one wrists reached clinical importance. (Table 2).

BCTQ SS. The distribution of BCTQ SS at all times was approximately normal. The mean BCTQ SS score was significantly different among study groups at baseline ($F_{2,63} = 3.2$, $p = 0.04$). Thus, we used analysis of covariance (ANCOVA) to examine changes over time after controlling for symptom severity at baseline. Results showed that there was a significant improvement in symptoms among participants over time ($F_{4,248} = 4.5$, $p = 0.002$; partial$\eta^2 = 0.09$), but symptom results did not differ by group. In addition, there was no significant interaction between group and time ($F_{8,248} = 1.6$, $p = 0.15$, partial$\eta^2 = 0.05$). Bonferroni post hoc comparisons showed that there was a significant drop in the overall severity symptoms between baseline and subsequent visits ($p < 0.01$) at all times.

Intervention Effects on Function

Grip and pinch. There was no significant difference in mean grip among groups at baseline (55.7±20.3 versus 63.8±23.4 versus 52.1±15.5, $p = 0.24$). However, a significant difference in mean grip among the groups was detected post-intervention (55.2±18.6 vs. 65.9±21.5 vs 53.3±15.0, $p = 0.04$). Using Mann Whitney U test, we found a significant difference in mean grip between the KG and SG ($p = 0.02$), and a difference between the splint and sham groups ($p = 0.05$). For pinch, there was no significant interaction between group and time ($_{F2,63} = 2.2$, $p = 0.12$, partial$\eta^2 = 0.07$) and no significant change over time ($F_{1,63} = 3.8$, $p = 0.06$, partial$\eta^2 = 0.06$).

BCTQ FS. Kruskal Wallis test was used to examine differences in BCTQ FS among groups at baseline. There was no significant difference in mean BCTQ FS at baseline ($\chi^2_{2,.05} = 2.6$, $p = 0.27$). When analyzing changes within each group separately over time, there was a significant improvement in function over time in the KG ($\chi^2_{4,.05} =$

10.5, p = 0.03). Post hoc comparisons showed that there was a significant improvement in function between baseline and visit 4 (p = 0.03) and baseline and visit 5 (p = 0.008). In the SG, however, there was no significant improvement in function over time ($\chi^2_{4,.05}$ = 6.2, p = 0.18). Yet, in the CG, there was a significant improvement in function over time ($\chi^2 = _{4,.05}$ = 17.6, p = 0.001). Post hoc comparisons showed that there was a significant improvement in function between baseline and visit 3 (p = 0.004), baseline and visit 4 (p = 0.003), and baseline and visit 5 (p = 0.003).

Discussion

This study investigated the efficacy of a dorsal application of Kinesio tape on occupational performance as measured by pain and function in individuals with CTS as compared to the usual and accepted non-surgical intervention of general cockup orthosis and lumbrical stretching exercises versus sham tape. The outcomes of this randomized controlled trial indicate Kinesio tape was effective for reducing pain and improving function with good statistical significance and good effect size on the NPRS, VAS, of both forearm and wrist, as well as for the BCTQ SS and BCTQ FS. While subjective reports improved, no significant changes in objective measures of grip and pinch were seen over time or among the different intervention groups. Evidence for the use of Kinesio tape for musculoskeletal disorders has progressed through regions of the body over the last few years, from the knee and low back, to the scapula, with more recent examinations for use in the distal upper extremity rehabilitation.[31-32] Our data provide promising evidence for the use of Kinesio tape as a conservative intervention for management of symptoms in individuals with chronic low-grade CTS, while also

illuminating additional interesting considerations of patient age and activity participation and the overall mechanism of effects on pain reduction.

Pain Relief

Symptom relief for participants in the Kinesio tape group were consistent as compared to an orthosis. It is increasingly understood that symptom relief and return to function is the measure of success for interventions for musculoskeletal conditions of the hand, wrist, and forearm such as CTS.[33] This is consistent with the Occupational Adaptation framework concept of internal and external mastery.[34] Symptom relief, such as with the dorsal application of Kinesio tape, allows for increased successful engagement in the environment.[21] There is growing evidence that interventions in hand therapy which allow for continued engagement in functional activities, the use of occupation-based assessment tools, and intervention activities is increasing for therapeutic treatment of hand injuries.[35-38] Jack and Estes[39] found that a holistic, client-centered, and occupation-based approach to the treatment of hand injures, resulted in improved patient outcomes. Similarly, Robinson and colleagues[40] as well as Colaianni and Provident[41] found that such interventions increased client motivation, satisfaction and adherence, and promoted a faster functional return.

Many hand therapy interventions use a biomechanical approach, however, evidence supporting the benefit of meaningful interventions focusing on client participation and engagement is important for the rehabilitation therapist to consider.[2] Providing an intervention, such as Kinesio tape, for low-grade CTS allows individuals to continue participation in meaningful occupations of self-care, work, and leisure with decreased pain and increased function.

Age and Activity Participation

In this study a majority of the participants had full-time employment with 73% as office workers, which is notable. The women to men ratio in other studies of 3:1 were mimicked in this study as well with 38 women and four men.[42] The median age of 29.5 years of the participants in the study cannot be explained posing contradiction to past demographics of individuals with CTS where the median age is often 45 – 65 years. [42] It is possible, though not established, that the young average age of participants in this study reflects a societal trend toward CTS in younger people, perhaps due to the increased use of computers, tablets, and smartphones among teens and young adults.

It is established that occupational risk factors for CTS include repetitive flexing and extension of the wrist, forceful grip, and use of vibratory handheld tools.[43] Evidence indicates prolonged and repetitive positions of the wrist, and high hand/wrist repetition rate, along with computer work increases the risk of CTS.[44,45] Also, the effect of wrist posture among computer users found positioning greater than 20 degrees wrist flexion and for greater than 20 hours per week was the threshold for contributing to related CTS symptoms.[46,47] Nadar, Dashti, and Cherian[48] found finger position alters properties of the median nerve at the wrist. Although Shiri and Falah-Hassani[49] conclude computer work is a minor occupational risk factor contributing to CTS, others state there is insufficient evidence that computer work actually causes CTS[50,51] O'Connor, Page, Marshall and Massy-Westropp[52] found no strong evidence for the use of ergonomic keyboards for the treatment of symptoms of CTS. However, Coggon et al.[53] found computer use of four hours per day led to a high incidence of CTS. Goldfarb[54] furthered Coggon's finding of those who use computers and work 12-hour days over an eight-year span are primarily

the at-risk population, which would apply to young adults in screen culture. More studies are needed to understand if keyboard use is directly linked to CTS signs and symptoms.

Non-occupational factors that need to be considered regarding the young population of the study include activity levels for individuals with CTS. Nathan and colleagues[55] found aerobic exercise to be effective on symptoms associated with CTS. However, in this current study 33% of the participants were already active but continued to experience signs and symptoms of low-grade CTS, indicating an alternative intervention such as Kinesio tape could be beneficial.

Mechanism of effect

Due to the number of participants with bi-lateral symptoms analysis was conducted using the more affected extremity on all outcomes and similar correlations for each test were found. Such results cannot rule out the possible psychological effect versus actual effect and in light of the improvement in pain and function reported from the sham group must be addressed. The reported improvement of symptoms in the sham group may be a type of contextual healing, as described by Miller and Kaptchuk[56] in which a specific clinical encounter contributes to therapeutic outcomes. It could also be described as a placebo effect; Beecher[57] found placebos can have an average effectiveness of $35.2 \pm 2.2\%$. However, a placebo effect that causes a real effect cannot be called a placebo and some physiological or psychological mechanism must be explained.

In consideration of other modalities that, like Kinesio tape, effect the fascial layer, the field of acupuncture was consulted.[11,12,58] Kinesio tape works at the hypodermal layer and influences fascial tissue.[11,12] Like acupuncture, it is possible that the afferent

pathways are activated during the application of Kinesio tape and regardless of placement, thus producing an analgesic effect, but not a placebo effect. It would be difficult to say that application of Kinesio tape on any body part would produce a result, but perhaps the placebo effect produced by the sham Kinesio tape application is related to the participant's perceptions, expectations, and bias, and does not negate the therapeutic effect of Kinesio tape. It does, perhaps, draw attention to the possibility that Kinesio tape, like acupuncture, produces a real effect and should not be called a placebo in future studies.[58-60]

Limitations

Results of the study may have been muted due to problems with the application of Kinesio tape on first and fifth digits maintaining full adherence for three days, especially during activities that included water. Future studies may need to evaluate effects based on varied intervention parameters (e.g., daily application versus every three days) and overall treatment dosage (e.g., length). Next, although symptoms were noted to improve, focusing the study on individuals with chronic low-grade CTS may have led to a floor effect, limiting our ability to measure meaningful statistical value despite actual effect from the Kinesio tape. Similarly, grip and pinch strength measures were already within normal limits at baseline, limiting the potential to observe any significant effect on these measures. Finally, utilizing data from bi-lateral wrists contributed to challenges in interpreting significant findings in the sham group. To further differentiate between a placebo versus actual effect, future studies might need to consider unilateral interventions or an alternative sham intervention.

Conclusion

This study intended to determine the efficacy of a dorsal application of Kinesio tape on pain and function for individuals with CTS as compared to an orthosis and exercises. The results indicate that applying Kinesio tape to the dorsal aspect of the forearm, wrist, and hand had an effect on decreasing pain and increasing function. Data from the study demonstrates a potential trend for all three intervention groups, supporting a need for future research to be conducted at a larger scale to substantiate these findings. As the number of individuals with carpal tunnel syndrome increases, current interventions continue to have their challenges. Surgical treatment may relieve symptoms of CTS but require a sacrifice of time for an invasive procedure and necessary recovery period. Conservative treatment interventions, such as orthotics, may be effective in managing pain but can be cumbersome, and limit or restrict various areas of occupation including self-care and sleep. The difficulties associated with wearing an orthosis often result in a lack of compliance which in turn interferes with treatment. Currently, there is a gap in evidence for non-surgical interventions for CTS. It is understood that Kinesio tape, with its elastic properties, can support the wrist while facilitating a neutral position and offer flexibility that allows for functional wrist positioning to occur, which may increase compliance and occupational performance of individuals with CTS. The dorsal application of Kinesio tape may provide a non-surgical intervention option for therapists treating CTS.

References

1. US Bone and Joint Initiative. *The burden of musculoskeletal diseases in the United States.* 3rd ed. Rosemont, IL: American Academy of Orthopaedic Surgeons; 2014. http://www.boneandjointburden.org
2. Martin H. Patients' health beliefs and adaptation to carpal tunnel syndrome based on duration of symptomatic presentation. *J Hand Ther* 2007; 20:29 – 36. http://doi.org/10.1197/j.hht.2006.10.002
3. Roll S. Current evidence and opportunities for expanding the role of Occupational Therapy for adults with musculoskeletal conditions. *Am J Occup Ther* 2017; 71:7101170010. http://doi.org/10.5014/ajot.2017.71102.
4. Amini D. Occupational therapy interventions for work-related injuries and conditions of the forearm, wrist, and hand: A systematic review. *Am J Occup Ther* 2011; 65:29-36. http://doi.org/10.5014/ajot.2011.09186
5. Baker N, Moehling K, Rubinstein E, Wollstein R, Gustafson N, and Baratz M. The comparative effectiveness of combined lumbrical muscle splints and stretches on symptoms and function in carpal tunnel syndrome. *Arch Phys Med Rehab* 2012; 93:1–http://doi.org/10.1016/j.apmr.2011.08.013
6. Manente G, Melchionda D, Staniscia T, D'Archivio C, Mazzone V, Macarini L. Changes in the carpal tunnel while wearing the Manu® soft hand brace: A sonographic study. *J Hand Surg,* 2012;38(1):57 – 60. http://dx.doi.org/10.1177/1753193412446112
7. Walker WC, Metzler M, Cifu D X, Swartz Z. Neutral wrist splinting in carpal tunnel syndrome: A comparison of night-only versus full-time wear instructions.

Arch Phys Med Rehab, 2000;81(4):424-429. http://dx.doi.org/10.1053/mr.2000.3856

8. Bulut G, Caglar N, Aytekin E, Ozgonenel L, Tutun S, Demir S. Comparison of static wrist splint with static wrist and metacarpophalangeal splint in carpal tunnel syndrome, *J Back & Musculo Rehab,* 2015*;*28*(*4), 761 – 767. http://dx.doi.org/10.3233/BMR-140580
9. Roll S, Hardison M. Effectiveness of occupational therapy interventions for adults with musculoskeletal conditions of the forearm, wrist, and hand: A systematic review. *Am J Occup Ther* 2017; 71:7101180010p1-p12. http://doi.org/10.5014/ajot.2017.023234
10. Nadar MS, Dashti MH, Cherian J. Finger position alters the median nerve properties within the carpal tunnel: a pre-post MRI comparison study. *Plos One,* 2013;8(11): e79273. http://dx.doi.org/10.1371/journal.pone.0079273
11. Kase K, Hashimoto T, Okane T. *Kinesio perfect taping manual: Amazing taping therapy to eliminate pain and muscle disorders*. Albuquerque, NM: Kinesio Taping Association, 1998.
12. Kase K. *Illustrated Kinesio taping* (4th ed.). Albuquerque, NM: Ken'i Kai
13. Jardine K, and Tsaggarellis B. *Neurostructural Taping Technique.* Toronto, Canada: COLLABORANS, Inc, 2013.
14. Mori A, Takasaki M. *Activation of cerebral cortex in various regions after using Kinesio tape*. Kinesio Symposium 20, 2005:141-144. KTUS-DoCol-4-09-Sept-2010. http://www.aevnm.com/docs/socios/Articulos/Aut-Mori%20A.pdf

15. Bae S, Lee J, Oh K, Kim K. The effects of Kinesio taping on potential in chronic low back pain patient's anticipatory postural control and cerebral cortex. *J Phys Ther Sc* 2013; 25:1367–1371. http://doi.org/10.1589/jphs.25.1367
16. Lemos TV, Pereira KC, Protássio CC, Lucas LB, Matheus JC. The effect of kinesio taping on handgrip strength. *Journal of Physical Therapy Science,* 2015;27(3):567-570. http://dx.doi.org/10.1589/jpts.27.567
17. Kamal-Eldeen R, Awooda H, El-Maksoud G. Effectiveness of Kinesio tape on Wrist extensor muscles in children with obstetric brachial plexus injuries. *J Appl Life Sc* 2016; 7(4):1 – 7. http://dx.doi.org/10.9734/JALSi/2016/27625
18. Guner A, Altan L, Kasapoglu Aksoy M. The effectiveness of the low-power laser and kinesiotaping in the treatment of carpal tunnel syndrome: A pilot study. *Rheumatol Int* 2018; 38(5):895-904. http://doi.org/10.1007/s00296-018-4020
19. Geler Kulcu D, Bursali C, Aktas I, et al. Kinesiotaping as an alternative treatment method for carpal tunnel syndrome. *Turk J Med Sc* 2016;46(4):1042–1049. http://doi.org/10.3906sag-1503-4
20. Kocjan J. Kinesio taping in conservative treatment of mild-to-moderate cases of carpal tunnel syndrome. *J Ed Health Sp* 2016;6(9):604 – 609. http://doi.org/10.5281/zenodo.155060
21. Krause, D, Ryan, S, Krpalek, A, Roll, S, Javaherian-Dysinger, H, Daher, N. Participants' Perceptions on the Effectiveness of Kinesio Tape for Carpal Tunnel Syndrome: A Qualitative study. *Hand Therapy* 2019;24(4). https://doi.org/10.1177/1758998319841646

22. Ferreira-Valente M, Pais-Ribeiro J, Jensen M. Validity of four pain intensity rating scales. *Pain,* 2011;152(10):2399 – 404. http://dx.doi.org/10.1016/j.pain.2011.07.005

23. Williamson A. Hoggart B. Pain: A review of three commonly used pain rating scales. *J Clin Nur* 2005;14(7), 798-804. http://dx.doi.org/10.1111/j.1365-2702.2005.01121

24. Hawker G Mian S, Kendzerska T, French M. Measures of adult pain: Visual Analog Scale for Pain (VAS Pain), Numeric Rating Scale for Pain (NRS), McGill Pain Questionnaire (MPQ), Short-Form McGill Pain questionnaire (SF-MPQ), Chronic Pain Grade Scale (CPGS), Short Form -36 Bodily Pain Scale (SF-36 BPS), and measure of intermittent and constant osteoarthritis pain (ICOAP). *Arthritis Care & Res* 2011;63(S11):S240 – S252. http://doi.org/10.1002/acr.20543

25. Hjermstad MJ, Fayers PM, Haugen DF, Caraceni A, Hanks GW, Loge JH…European Palliative Care Research Collaborative. Studies comparing Numerical Rating Scales, Verbal Rating Scales, and Visual analogue Scales for assessment of pain intensity in adults: A systematic literature review. *J Pain Symptom Manage* 2011;41(6):1073 – 93. http://doi.org/10.1016/j.jpainsymman.2010.08.016

26. Mathiowetz V, Kashman N, Volland G, Weber K, Dowe M, Rogers S. Grip and pinch strength: Normative data for adults. *Arch Phys Med Rehab* 1985;66:69 - 74.

27. Roberts H, Denison H, Martin H, Patel H, Syddall H, Cooper C, Sayer A. A review of the measurement of grip strength in clinical and epidemiological studies: Towards a standardized approach. *Age and Ageing* 2011;40(4):423 – 429. http://dx.doi.org 10.1093/ageing/afr051

28. Trampisch, U S, Franke J, Jedamzik N, Hinrichs T, Platen P. Optimal Jamar dynamometer handle position to assess maximal isometric hand grip strength in epidemiological studies. *J Hand Surg* 2012;37(11):2368-2373. http://dx.doi.org/10.1016/j.jhsa.2012.08.014

29. Lue Y, Wu Y, Liu , Lin, G, Lu, Y. Confirmatory factor analysis of the Boston Carpal Tunnel Questionnaire. *J Occup Rehab* 2015*;25*,717 – 724. http://dx.doi.org/10.1007/s10926-015-9579-0

30. Carvalho Leite J, Jerosch-Herold C, Song, F. A systematic review of the psychometric properties of the Boston Carpal Tunnel Questionnaire. *BMC Musculoskel Disorders* 2006; 7(78). http://dx.doi.org/10.1186/1471-2474-7-78.

31. Anandkumar S, Sudarshan, S Nagpal, P. Efficacy of kinesio taping on isokinetic quadriceps torque in knee osteoarthritis: A double blinded randomized controlled study. *Physio Theory Prac* 2014;30(6):375 – 383. http://doi.org/10.3109/09593985.2014.896963

32. Kelle B, Guzel R, Sakalli H. The effect of kinesio taping application for acute non-specific low back pain: A randomized controlled trial. *Clinical Rehab* 2016. http://doi.org/10.1177/0269215515603218

33. Jerosch-Herold C, Mason R, and Chojnowski A. A qualitative study of the experiences and expectations of surgery in patients with carpal tunnel syndrome. *J Hand Ther* 2008;21:54-62. http://doi.org/10.1016/j.jht.2017.05.018

34. Schkade J, Schultz S. Occupational Adaptation: Toward a holistic approach for contemporary practice Part 1. *Amer J Occ The 1992;*46(9):829 – 837. http://dx.doi.org/10.5014/ajot.46.9.829

35. Bachman S. The Issue is – Evidence-based approach to treating lateral epicondylitis using the occupational Adaptation Model. *Am J Occup Ther*, 2016; 70,7002360010. http://dx.doi.org/10.5014/ajot.2016.016972

36. Bates E, and Mason R. Coping strategies used by people with a major hand injury: A review of the literature. *Br J Occup Ther* 2014; 77(6):289-295. http://doi.org/10.4276/030802214X14018723137995

37. Arbesman M, Lieberman D, and Thomas V. Methodology for the systematic reviews on occupational therapy for individuals with work-related injuries and illness. *Am J Occup Ther* 2011; 65(1):10-15.

38. College of Occupational Therapists. *Occupational Therapy Evidence: The importance of occupational therapy in hand therapy* [Fact sheet]. Retrieved from http://www.rcot.co.uk/file/666/download?token=EZrq4z2A

39. Jack J, and Estes R. Documenting progress: Hand therapy treatment shift from biomechanical to occupational adaptation. *Amer J Occup Ther* 2010; 64:82–87. http://doi.org/10.5014/ajot.64.1.82

40. Robinson, L., Brown, T., & O'Brien, L. (2016). Embracing an occupational perspective: Occupation-based interventions in hand therapy practice. *Australian*

Occupational Therapy Journal, 63, 293 – 296. http://dx.doi.org/10.1111/1440-1630.12268.

41. Colaianni D, and Provident I. The benefits of and challenges to the use of occupation in hand therapy. *Occup Ther Health Care* 2010; 24(2):130–146. https://doi.org/10.3109/07380570903349378
42. Ali R, Battecha K., and Mansour WT. Influence of kinesio tape in treating carpal tunnel syndrome. *J Med Sc and Clin Research* 2013; 1:1-9. http://www.jmscr.igmpublication.org
43. Luckhaupt S, Dahlhamer J, Ward B, Sweeney M, Sestito J, and Calvert G. Prevalence and Work-Relatedness of Capral Tunnel Syndrome in the Working Population, United States, 2010 National Health Interview Survey. *Am J Ind Med 2013*; 56:615–624
44. American Academy of Orthopaedic Surgeons. The American Academy of Orthopaedic Surgeons Evidence-based Clinical Practice Guideline on: Management of Carpal Tunnel Syndrome, *J Bone and Joint Surg*, Am Vol, 2016;98(20). https://dx.doi.org/10.2016/JBJS.16.00719
45. Newington, L., Harris, E., & Walker-Bone, K. (2015). Carpal tunnel syndrome and work. *Best Practice and Research: Clinical Rheumatology, 29*(3), 440 – 453. http://dx.doi.org/10.1016/j.berh.2015.04.026
46. Liu C, Chen C, Lee C, Huang M, Chen T, Wang M. Relationship between carpal tunnel syndrome and wrist angle in computer workers. *Kaohsiung J Med Sc,* 2003;19(12):671-622. http://doi.dx.org/10.1016/S1607-551X(09)70515-7
47. Rempel D, Keir P, Bach J. Effect of wrist posture on carpal tunnel pressure while

typing. *J Orthop Res* 2008; 2699);1269 – 1273. http://doi.org/10.1002/jor.20599

48. Nadar MS, Dashti MH, Cherian J. Finger position alters the median nerve properties within the carpal tunnel: A pre-post MRI comparison study. *Plos One* 2013
8(11):e79273. http://dx.doi.org/10.1371/journal.pone.0079273
49. Shiri R, Falah-Hassani K. Computer use and carpal tunnel syndrome: A meta-analysis. *J Neuro Sc*, 2014;349(1-2):15-19
50. Mediouni Z, deRoquemaurel A, Dumontier C, Becour B, Garrabe H, Roquelaure Y Descatha A. Is carpal tunnel syndrome related to computer exposure at work? A review and meta-analysis. *J Occup Enviro Med*, 2014;56(2):204-208 http://dx.doi.org/10.1097/JOM.0000000000000080
51. Thomsen J, Gerr F, Altroshi, I Crpal tunnel syndrome and the use of computer mouse and keyboard: a systematic review. *BMC Musculo Dis*, 2008;9(1):134
52. O'Connor D, Page M, Marshall S, Massy-Westropp M. Ergonomic positioning or equipment for treating carpal tunnel syndrome. *Cochrane Database of Sys Rev,* 2012;18. http://doi.dx.org/10.1002/14651858.CD009600
53. Coggon D, Ntani G, Palmer K, Felli V, Harari R, Barrero L, ... and Bonzini M. Disabling musculoskeletal pain in working populations: Is it the job, the person, or the culture? *Pain*, 2013; 154(6):856-863. http://doi.dx.org/10.1016/j.pain.2013.02.008
54. Goldfarb C. The clinical practice guideline on carpal tunnel syndrome and workers' compensation. *J Hand Surg*, 2016; 41(6):723-725. doi:10.1016/j.jhsa.2016.04.003

55. Nathan P, Wilcox A, Emerick P, Meadows K, and McCormack A. Effects of an aerobic exercise program on median nerve conduction and symptoms associated with carpal tunnel syndrome. *J Occup Environ Med* 2001;43,10:840 – 843. https://journals.lww.com/joem/pages/default.aspx

56. Miller F, Kaptchuk T. The power of context: Reconceptualizing the placebo effect. *J R Soc Med* 2008;101(5):222 – 225. http://doi.org/10.1258/jrsm.2008.070466

57. Beecher HK, The powerful placebo. *J Am Med Assoc*, 1955;159(17):1602-6

58. Lim TK, Ma Y, Berger F, & Litscher G. Acupuncture and neural mechanism in the management of low back pain – An update. *Medicines*, 2018;5(3):63. https://dx.doi.org/10.3390/medicines5030063

59. Xiang Y, He J, Li R. Appropriateness of sham or placebo acupuncture for randomized controlled trials of acupuncture for nonspecific low back pain: a systematic review and meta-analysis. *J of Pain Res,* 2017;11:83-94. http://dx.doi.org/10.20147/JPR.S152743

60. Marcus, D. Acupuncture and sham acupuncture for pain relief. *JAMA.* 2017;318(15):1502-1503. http://dx.doi.org/10.1001/jama.2017.13390

61. Giannini F, Cioni R, Mondelli M, Padua R, Gregori B., D'Amico P, and Padua L. A new clinical scale of carpal tunnel syndrome: validation of the measurement and clinical-neurophysiological assessment. *Clin Neurophysiol* 2002; 113:71–77. http://doi.org/10.1016/S1388-2457(01)00704-0

Figure 1. Dorsal application of Kinesio tape.

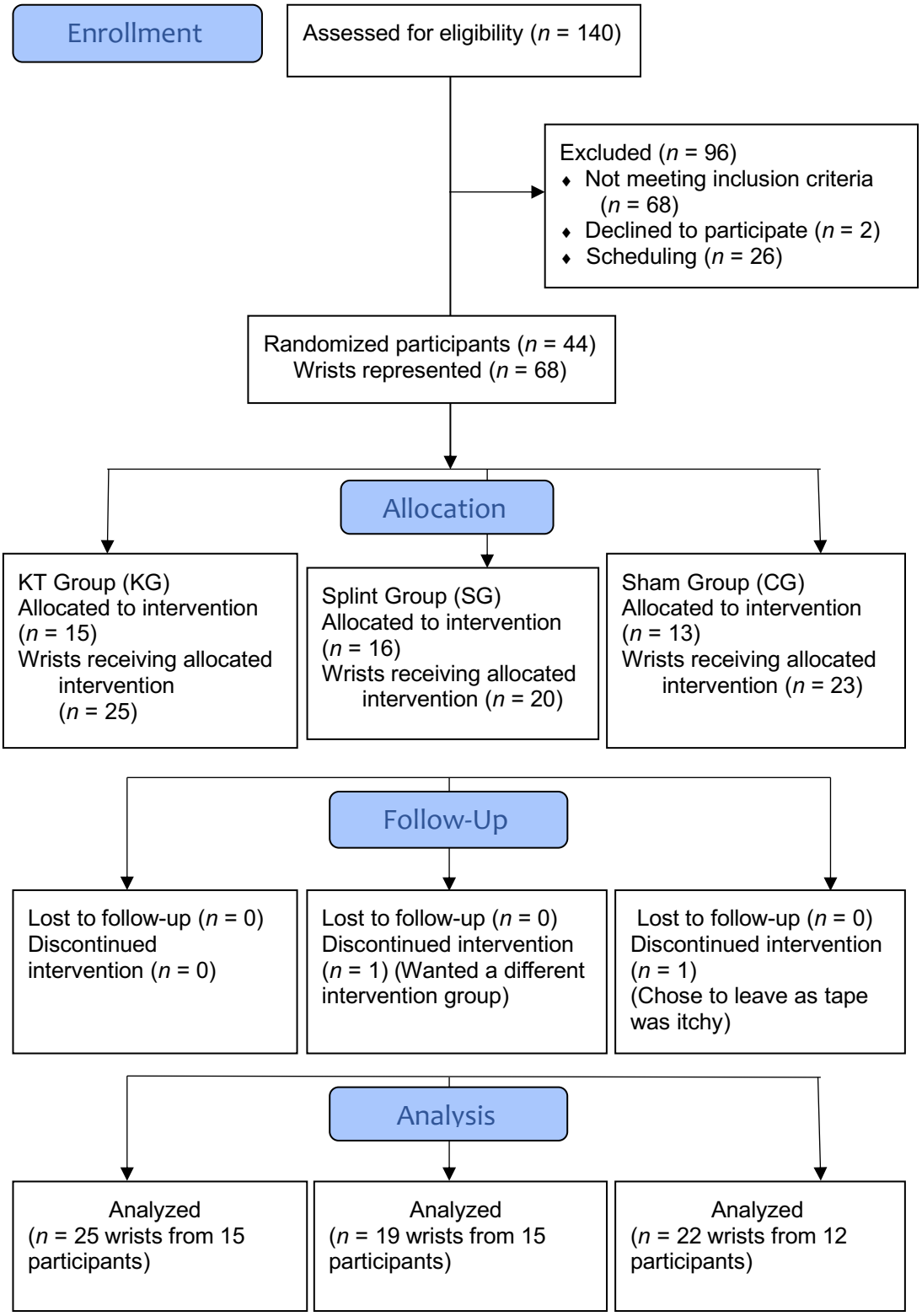
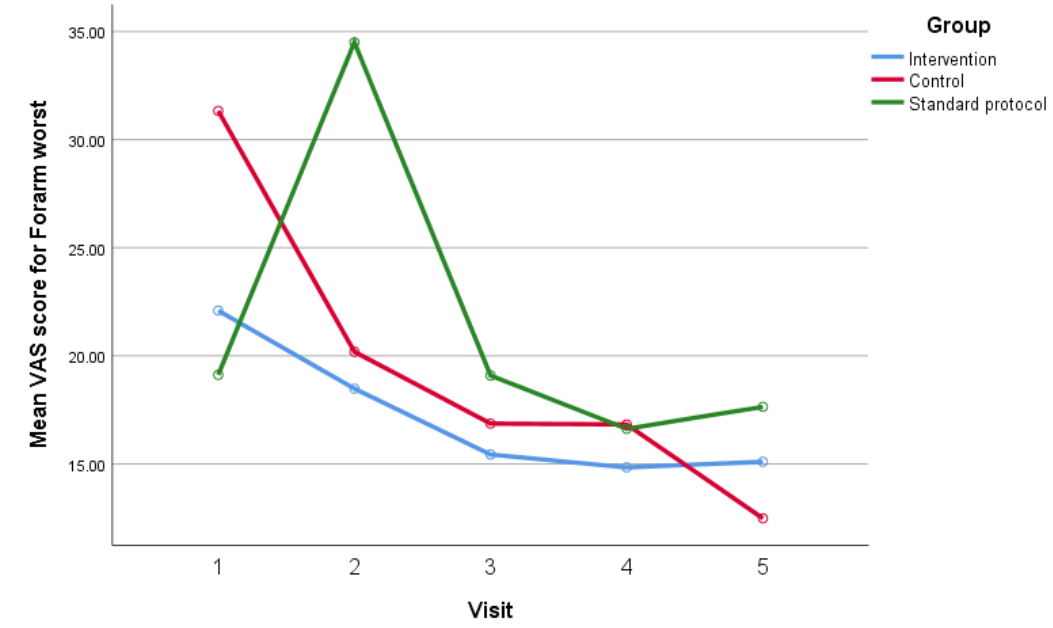


Figure 2. CONSORT Flow Diagram of participants and wrists allocated to the study.



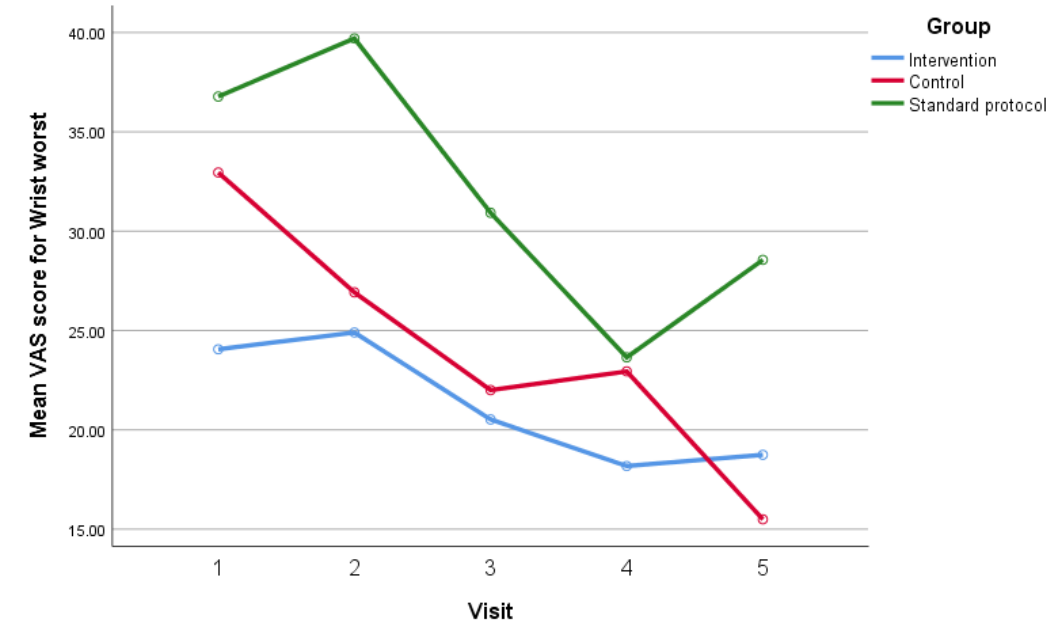


Figure 3. Changes in the worst pain experienced in the forearm and wrist across the 2-week intervention as reported on a visual analogue scale (VAS) by intervention group.

Table 1. Frequency (%) of baseline characteristics of the participants (N = 42).

	Kinesio tape (n = 15)	Splint (n = 15)	Sham (n = 12)
Right handed	12 (80.0)	15 (100.0)	12 (100.0)
Age; Median (min, max)	28 (23, 67)	28 (21, 57)	45 (23, 76)
Female *n* (%)	13 (86.7)	14 (93.3)	11 (91.7)
Ethnicity			
African American	0 (0.0)	0 (0.0)	1 (8.3)
Asian	4 (26.7)	3 (20.0)	2 (16.7)
Caucasian or White	7 (46.7)	8 (53.3)	7 (58.3)
Latino/Hispanic	4 (26.7)	2 (13.3)	1 (8.3)
Non-Hispanic	0 (0.0)	0 (0.0)	1 (8.3)
Mixed	0 (0.0)	2 (13.3)	0 (0.0)
Employment type *n* (%)			
Full time	5 (33.3)	8 (53.3)	6 (50.0)
Part time	4 (26.7)	3 (20.0)	3 (25.0)
Retired	0 (0.0)	0 (0.0)	1 (8.3)
Unemployed	6 (40.0)	4 (26.7)	2 (16.7)
Years in position	5.0 (2, 22)	3.0 (0, 35)	1.5 (1, 30)
Occupation *n* (%)			
Construction/Labor	0 (0.0)	0 (0.0)	1 (8.3)
Health Care	2 (13.3)	5 (33.3)	2 (16.7)
Office work	11 (73.3)	5 (33.3)	6 (50.0)
Service Industry	0 (0.0)	1 (6.7)	1 (8.3)
Full-time Student	2 (13.3)	4 (26.7)	2 (16.7)
Months in pain; Median (min, max)	12 (1, 204)	24 (1, 240)	24 (1, 168)
Hours of computer use daily *n* (%)			
<1 hour	0 (0.0)	0 (0.0)	3 (25.0)
2-4 hours	1 (6.7)	1 (6.7)	1 (8.3)
5-7 hours	7 (46.7)	6 (40.0)	5 (41.7)
8-10 hours	5 (33.3)	6 (40.0)	3 (25.0)
≥11 hours	2 (13.3)	2 (13.3)	0 (0.0)
Hours of smartphone use daily *n* (%)			
<1 hour	1 (6.7)	2 (13.3)	0 (0.0)
2-4 hours	9 (60.0)	6 (40.0)	10 (83.3)
5-7 hours	4 (26.6)	4 (26.7)	2 (16.7)
8-10 hours	0 (0.0)	2 (13.3)	0 (0.0)
≥11 hours	1 (6.7)	1 (6.7)	0 (0.0)
Leisure Activity*			
Sewing	0 (0.0)	1 (6.7)	0 (0.0)
Aerobic	5 (33.3)	3 (20.0)	2 (16.7)
Playing Cards	0 (0.0)	2 (13.3)	0 (0.0)
Shopping	4 (26.7)	2 (13.3)	3 (25.0)
Billiards	0 (0.0)	1 (6.7)	0 (0.0)
Bowling	0 (0.0)	1 (6.7)	1 (8.3)
Arts & Crafts	3 (20.0)	4 (26.7)	3 (25.0)
Music	1 (6.7)	0 (0.0)	0 (0.0)
Symptom Severity Scale*[61]			
Pain at night	1 (6.7)	0 (0.0)	0 (0.0)
Pain/numbness	6 (40.0)	3 (20.0)	7 (58.3)
Decreased sensation	0 (0.0)	3 (20.0)	2(16.7)
Clumsiness/weak grip	6 (40.0)	6 (40.0)	2 (16.7)
Thumb muscle wasting	1 (6.7)	3 (20.0)	0 (0.0)

*Percentages do not add to 100% due to missing data

Table 2. Mean±SE of changes in pain symptoms across visits by study group (n = 66).

	Group			Group x Time	Across Time
NPRS* (Forearm)	1.0 (0, 7)	2.0 (0, 7)	1.0 (0, 7)	N/A	N/A
Baseline	0.0 (0, 7)	1.5 (0, 8)	1.0 (0, 6)		
Visit 2	1.0 (0, 6)	1.0 (0, 5)	1.0 (0, 5)		
Visit 3	0.0 (0, 6)	1.0 (0, 5)	1.0 (0, 4)		
Visit 4	0.0 (0, 6)	1.0 (0, 5)	1.0 (0, 4)		
Visit 5	p = 0.01	p = 0.17	p = 0.30		
NPRS* (Wrist)					
Baseline	3.0 (0, 8)	3.0 (0, 8)	1.0 (0, 9)	N/A	N/A
Visit 2	2.0 (0, 8)	2.5 (0, 8)	1.0 (0, 6)		
Visit 3	1.0 (0, 8)	1.5 (0, 7)	2.0 (0, 6)		
Visit 4	1.0 (0, 8)	3.0 (0, 7)	2.0 (0, 5)		
Visit 5	1.0 (0, 8)	1.5 (0, 7)	1.0 (0, 7)		
	p = 0.005	p = 0.11	p = 0.43		
VAS Forearm Worst					
Baseline[c]	22.1 ± 5.6	19.1 ± 5.9	31.3 ± 6.6	0.001 (0.09)	0.001 (0.11)
Visit 2	18.5 ± 5.1	34.5 ± 6.2	20.2 ± 6.0		
Visit 3	15.4 ± 4.2	19.1 ± 5.3	16.9 ± 4.3		
Visit 4	14.8 ± 4.1	16.6 ± 4.6	16.8 ± 4.4		
Visit 5	15.1 ± 4.0	17.6 ± 5.3	12.5 ± 4.0		
p[#] (partialη^2)	0.03 (0.10)	0.003 (0.19)	0.03 (0.18)		
VAS Wrist Worst					
Baseline [d]	24.1 ± 5.7	36.8 ± 6.0	33.0 ± 6.5	0.50 (0.03)	0.001 (0.81)
Visit 2	24.9 ± 5.5	39.7 ± 5.9	26.9 ± 6.3		
Visit 3	20.5 ± 4.9	30.9 ± 5.2	22.0 ± 5.6		
Visit 4	18.2 ± 4.9	23.6 ± 5.2	22.9 ± 5.6		
Visit 5	18.7 ± 4.8	28.6 ± 5.1	15.5 ± 5.5		
BCTQ SS					
Baseline[e]	1.9 ± 0.7	2.3 ± 0.5	2.3 ± 0.6	0.15 (0.05)	0.002 (0.09)
Visit 2	1.7 ± 0.6	2.1 ± 0.4	2.2 ± 0.5		
Visit 3	1.7 ± 0.6	2.1 ± 0.5	2.0 ± 0.6		
Visit 4	1.7 ± 0.6	2.1 ± 0.5	2.0 ± 0.5		
Visit 5	1.7 ± 0.7	2.0 ± 0.5	1.9 ± 0.5		

Values are Mean ± SE or as otherwise indicated

*Median (min, max)

[#] Tests the hypothesis that there was a significant change across visits

[c,d,e] significant changes between baseline and visits 2 through 5 ($p<0.001$)

Table 3. Mean±SE of changes in function across visits by study group (n = 66).

	Time	**Group**		**Group x Time**	**Across**
Visit	Kinesio tape (n_1 = 25)	Splint Group (n_2 = 19)	Sham Group (n_3 = 22)	p (partialη^2)	p (partialη^2)
BCTQ FS[a]					
Baseline	1.7 ± 0.5	2.0 ± 0.7	2.0 ± 0.7	0.60 (0.02)	<0.001(0.14)
Visit 2	1.6 ± 0.6	1.9 ± 0.5	1.9 ± 0.9		
Visit 3	1.7 ± 0.6	1.8 ± 0.5	1.7 ± 0.7		
Visit 4	1.6 ± 0.6	1.9 ± 0.5	1.7 ± 0.7		
Visit 5	1.5 ± 0.6	1.8 ±0.7	1.7 ± 0.6		
	p = 0.02	p = 0.02	p = 0.03		
Grip					
Baseline	55.7 ± 4.0	63.8 ± 4.3	52.1 ± 4.6	0.24 (0.01)	0.48 (0.01)
Visit 5	55.2 ± 3.7	65.9 ± 4.0	53.3 ± 4.3		
3-Jaw Pinch					
Baseline	12.3 ± 0.8	12.0 ± 0.8	10.2 ± 0.9	0.12 (0.07)	0.06 (0.06)
Visit 5	11.9 ± 0.9	13.0± 0.9	11.5 ± 1.0		

[a]significant changes between baseline and visits 3 through 5 ($p<0.01$)

CHAPTER THREE

Participants' Perceptions of Kinesio Tape for Carpal Tunnel Syndrome: A Qualitative Study

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Abstract

Introduction

Kinesio tape is an alternative non-surgical treatment approach for addressing symptoms of carpal tunnel syndrome (CTS). The purpose of the study was to investigate individuals' experiences with the dorsal application of Kinesio tape for CTS management and its impact on pain and function.

Method

The study design was a limited phenomenological design study embedded in a randomized controlled trial (RCT). Daily symptom journals and semi-structured interviews were completed with 15 participants who were purposefully recruited and randomly allocated to the intervention group of a single blind RCT. Kinesio tape was applied dorsally on the affected forearm, wrist, and digits for a duration of two weeks. Transcribed data were analyzed using descriptive coding, coding schemes, and frequency charts to identify emerging themes.

Results

Three themes emerged: Kinesio tape was positively perceived to be effective on decreasing pain, increasing self-efficacy, and improving daily functional performance on tasks previously avoided or abandoned. The most common problem identified was maintaining Kinesio tape on the hands and fingers, to which the majority of participants expressed a desire to learn application.

Discussion

Results of this study suggest that Kinesio tape is a positively perceived intervention for decreasing pain and increasing function for individuals with CTS and warrants further consideration as an alternative conservative intervention for CTS.

MeSH Terms: Carpal Tunnel Syndrome, Kinesio tape, Qualitative, Functional performance

Participants' Perceptions of Kinesio Tape for Carpal Tunnel Syndrome: A Qualitative Study

Carpal Tunnel Syndrome (CTS) is the most common neuropathy of the hand; it causes pain and disability, and affects approximately 22 million individuals in the United States alone.[1] In the past 10 years there has been a 5% increase in proportion of population needing care for upper extremity (UE) musculoskeletal disorders, including CTS.[1,2] However, less than 2% of the US National Institute for Health budget is allocated to researching solutions for these disorders, which limits the number of comprehensive studies available to inform therapeutic interventions for conditions such as CTS.[3]

Individuals with CTS commonly experience symptoms of pain, numbness, burning, and weakness of the forearm, wrist, and hands.[4] Moreover, loss of participation in meaningful occupations of self-care, work, and leisure frequently impacts their quality of life, functional performance, and mastery over their environments.[4] Symptoms of CTS can be intermittent and individuals with CTS often delay seeking skilled treatment, with options ranging from conservative treatments to surgical interventions.[5] In one study 30% of individuals experienced a return of symptoms following surgical intervention.[6] One effective non-surgical intervention for long-term relief of CTS symptoms is a combination of orthoses with lumbrical exercises.[7] Despite effectiveness, there are no standardized protocols for the management and treatment of CTS and a number of studies have found that client compliance and adherence to orthotic wearing schedules and exercise routines is limited.[8-10] Additionally, there is no evidence for how to increase client adherence to these interventions over time, nor is there consensus

regarding which type of orthotic design to use or what wearing schedule is most effective.[4,8-10]

The need to find alternative non-surgical interventions that may improve client adherence and thereby reduce symptoms for the effective management of CTS has led to a range of clinical investigations, including Kinesio tape.

Kinesio tape is applied to the skin creating: Improved muscle contraction, increased circulation of blood and lymphatic fluid, activation of an endogenous analgesic system which inhibits nociceptive pain impulses, and musculoskeletal correction.[11-13] Emerging evidence is suggestive for the use of Kinesio taping for individuals with CTS, with studies indicating improvements in symptoms, function, and physiologic parameters similar to that of other modalities such as low-power laser treatments.[14,15] Moreover, although CTS is the third most studied diagnosis for distal UE rehabilitation less than five percent of studies have explored patient experiences using qualitative methods.[16] Such studies are needed to better answer clinical questions regarding successful intervention options, the impact of self-efficacy on performance, and adapted responses to environmental tasks. In the absence of recent evidence regarding perceptions of interventions for CTS outside of surgical interventions, and no evidence regarding perceptions of Kinesio tape as a treatment option, there is a need to further explore and understand individuals' experiences when using Kinesio tape. Learning the perspectives of individuals using Kinesio tape for CTS may provide insight regarding functional performance, sense of self-efficacy, and likelihood of follow through with the intervention.

Purpose

The purpose of this qualitative study was to investigate how participants experiencing CTS in a single blind randomized controlled trial (RCT) using a dorsal application of Kinesio tape on wrist extensors perceived the Kinesio tape intervention and if changes in functional performance were noted. Understanding the perspectives of individuals using Kinesio tape for CTS may provide needed insight regarding the therapeutic potential of Kinesio tape as an alternative intervention for CTS.

Methods

Study Design and Qualitative Approach

This was a qualitative study embedded within a RCT and employed a limited phenomenological research design. Phenomenology is a qualitative approach used to describe how people experience a specific phenomenon,[17] which in this study was the perceived effect and experiences of individuals with CTS who wore Kinesio tape. Further, this study's qualitative design reflects the constructivist paradigm which recognizes that personal experiences are realities that are context dependent, idiographic, and can vary from person to person.[17] Though the qualitative study could have employed a Case Study method; the initial purpose of this study was to explore individual experiences related to wearing the Kinesio tape within a short time frame and in whatever context the participants completed their daily life tasks. Data for this qualitative study were obtained through a demographic questionnaire, direct self-report on daily symptom journals, and face-to-face semi-structured interviews conducted at the conclusion of the intervention period.

Participants

Participants for the RCT were recruited from the general population in Southern California by advertising at public facilities, clinics, common public places, and snowball sampling as well as social media following approval from the Institutional Review Board. To be included in the study participants were adults over 18-years of age and fluent in English who reported symptoms of CTS and demonstrated a positive Phalen's Test or Tinel's Test.[18] Qualifying symptoms of CTS included pain, numbness, and tingling of the forearm, wrist, or hand within the median nerve distribution. Exclusion criteria included undergoing current treatment for CTS, a history of surgical carpal tunnel release, an allergy to adhesives, compromised skin integrity, or past history of traumatic event, surgery, or congenital impairment of the forearm, wrist, or hand. In addition, individuals with the following conditions were excluded: pregnancy, diabetes not controlled by medication, radiculopathy (e.g., cervical radiculopathy, diabetic radiculopathy), and thoracic outlet syndrome. Signed informed consent was obtained from all participants prior to the study. Individuals randomized to the Intervention Group were asked to volunteer for a face-to-face recorded semi-structured interview of approximately 30-minutes immediately following enrollment in the study in order to capture the perceptions of the use of Kinesio tape, none declined. Of the 44 adults who participated in the single blind RCT, 15 were randomized to the intervention group (i.e., Kinesio tape), and participated in the interviews which are the focus of this paper.

Data Collection

Three intervention groups were part of a randomized controlled trial examining the efficacy of the dorsal application of Kinesio tape for CTS: A Sham Group with a

four-inch strip of Kinesio tape applied to the participant's shoulder worn continuously between visits (scapular spine), the Intervention Group with Kinesio tape applied to the dorsal surface of the forearm, wrist, and digits one and five and worn continuously between visits, and the Splint Protocol group assigned to wear a wrist cock-up splint nightly or as able and lumbrical stretching exercises throughout the day. A total of 68 participant wrists (44 participants) were in the study.

Study procedures consisted of completing a demographic questionnaire, obtaining baseline and subsequent measurements of grip and pinch, completion of pain scale questionnaires, the Boston Carpal Tunnel Questionnaire[19], and application of the intervention. Participants were encouraged to record daily activities, pain ratings, and perceptions of the Kinesio tape while completing functional tasks within the context of their daily lives in symptom journals. The symptom journal was collected at each of the subsequent meetings during the intervention period. The journals were a means of capturing the daily experiences of the participants (See Figure 1). Symptom journals were transcribed and entered verbatim alongside the interview transcription onto an Excel spreadsheet, no data is missing.

The use of semi-structured interview questions guided the conversation while still allowing participants to raise other important issues.[20] Interviews were guided by the Theory of Occupational Adaptation,[21] in which occupational performance is described as one's ability to perform daily activities, and will be referred to as functional performance. This framework focuses on the person, the environment, and the interaction of the two; and for which successful performance or mastery of a task requires adaptation of either the person (internal mastery) or the environment (external mastery).[21] Six open ended

questions were asked, such as "Tell me about wearing the Kinesio tape?", with follow-up questions under each question and centered around understanding the experience of wearing the Kinesio tape and its impact or effect on pain and functional performance (see Table 1). Interviews were conducted from February 2018 to October 2018, lasting approximately 30-minutes, ranging nine to 61-minutes. Interviews were recorded and transcribed verbatim. All participants had equivalent levels of participation, except those who wrote or spoke more than others in the symptom journals or interviews.

Data Analysis

Data analysis followed a modified grounded theory procedural approach as the intent was to answer specific research questions related to understanding participant's experiences wearing the Kinesio tape for CTS, if Kinesio tape had an effect on functional performance, and the perceived effectiveness of Kinesio tape as an intervention.[22]

Participants were coded with pseudonyms and all qualitative data from the interviews, demographic questionnaire, and symptom journals were managed through a computer assisted qualitative data analysis software (CAQDAS), Dedoose (Version 8.0.35).[23] Descriptive coding was applied to analyze the data.[20] Three researchers coded the transcripts independently, followed by two of the researchers clarifying and confirming the codes. The same two researchers continued to condense the codes by developing coding schemes and applying frequency mapping and code co-occurrence within Dedoose, to identify categories until the emerging themes were identified and consensus reached. The symptom journals provided indirect daily responses from participants while the interviews provided direct responses at the end of the study.

The same researcher, a registered occupational therapist with advanced certification in Kinesio Taping, proposed the study, completed the tape application, and conducted the post semi-structured interviews. In this way rapport and familiarity developed between the researcher and the participants; however, this also presented opportunity for response bias. In order to mitigate for researcher and response bias, open-ended questions were asked in the interviews, and both positive and negative aspects of participants' experiences were collected, reported, and coded. Furthermore, interview and symptom journal content were independently coded by two researchers in addition to the interviewer. The daily symptom journals served as an indirect communication method to elicit natural responses without the researcher present. Dedoose was used to further address researcher bias by structuring the data analysis process.

Results

Fifteen participants were included in this study, two males and 13 females (See Table 2), who represented a wide age range from 23 years to 67 years with a median age of 29.5 years. The duration of CTS symptoms ranged from six months to 10 years between participants with two indicating symptoms of CTS, one for 10 years and the other 17 years.

Three themes emerged: (1) Effect of Kinesio tape on pain, (2) Effect of Kinesio tape on functional performance, (3) Increased self-efficacy. Problems regarding the use of Kinesio tape for UE rehabilitation were also identified.

Impact of CTS on Functional Performance

Limited range of motion, pain, and weakness among other symptoms made it difficult for participants to engage in meaningful roles and increase self-efficacy. For example, CTS-related tension and decreased range of motion impacted Grace's ability to engage daily activities. She commented, "*In general, I can't bend my wrist, I'll start getting an increase in pain, and that affects a lot of the daily things I do*". Notably, Grace was in school to be an illustrator, but signs and symptoms of CTS were impeding her career choice. Seven participants also identified numbness as a problem, typical of CTS, which was impacting their general daily tasks.

Daily tasks that were most commonly impacted were in the areas of work, leisure, self-care, and driving. Related to work, fourteen participants commented that working on the computer increased symptoms of CTS. Additionally, eight participants specifically identified writing required in their work and daily life as increasing symptoms of pain, numbness, and tingling. Impacted leisure activities included crafting, swimming, jogging, boxing, working out, doing bench presses, and yoga. In terms of self-care, respondents described dressing and household chores such as cleaning and meal preparation as activities noticeably impacted by CTS. Lastly, a significant majority of participants (n = 12) identified driving as impacted by CTS pain and numbness.

Effect of Kinesio Tape on Pain

Participants reported both immediate pain relief with Kinesio tape and increased pain relief over time even for those with chronic symptomology. Example statements include: *"[I felt] immediate relief with tape on"* [Joy], *"[The tape] made me feel stronger and helped the pain to go away, especially in my wrists"* [Sue], and *"I [noticed] I was*

rolling my wrists less to relieve the tension while working on stuff at the computer" [Donna]. Participants shared experiencing less pain in the morning and throughout the night while wearing the Kinesio tape. For instance, Valerie stated, *"the tape felt like an extra support for my hands, especially while sleeping. [The] weeks I've been wearing the Kinesio tape, my pain is almost gone"*. The tape's application contributed to comments such as *"I liked [the tape] and it made my hands feel like they were more open, whenever you put it on freshly, it felt super secure"* [Kay]. Additionally, Corie thoughtfully responded, *"I think that in the middle of a flareup, that putting the Kinesio tape on can help reduce the pain from the flareup and get over it more quickly".*

Impact of Kinesio Tape on Chronic Pain

One of the surprise findings, came from four of the participants who having experienced CTS pain for 7.5 - 10 years who reported Kinesio tape to be effective in decreasing pain. Lee commented, *"It's not typical for me to go this long without symptoms"*. Some described their symptoms as being absent entirely while wearing the Kinesio tape. *"I can't believe 'zero pain'",* Valerie happily stated. In addition to reporting a decrease in symptoms, participants commented on how unusual this experience was for them. "*My hands feel more relaxed and the pain is almost gone. Especially at night [with] very little discomfort on the wrists, which is all so new"* [Grace]. Participants stated they looked forward to a fresh application of Kinesio tape as symptom relief was the greatest at that time. Grace expressed it clearly*, "I was feeling pain on my palms and wrists throughout the day, which diminished right after tape was applied in the evening"*. Joy experienced symptoms of CTS for over 12 years and

expressed great surprise at how quickly the Kinesio tape decreased symptoms. *"[I] felt immediate relief with the rigidity and application of Kinesio tape!"*

Progression of Effect

During the 14 days of wearing Kinesio tape improvement was noted for some participants in days one through six (n = 8); however, by day seven, 12 participants were able to remark no pain, and could resume activities. Comments such as *"[My]wrist felt relief with new tape application"* [Molly]. *"My daily activities include driving, typing on my laptop, and writing, which commonly causes problems, but I do not feel pain or any tingly sensation, [I] haven't felt it in a while since wearing the tape"* [Sue]. Positive effects while wearing the Kinesio tape were reported not only for participants with recent symptoms of CTS but also those who indicated experiencing many years of CTS-related pain.

With a decrease in pain participants went on to describe the functional activities they were able to complete.

Effect of Kinesio Tape on Functional Performance

The impact Kinesio tape had on pain translated to positive impact on daily life activities for 14 of the 15 participants identified Kinesio tape as positive and effective, particularly on decreasing pain. The quicker the pain was gone, the more involvement and engagement participants reported. For example, Cinthia expressed, "*When the tape was on it made me feel more at ease, that I was like Oh, I'm gonna feel less pain. And then, because there was less pain I was able to come out of my shell".* Cinthia's comments are representative of other participants who also commented that they were

better able to tolerate work tasks and writing, engage in leisure pursuits, grasp objects, complete self-care activities and drive longer distances with less pain.

Cinthia shared, "*Kinesio tape helps to easily be aware when overextending [my wrist] to change position to avoid pain"*. Adding to this, Valerie shared, "*With the tape I'm just doing my normal activities and because it's not invasive I am able to do everything"*.

Work. Fourteen of the 15 participants reported a significant decrease in pain and increase in amount of time without pain during functional work-related activities such as using computers, small devices, and writing. Some participants reported being able to engage in these activities for three or more hours with zero pain while wearing the Kinesio tape. Sue explained, *"Usually I feel it is difficult to grip my pen for a long period of the time, but the tape helped open my hand and release some pressure from my wrist*". Similarly, Kay reported that the motion and position of clicking a mouse at work did not bother her. Lee, who does a lot of writing at work, summed it up, *"So, I think that having the tape definitely helps to prevent symptoms from happening because I didn't experience any symptoms while I was at work, while I was wearing the tape*".

Leisure. One third of the participants reported improved engagement in leisure activities while wearing Kinesio tape. They identified increased engagement in specific tasks such as holding a book while reading and manipulating their smart phones. They also identified increased engagement in high intensity, high repetition activities such as yoga, bouldering, working out, setting up a campsite, and playing the string bass. Lee found that she experienced less pain while practicing yoga and Molly felt stronger and climbed higher on the rock wall. In addition to these examples, two participants

experienced an extended duration of participation in high intensity physical activities. Lee reported being able to hike and camp without pain. *"I spent the day hiking and did not feel my hands swell and fill as usual. I was able to set up the campsite including grasping, twisting, and pulling without numbness or tingling with the tape on".* Corie, who plays the string bass, commented that she was thrilled to be pain-free while playing repeatedly during a weekend musical event after the third application of Kinesio tape.

Functional tasks. In addition to work and leisure, participants reported being able to return to a wide array of functional tasks while wearing the Kinesio tape. These included daily tasks of personal care and home management to community activities such as running errands and driving a car. Being able to return to such basic life management tasks elicited positive emotional responses as well. Josey shared, "*I did cooking tasks yesterday, like whisking, without pain. That was wonderful*!" All of the functional tasks that participants reported returning to include daily self-management activities as well. Valerie called them her "normal activities" when she said, "*With the tape I'm just doing my normal activities and because it's not invasive I am able to do everything".*

The everyday personal care activities that participants discussed were being able to get dressed with less pain and complete grooming tasks such as putting on makeup and using hair curling or straightening tools. Everyday tasks related to home management included cooking, carrying grocery bags, cleaning, laundry, and vacuuming. Randi reflected, *"I vacuumed at one point and that was fine. I have not done that in a while, I let my husband to it because I always get a flareup after, except this time".* Some of the home management tasks reported were more rigorous. Lee was one of the more physically active participants who reported painting her kitchen, *"I did not have any*

symptoms today, even though I painted the kitchen and ran errands". Overall, however, the emphasis of the comments about returning to functional tasks was on the everyday activities that keep life going.

Some of the everyday tasks discussed extended into the community, such as driving and errands. Several (n = 12) participants reported a decrease in symptoms while driving and ability to drive for longer periods of time. Randi felt better even on short 20 - 40 minute drives. Grace expressed surprise when reporting being able to drive two hours without pain when the tape was on. *"Now, I drove two hours to my mom's home and noticed my arms and wrists did not feel tired, no pain on my palms and wrists"*. Everyday life management tasks such as driving, home management and self-care were all found to be improved while participants were wearing the Kinesio tape.

Perceptions of Wearing Kinesio Tape

Together, all 15 participants made 219 positive comments regarding the wearing of Kinesio tape. They also commonly compared Kinesio tape to their experiences with wearing orthotic devices, and discussed both difficulties and recommendations related to the use of Kinesio tape.

Strength and stability. *"I'm a superhero with the tape on"* said Derek when summarizing his perceptions of wearing Kinesio tape. While not every participant used such illustrative language, the majority of them expressed positive perceptions of the tape. *"I felt more stabilized"* [Kay], *"My hands feel stronger and supported"* [Grace]. Overall, participants' perceptions of increased strength and stability were prevalent. Comments such as *"I feel more support there"*, or *"I don't feel [my wrists are] as weak as before"* may also contribute to successful environmental interactions. Matt, (an

exercise enthusiast) commented, *"I think the tape worked great, [I felt] it helped my strength improve". "I noticed when I did have the Kinesio tape on my left, I felt a lot better driving with it. I felt confident, it put my wrist where it should be"* shared Molly

Responses indicated not only did participants like the Kinesio tape but that it made their *hands feel more open and secure* but also *stronger and stable*, which led them to attempt tasks previously avoided or abandoned.

Tape not in the way. Participants liked wearing the Kinesio tape as it was comfortable, did not restrict movement or involvement in activities and tasks for daily living.

"I would always try to be so careful on the way I move my hands or position my hands so that pain would not increase, but with the tape, I'm just back to my normal. I don't have to be so conscious on the way I move my hands or rest my hands because the pain is almost gone" [Valerie].

Lee expressed *"I liked that it was discreet".* This comment was echoed by other participants during the course of the study. *"It was like a second skin, so I could do what I wanted"* [Valerie]. Participants specifically shared that they felt the Kinesio tape was not in their way. For example, Sue explained, *"As a student I spend a lot of time on the computer, and I think anything else would be in the way".* Randi stated, *"You can't do things with those [splints] on, you can't wash dishes or anything".* While one participant stated they would ''choose a splint over tape" four participants specifically referred to the positive use of Kinesio tape as compared to an orthotic device. Valerie added,

"I was trying to do painting with the splint on but it wasn't ideal so I had two choices, to not paint or paint and be in pain. I was able to paint while wearing the

Kinesio tape and it helped hold my wrist in correct position and I did not have pain. I painted for six to eight or more hours a day, so this is really remarkable".

One participant Cinthia, was concerned that by wearing the tape on the back of the hand would cause others to think she was injured, weak, or contagious, and consequently she missed church one week. However, after needing to wear the tape to the grocery store she received questions, such as people asking if she was injured while working out? After this experience Cinthia reflected, "*Instead of seeing me as weak, like when I wear a splint, people saw the tape as something that is going to help you get stronger, like an active person trying to get better"*. In line with this Kay commented *"I am familiar with Kinesio tape from an athletic perspective, but had not considered it in a rehab context"*.

Problems with Kinesio tape. Two participants said they experienced *"no change in pain or function"* [Donna], and *"I don't think it made a huge difference for me"* [Josey]. Nia was dissatisfied with having to fuss with the Kinesio tape. However, she wanted to learn how to apply the Kinesio tape because she experienced symptom relief, though not until closer to the end of the 14 days of her enrollment. While most participants expressed symptom relief by the third application, a few participants did not feel symptom relief until the fourth or fifth application. Further, two participants also commented that the tape felt itchy. Donna remarked, *"After we took it off, my skin was very sensitive to touch, it almost felt similar to when your foot is asleep, I would not leave it on the prescribed three days"*.

Problems with Kinesio tape application specifically on the digits, not wrist or forearm, were identified by all 15 participants. Common complaints with the dorsal

application of Kinesio tape particularly focused on its lack of adherence with activities involving water, when dressing, or while working out. For instance, Kay shared, *"The tape came loose while exercising and I felt it got nasty. I wanted to be able to remove it and re-apply it"*. Similarly, Randi stated, *"If water or soap got under the finger strips they peeled and just did not adhere the same"*. Another issue occurred while wearing long sleeve tops such as athletic wear or sweaters and participants complained that the tape over digits one and five got caught and rolled. This also happened when putting hands in jean pockets as expressed by one participant.

Additionally, Josey commented that the *"Tape was itchy, but better than an orthotic device"*.

Self-application request. All participants requested to learn the Kinesio tape application method, but only if trained first and received some education and protocols. *"I think I do enjoy the feeling that it gives me, but I feel like I would probably change it every day, I wouldn't wear it for three days"* remarked Molly. Similarly, Lee shared, *"If I would have been able to take it off and redo it when it started peeling back I think that I would have loved to do that and [then] re-apply it on myself at home"*. Though participants suffered CTS pain and several as a chronic pain issue, none had attempted to apply the tape themselves but deferred to the experiences of a professional.

When issues of tape management arose, such as if it unraveled or lost adherence over the digits before returning to the lab, the participants stated a desire to contact the researcher for problem solving and guidance, though none of them did and waited for the next visit. Even in light of the problems encountered with using Kinesio tape on the

hand, all 15 participants stated they would use the dorsal application of Kinesio tape again if someone showed them how.

Discussion

The study investigated the experiences of individuals with CTS and their perspectives on the dorsal application of Kinesio tape for symptom management and functional performance. The outcomes indicate perceptions regarding the use of Kinesio tape were positive and perceived as effective for decreasing symptoms of CTS and increasing self-efficacy. The primary implications noted in the data relate to the impact of CTS and Kinesio tape on functional performance and pain.

Occupational Adaptation Framework

The Occupational Adaptation framework focuses on the person, the environment, and the interaction of the two. It emphasizes that successful performance of a task requires adaptation of either the person (internal mastery) or the environment (external mastery).[21] In this study, the dorsal application of Kinesio tape on the forearm, wrist, and fingers was an adaptation of the person that enabled increased functional performance in their environments.

Evidence suggests that Kinesio tape provides proprioceptive input which leads to increased action potentials in the cerebral cortex resulting in muscular co-contraction and joint stability.[13,24] Participants commented that the Kinesio tape helped them feel as if their hand were stable and supported when in an open position, which is necessary for engaging in daily activities. The co-contraction provided by the tape may have contributed to the feeling of stability participants reported in the wrist, leading to increased engagement in functional tasks.

While the focus of non-surgical interventions for CTS has been on wearing orthoses and completing lumbrical exercises, functional performance is often inhibited. Orthoses have been shown to biomechanically position the wrist in neutral and relieve CTS symptoms,[7] but this intervention limits successful engagement with functional tasks, further limiting external mastery. Researchers have acknowledged this limitation and recommended alternative interventions in hand therapy which allow individuals to participate in meaningful activities.[16 25-27] Kinesio tape is one such intervention, as it has been shown in this study to result in greater internal and external mastery.

External mastery. It is increasingly understood that symptom relief and return to function is the measure of success for interventions for musculoskeletal conditions of the hand, wrist, and forearm such as CTS.[28] This is consistent with the Occupational Adaptation framework concept of external mastery. There is growing evidence for using occupation-based assessment tools and intervention activities for therapeutic treatment of hand injuries.[25,29,30,31] Jack and Estes[27] found that a holistic, client-centered, and occupation-based approach to the treatment of hand injures, resulted in improved patient outcomes. Similarly, Colaianni and Provident[26] found that such interventions increased client motivation, satisfaction and adherence, and promoted a faster functional recovery due to the relevance of the activities to the individual's daily life and interests. Functional treatment activities increased confidence and decreased fear. Results of this study indicate that wearing the Kinesio tape increased client confidence and engagement in personal care, household activities, and community engagement. Several participants had a significant increase in the amount of time they were able to sustain their participation in activities, and others were able to return to high intensity, high repetition

leisure activities. Most of the participants expressed symptom relief and improved function in self-care, home management, driving, work, community engagement, and/or leisure activities.

Internal mastery. Internal mastery, according to the Occupational Adaptation framework, is the belief in the ability to succeed in accomplishing a task though adaptations of the person or environment may be needed for successful task completion.[21] The use of Kinesio tape to manage CTS symptoms is an adaptation to the person that has been shown to improve participant's perceptions and report of external mastery in this study. Their response to the experiences of external mastery was to express the desire to learn to apply the tape themselves. The Occupational Adaptation model illustrates the interrelationship between internal and external mastery, showing how improvements in one lead to increases in the other in a cyclical manner.[21] In the case of wearing Kinesio tape for CTS, it appears that not only did Kinesio tape adaptation to the person lead to perceptions of increased self-efficacy and environmental mastery, but the improved external mastery also led back to a drive for increased internal mastery. This was evidenced by participants requesting to learn how to apply the tape themselves.

The need for an intervention that can be functionally integrated into daily life appealed to participants. They indicated that self-application of the Kinesio tape would allow them greater flexibility of wearing schedules. Being able to remove the tape for cosmetic concerns such as peeling edges, exposure to water or soap, following exercise, or due to skin sensitivity may enhance compliance with the use of the intervention. It is possible that being able to self-manage the dorsal application of Kinesio tape could

improve adherence to the intervention, which is a known weakness of orthoses and exercises.[7,8]

It is recommended that application of Kinesio tape be overseen by a skilled professional, as clinical reasoning skills are necessary in order to ensure correct application and understanding of Kinesio tape properties, education, and problem management.

Implications for a younger demographic. It is possible, though not established, that the young average age of participants in this study reflects a societal trend toward CTS in younger people. Studies have identified that repetitive use of the fingers and wrist may contribute to symptoms of CTS.[32] Office workers who use computers four hours a day or more experience a high incidence of CTS.[33] Furthermore, those who use computers and work for extended periods of time may be the primary at-risk population for CTS. This description may increasingly apply to young adults in screen culture.

Limitations

Limitations of the study include the application of Kinesio tape on first and fifth digits. The problems with tape adhering during activities that included water may have interfered with results. Participants were from Southern California and may not include other geographical or environmental challenges when wearing Kinesio tape for upper extremity rehabilitation. The sample was limited to the intervention Kinesio Tape Group of the RCT and therefore sampling was not continued through saturation.

Recommendations for future studies could focus on gathering participants perceptions over a longer period of time, perhaps including the experiences of individuals applying and using the tape. Other recommendations include gathering perspectives from

participants in other geographical areas outside Southern California. Longer study duration for the comparative study between orthosis, orthosis types, and Kinesio tape are recommended as well.

Conclusions

Overall, participant's perceived Kinesio tape as effective for decreasing pain, increasing self-efficacy, and daily functional performance improved, as demonstrated by successful engagement in work tasks, leisure activities, and functional activities including driving which had been avoided or abandoned. Problems were identified with maintaining Kinesio tape use on the hand and fingers, and consequently, learning self-application was recommended. The use of Kinesio tape allows for continued activity and participation in the environment and may be an option for therapists working in distal UE rehabilitation to consider, particularly the dorsal application of Kinesio tape for CTS.

References

1. US Bone and Joint Initiative. *The burden of musculoskeletal diseases in the United States.* 3rd ed. Rosemont, IL: American Academy of Orthopaedic Surgeons; 2014. http://www.boneandjointburden.org
2. United States Bureau of Labor Statistics. *Nonfatal occupational injuries and illnesses requiring days away from work, 2014 (USDL 15-2205)* [News release]; 2015. http://www.bls.gov/news.release/pdf/osh2.pdf
3. Weinstein SL. The burden of musculoskeletal conditions. *J Bone Joint Surg* 2016; 98, 1331. http://doi.org/10.2106/jbjs.16.00595
4. Ali R, Battecha K., and Mansour WT. Influence of kinesio tape in treating carpal tunnel syndrome. *J Med Sc and Clin Research* 2013; 1:1-9. http://www.jmscr.igmpublication.org
5. Martin H. Patients' health beliefs and adaptation to carpal tunnel syndrome based on duration of symptomatic presentation. *J Hand Ther* 2007; 20:29–36. http://doi.org/10.1197/j.hht.2006.10.002
6. Nanavati N, Walker-Bone K, Stanworth H, and Williams C. Outcomes of open carpal tunnel decompression. *N Z Med J,* 2013; 126(1369):60–67.
7. Baker N, Moehling K, Rubinstein E, Wollstein R, Gustafson N, and Baratz M. The comparative effectiveness of combined lumbrical muscle splints and stretches on symptoms and function in carpal tunnel syndrome. *Arch Phys Med Rehabil* 2012; 93:1–10. http://doi.org/10.1016/j.apmr.2011.08.013

8. Amini D. Occupational therapy interventions for work-related injuries and conditions of the forearm, wrist, and hand: A systematic review. *Am J Occup Ther* 2011; 65:29-36. http://doi.org/10.5014/ajot.2011.09186
9. Roll S. Current evidence and opportunities for expanding the role of Occupational Therapy for adults with musculoskeletal conditions. *Am J Occup Ther* 2017; 71:7101170010. http://doi.org/10.5014/ajot.2017.71102.
10. Roll S, and Hardison M. Effectiveness of occupational therapy interventions for adults with musculoskeletal conditions of the forearm, wrist, and hand: A systematic review. *Am J Occup Ther* 2017; 71:7101180010p1-p12. http://doi.org/10.5014/ajot.2017.023234
11. Kase K, Hashimoto T, and Okane T. *Kinesio perfect taping manual: Amazing taping therapy to eliminate pain and muscle disorders*. Albuquerque, NM: Kinesio Taping Association, 1998.
12. Jardine K, and Tsaggarellis B. *Neurostructural Taping Technique.* Toronto, Canada: COLLABORANS, Inc, 2013.
13. Bae S, Lee J, Oh K, and Kim K. The effects of Kinesio taping on potential in chronic low back pain patient's anticipatory postural control and cerebral cortex. *J Phys Ther Sc* 2013; 25:1367–1371. http://doi.org/10.1589/jphs.25.1367
14. Guner A, Altan L, and Kasapoglu Aksoy M. The effectiveness of the low-power laser and kinesiotaping in the treatment of carpal tunnel syndrome: A pilot study. *Rheumatol Int* 2018; 38(5):895-904. http://doi.org/10.1007/s00296-018-4020

15. Geler Kulcu D, Bursali C, Aktas I, et al. Kinesiotaping as an alternative treatment method for carpal tunnel syndrome. *Turk J Med Sc* 2016; 46(4):1042–1049. http://doi.org/10.3906sag-1503-4

16. Takata S, Wade E, and Roll S. Hand therapy interventions, outcomes, and diagnoses evaluated over the last 10 years: A mapping review linking research to practice. *J Hand Ther* 2017; 1-8. http://doi.org/10.1016/j.jht.2017.05.018

17. Miles M, Huberman AM, and Saldana J. *Qualitative data analysis: A methods sourcebook*. 3rd ed. Thousand Oaks, CA: SAGE, 2014.

18. Denham S, Lee J, Wilhite M, McGrady T, Booth B. Agreement between the upper limb tension test and the phalen test in the diagnosis of carpal tunnel syndrome. *Ortho Phys Ther Pract,* 2015, 27(1):20-24.

19. Carvalho Leite J, Jerosch-Herold C, and Song F. A systematic review of the psychometric properties of the Boston Carpal Tunnel Questionnaire. *BMC Musculo Dis,* 2006; 7(78). http://dx.doi.org/10.1186/1471-2474-7-78.

20. Lysack C, Luborsky M, and Dillaway H. Collecting Qualitative Data in Kielhofner's Research in Occupational Therapy: Method of Inquiry for Enhancing Practice (2nd ed.) Ed. Rene Taylor. Philadelphia, PA: F.A. Davis Company, 2017.

21. Schkade J, and Schultz S. Occupational Adaptation: Toward a holistic approach for contemporary practice Part 1. *Amer J Occup Ther* 1992; 46(9):829–837. http://doi.org/10.5014/ajot.46.9.829

22. Creswell J. *Qualitative inquiry and research design*. Thousand Oaks, CA: SAGE, 2013.

23. Dedoose Version 8.0.35 Web application for managing, analyzing, and presenting qualitative and mixed method research data [Computer software]. Los Angeles, CA: SocioCultural Research Consultants, LLC, 2018.
24. Mori A, and Takasaki M. *Activation of cerebral cortex in various regions after using Kinesio tape*. Kinesio Symposium 20, 2005:141-144. KTUS-DoCol-4-09-Sept-2010. http://www.aevnm.com/docs/socios/Articulos/Aut-Mori%20A.pdf
25. Bachman S. The Issue is – Evidence-based approach to treating lateral epicondylitis using the occupational Adaptation Model. *Am J Occup Ther*, 2016; 70,7002360010. http://dx.doi.org/10.5014/ajot.2016.016972
26. Colaianni D, and Provident I. The benefits of and challenges to the use of occupation in hand therapy. *Occup Ther Health Care* 2010; 24(2):130–146. http://doi.org/10.3109/07380570903349378
27. Jack J, and Estes R. Documenting progress: Hand therapy treatment shift from biomechanical to occupational adaptation. *Amer J Occup Ther* 2010; 64:82–87. http://doi.org/10.5014/ajot.64.1.82
28. Jerosch-Herold C, Mason R, and Chojnowski A. A qualitative study of the experiences and expectations of surgery in patients with carpal tunnel syndrome. *J Hand Ther* 2008; 21:54-62. http://doi.org/10.1016/j.jht.2017.05.018
29. Bates E, and Mason R. Coping strategies used by people with a major hand injury: A review of the literature. *Br J Occup Ther* 2014; 77(6):289-295. http://doi.org/10.4276/030802214X14018723137995

30. Arbesman M, Lieberman D, and Thomas V. Methodology for the systematic reviews on occupational therapy for individuals with work-related injuries and illness. *Am J Occup Ther* 2011; 65(1):10-15.
31. College of Occupational Therapists. *Occupational Therapy Evidence: The importance of occupational therapy in hand therapy* [Fact sheet]. Retrieved from https://www.rcot.co.uk/file/666/download?token=EZrq4z2A
32. Luckhaupt S, Dahlhamer J, Ward B, Sweeney M, Sestito J, and Calvert G. Prevalence and Work-Relatedness of Capral Tunnel Syndrome in the Working Population, United States, 2010 National Health Interview Survey. *Am J Ind Med 2013*; 56:615–624
33. Coggon D, Ntani G, Palmer K, Felli V, Harari R, Barrero L, ... and Bonzini M. Disabling musculoskeletal pain in working populations: Is it the job, the person, or the culture? *Pain*, 2013; 154(6):856-863. http://doi.org/10.1016/j.pain.2013.02.008
34. Goldfarb C. The clinical practice guideline on carpal tunnel syndrome and workers' compensation. *J Hand Surg*, 2016; 41(6):723-725. http://doi.org/10.1016/j.jhsa.2016.04.003
35. Giannini F, Cioni R, Mondelli M, Padua R, Gregori B., D'Amico P, and Padua L. A new clinical scale of carpal tunnel syndrome: validation of the measurement and clinical-neurophysiological assessment. *Clin Neurophysiol* 2002; 113:71–77. http://doi.org/10.1016/S1388-2457(01)00704-0

Table 1. Semi-Structured Interview Guide.

1. Tell me how carpal tunnel syndrome forearm wrist hand pain has affected your daily occupations such as work or taking care of your home?
    a. Can you give me an example?
    b. Are there any other areas such as in dressing that carpal tunnel syndrome has affected you?
2. Tell me about wearing the Kinesio Tape?
    a. How was it in regard to comfort?
    b. Did it feel "in the way"? Tell me about that.
    c. How did you like the look of the Kinesio Tape?
3. Do you feel wearing the Kinesio Tape impacted your ability to do your job? Please share.
    a. Do you feel the Kinesio Tape assisted? If so, how?
    b. Can you give me an example?
3. Describe how the Kinesio Tape impacted your activities of daily living, such as dressing?
    a. Tell me about that.
    b. Anything else you do at home?
4. How do you feel the Kinesio Tape influenced sleep and rest?
    a. Can you provide a specific example?
5. Have you noticed any changes in your participation with leisure activities with the Kinesio
    Tape on?
    a. Can you describe that more for me?
6. What is the most important message that you want us to take away from this interview?

Is there anything else that you would like to add about any of the topics that we've discussed or other areas that we didn't discuss but you think are important.

Table 2. Demographic characteristics of the participants at baseline.

Variable	Intervention Group (*n* = 15)
Right handed (*n*, %)	12 (80.0)
Age, y (*Median*, Range)	28 (23-67)
Female (*n*, %)	13 (86.7)
Ethnicity (*n,* %)	
Asian	4 (26.7)
Caucasian or White	7 (46.7)
Latino/Hispanic	4 (26.7)
Employment type (*n,* %)	
Full time	5 (33.3)
Part time	4 (26.7)
Unemployed	6 (40.0)
Years in position (*Median,* Range)	5.0 (2,22)
Occupation (*n*, %)	
Construction/Labor	0 (0.0)
Health Care	2 (13.3)
Office work	11 (73.3)
Service Industry	0 (0.0)
Full-time Student	2 (13.3)
Number of months in pain (*Median, Range)*	12 (1,204)
Hours of computer use daily (*n*, %)	
2-4 hours	1 (6.7)
5-7 hours	7 (46.7)
8-10 hours	5 (33.3)
≥11 hours	2 (13.3)
Hours of smartphone use daily (*n*, %)	
<1 hour	1 (6.7)
2-4 hours	9 (60.0)
5-7 hours	4 (26.6)
≥11 hours	1 (6.7)
Leisure Activity*	
Aerobic	5 (33.3)
Shopping	4 (26.7)
Arts & Crafts	3 (20.0)
Music	1 (6.7)
Symptom Severity Scale [35]	
Pain at night	1 (6.7)
Pain/numbness	6 (40.0)
Decreased sensation	0 (0.0)
Clumsiness/weak grip	6 (40.0)
Thumb muscle wasting	1 (6.7)

*Percentages do not add to 100% due to missing data

CHAPTER FOUR

CONCLUSIONS AND FUTURE DIRECTIONS

The intent of this study was two-fold: a) to determine the efficacy of a dorsal application of Kinesio tape on pain and function as compared to orthosis and exercises for individuals with CTS and, b) to explore perspectives of participants wearing Kinesio tape to understand if Kinesio tape contributed to changes in occupational performance, pain, function and compliance.

To meet the first objective a single blind randomized controlled trial was conducted whereby 42 participants (66 wrists) completed a two-week intervention period. Participants were randomized to one of three intervention groups: Kinesio tape group (KG), sham control group (CG), or splint group (SG).

Participants in the KG (n = 15, 35.7%) had Kinesio tape applied to the dorsal upper extremity from proximal aspect of the forearm to the interphalangeal joint of the first digit and distal interphalangeal joint of the fifth. Participants were instructed not to remove the tape, but to complete all of their typical activities. New tape was reapplied at each consecutive visit approximately three days apart across the two-week study period.

Participants in the CG (n = 12, 28.6%) had a four-inch strip of Kinesio tape applied to the spine of the scapula that corresponded with the arm that had carpal tunnel syndrome (CTS). The CG used the same wear, activity, and replacement pattern as the KG. Participants in the SG (n = 15, 35.7%) were provided a prefabricated Mueller Sport Care one-size-fits-all adjustable maximum support orthosis with instructions to wear the orthosis while sleeping and to complete lumbrical stretching exercises throughout the day as able. Changes in pain and function were recorded for all groups through use of the

Numeric Pain Rating Scale (NPRS), Visual Analog Scale (VAS), Boston Carpal Tunnel Questionnaire (BCTQ) Symptom Severity (SS) Functional Scale (FS), and functional grip and pinch measurements. Outcomes indicated that Kinesio tape was effective for reducing pain and improving function with good statistical significance and good effect size on the NPRS, VAS, of both forearm and wrist, as well as for the BCTQ SS and BCTQ FS. There were no significant differences in functional grip and pinch measures between groups over time.

In order to meet the second objective, a limited phenomenological study embedded in an RCT was conducted. Daily symptom journals and semi-structured interviews were completed with 15 participants who were purposefully recruited and randomly allocated to the intervention group (KG). Three themes emerged: Participants positively perceived Kinesio tape to be effective on decreasing pain, increasing self-efficacy, and improving daily functional performance on tasks previously avoided or abandoned. Participants were compliant with wearing the Kinesio tape as outlined in the protocol. However, the most common problem identified was maintaining Kinesio tape on the hands and fingers, to which the majority of participants expressed a desire to learn application.

It is increasingly understood that symptom relief and return to function are the measure of success for interventions for musculoskeletal conditions of the hand, wrist, and forearm such as CTS (Jerosch-Herold et al., 2008). Overall, both objective and subjective findings of this study suggest that Kinesio tape is effective in reducing pain and improving function. Most of the participants expressed symptom relief and improved function in self-care, home management, driving, work, community

engagement, and/or leisure activities. This is consistent with the growing body of evidence for using occupation-based assessment tools and intervention activities for therapeutic treatment of hand injuries, including CTS (Arbesman et al., 2011; Bachman, 2016; Bates & Mason, 2014; College of Occupational Therapists, n.d.).

While subjective reports improved, no significant changes in objective measures of functional grip and pinch were seen over time or among the different intervention groups. A possible explanation for this finding is that grip and pinch strength measures were already within normal limits at baseline, limiting the potential to observe any significant effect on these measures. Even still, this finding suggests that further more robust studies are needed.

In conclusion, while a larger study may reveal larger statistical significance, participants perceived Kinesio tape as effective for decreasing pain, increasing self-efficacy, and improving daily functional performance. This improvement was demonstrated by successful engagement in work tasks, leisure activities, and functional activities which had been avoided or abandoned. The use of Kinesio tape allowed for continued activity and participation in the environment and may be an option for therapists working in distal upper extremity rehabilitation to consider, particularly the dorsal application of Kinesio tape for CTS.

References

Arbesman M, Lieberman D, and Thomas V. Methodology for the systematic reviews on occupational therapy for individuals with work-related injuries and illness. *Am J Occup Ther* 2011; 65(1):10-15.

Bachman S. The Issue is – Evidence-based approach to treating lateral epicondylitis using the occupational Adaptation Model. *Am J Occup Ther*, 2016; 70,7002360010. http://dx.doi.org/10.5014/ajot.2016.016972

Bates E, and Mason R. Coping strategies used by people with a major hand injury: A review of the literature. *Br J Occup Ther* 2014; 77(6):289-295. http://doi.org/10.4276/030802214X14018723137995

College of Occupational Therapists. *Occupational Therapy Evidence: The importance of occupational therapy in hand therapy* [Fact sheet]. Retrieved from https://www.rcot.co.uk/file/666/download?token=EZrq4z2A

Jerosch-Herold C, Mason R, and Chojnowski A. A qualitative study of the experiences and expectations of surgery in patients with carpal tunnel syndrome. *J Hand Ther* 2008; 21:54-62. http://doi.org/10.1016/j.jht.2017.05.018

Roll S. Current evidence and opportunities for expanding the role of Occupational Therapy for adults with musculoskeletal conditions. *Am J Occup Ther* 2017; 71:7101170010. http://doi.org/10.5014/ajot.2017.71102.