The effect of a carpometacarpal joint thumb splint on perception pain

Daniel C. Osten

The University of Toledo

Follow this and additional works at: http://utdr.utoledo.edu/graduate-projects

This Scholarly Project is brought to you for free and open access by The University of Toledo Digital Repository. It has been accepted for inclusion in Master's and Doctoral Projects by an authorized administrator of The University of Toledo Digital Repository. For more information, please see the repository's About page.
The Effect of a Carpometacarpal Joint Thumb Splint on Perception of Pain

Daniel C. Osten

Research Advisor: Julie J. Thomas, Ph.D, OTR/L, FAOTA

Department of Occupational Therapy

Occupational Therapy Doctorate Program

The University of Toledo Health Science Campus

May 2009
Abstract

The purpose of this study was to determine if the Colditz’ design custom fabricated thermoplastic carpometacarpal (CMC) wrap splint is effective in reducing perceived levels of CMC thumb pain in patients with CMC arthritis. A secondary purpose was to determine whether the completion of daily occupations were “easier”, “harder” or “about the same” when wearing the CMC splint compared to not wearing the CMC splint.

The research design was a repeated measures counterbalanced design. Participants were randomly assigned into one of two orders of conditions to account for order effects. The study had a sample size of 23. Three participants were male, 20 were female. The mean age was 54.4 years (sd = 11.7 years), range was 24 to 83 years. Perceived pain was measured using four visual analog scales per participant. The participants rated their perceived pain at rest with no splint (baseline), during a CMC loading hand writing occupation with no splint, at rest with the splint, and during a CMC loading hand writing occupation with the splint. Take home surveys listing 22 common tasks of daily living were completed approximately two weeks after splint fabrication.

The CMC wrap splint significantly reduced perceived pain both at rest and when writing. The majority of participants rated home survey tasks as either, “harder” or “easier” with many fewer tasks being rated as “about the same” to complete with the splint on.

Additional studies would be beneficial to show how well the splint reduces pain during daily living tasks at home in addition to asking if the splint makes the tasks easier or harder to do. A larger overall sample size will lead to more powerful statistical analyses. More specific inclusion criteria should also be added for future studies to help eliminate a floor effect seen with the present study.
The Effect of a Carpometacarpal Joint Thumb Splint on Perception of Pain

Osteoarthritis (OA) is the most common health problem in populations over age 40 and is a leading cause of pain and disability in the United States (Barnes & Edwards, 2005; Menon, 1983). With a large number of the American population surpassing this age (baby-boomer generation) there is likely to be an increase in the number of cases of osteoarthritis in the upcoming decades. By the year 2030, nearly 67 million (25%) US adults will have been diagnosed with arthritis (Hootman & Helmick, 2006). This is mostly due to the large aging population and the continuously increasing activity levels of this population (Moran, 2001). As medicine progresses, so does the ability of the elderly to carry out occupations of daily living.

Many occupations of daily living involve the use of the thumb, and more specifically the carpometacarpal (CMC) joint of the basal thumb. As the CMC joint is affected by OA, function is interrupted due to the instability and pain caused by the deterioration of the joint. Pain at the base of the thumb due to arthritis of the trapeziometacarpal and scaphotrapezial joints is a common problem, especially for women in the fifth to seventh decades of life (Swigart, Eaton, Glickel & Johnson, 1999). Severe cases of CMC arthritis typically result in surgical repair; however, splinting in the early stages has been shown to have a positive effect on the prognosis and may even delay the need for surgery. Splinting as a form of enforced rest may sufficiently diminish the acute inflammation so that the patient will be able to return to a normal level of function without significant pain (Swigart et al., 1999).

This study examined the immediate effect of splinting the CMC joint on the perception of pain at rest and under CMC stress, as in the process of writing. In addition, after two weeks of splint wear, the patients assessed by self-report the splint’s effect
during specified meaningful and purposeful occupations of daily living. The study helps occupational therapists to determine how effective and practical the use of custom made thermoplastic short opponens CMC splints are for reducing perception of pain in the thumb CMC joint. The following literature review discusses osteoarthritis (OA); describes common populations affected by OA, examines how OA affects the thumb CMC joint, and considers past research that has investigated CMC splinting.

Arthritis is not just one disease; it is comprised of more than 100 types of conditions with the most prevalent being osteoarthritis. The Arthritis Foundation (2007) estimates that 21 million Americans live with this disease. Before the age of 50, men have a higher incidence of OA, whereas after the age of 50 women have a higher prevalence and incidence (Schlesinger, 2001). Women past the age of 40 make up the most common demographic seen for CMC-OA and OA is commonly seen in the elderly population, as well. The 65-plus population continues to be engaged in physical activities, continues to be in the work force, and performs activities that can contribute to the development of symptoms of OA (Moran, 2001).

Osteoarthritis is only one specific type of arthritis, and it is a group of overlapping distinct diseases that have different etiologies but similar biologic, morphologic, and clinical outcomes (Schlesinger, 2001). Osteoarthritis begins by first involving the tissues of the diarthrodial joint’s cartilage and breaking it down. As the breakdown continues, the gradual loss of joint tissue determines the level of joint degeneration. If left untreated, the tissue loss will completely degenerate the cartilage and begin deteriorating the bone.

Many types of arthritis affect many different areas of the body; OA is one such type. OA does not affect just one tissue, as the inflammation and deterioration affects all surrounding joint tissues. The primary abnormality in OA can be in the articular cartilage,
synovium, subchondral bone, ligaments, or neuromuscular apparatus (Brandt, 1996). As individuals age, water loss is common. Cartilage loses water, causing it to become brittle and susceptible to inflammation and OA. Joints with a high synovium-to-cartilage ratio, such as the hands, are the most frequently affected (Shanku, 2000).

A common site for OA to develop is the CMC joint, also referred to as the trapeziometacarpal joint. This is the thumb joint where the first metacarpal and the trapezium carpal bone articulate. The thumb is the most important digit of the hand and greatly magnifies the complexity of human prehension. Functionally, the most important joint of the thumb is the CMC joint (Neumann & Bielefeld, 2003). The thumb CMC joint allows for two degrees of freedom, being movement in the sagittal plane (thumb abduction and adduction) as well as movement in the frontal plane (flexion and extension). The joint also permits some axial rotation which occurs concurrently with the other motions. The net effect at this joint is commonly termed opposition (Levangie, 2001). With engagement in movement at the metacarpophalangeal (MCP) joint, the thumb is able to move in triaxial directions, allowing for rotation. This coordination of movement allows us to engage in occupations that would be very difficult without the ability to oppose the thumb. The ability to pinch and grasp all stem from the thumb's capability to move freely through its full range of motion.

Any occupation requiring the thumb to be positioned in flexion and adduction places a great deal of force through the CMC joint. Forces at the first CMC joint can range from 12 kg in fine motor occupations to as high as 120 kg with twisting occupations (opening door, wringing washcloth) and cause discomfort (Weiss, LaStayo, Mills & Bramlet, 2000). For those with OA, loading forces through the thumb CMC joint can trigger pain.
Along with pain, there is a common occurrence of joint instability found with OA of the CMC. This may be due to the inherent shallowness of the saddle joint and the laxity of the volar ligaments (Menon, 1983). Laxity of the joints and ligaments are common pathologic features of the disease. Joint laxity is common in women, leaving them susceptible to thumb instability later in life. Women experience this effect more than men and postmenopausal women are especially prone to joint laxity (Moran, 2001). In young women, joint laxity and hypermobility are underlying causes for the eventual development of OA (Doerschuk, Hicks, Chinchilli & Pellegrini, 1999). The instability of the CMC joint results in a typical collapse deformity of the thumb. Both pain and instability will lead to weakness in pinch and grasp making occupations of daily living more difficult.

Just as with any other disease, there will be certain signs and symptoms to look for with OA. In the early stages (of OA), patients feel well in the morning, and the degree of pain is directly proportional to use. By the late stages, pain may be constant and may even disrupt sleep (Burkholder, 2000). Pain may also be seen in the wrist even though the CMC joint articulates with the distal row of the carpal bones; however, it is still within close enough proximity to cause pain in the wrist.

The domain of occupational therapy includes the personal, cultural, social, and spiritual contexts of a client's life that influence the meaning and the importance of the client's daily activities (Ramsey, 2004). A way to ensure the client's personal success is through patient education. The occupational therapist has many roles with regard to CMC-OA. The therapist teaches energy conservation techniques to improve occupational performance and educates the clients on proper positioning, support, and protection of their CMC joints. The use of home exercise programs can increase range of motion and
strengthening outside the clinical setting. The therapist can introduce pain management for home care. Therapists incorporate and teach thermal modalities to patients to promote long-term self-management of their pain (Moran, 2001).

Another early intervention for CMC-OA is splinting. The occupational therapist designs, constructs and/or fits CMC splints that are functional and comfortable. Splinting offers an alternative to invasive surgical repair by reducing the pain associated with stress to the CMC joint.

Physicians prescribe corticosteroids to suppress inflammation, whether by oral or intra-articular injection. Nonsteroidal anti-inflammatory drugs (NSAIDs) have become the most widely prescribed class of medicines in this country, and the majority of prescriptions are written for the chronic pain and functional limitations of OA (Burkholder, 2000). The splinting of the CMC thumb joint also allows inflammation to subside. When the patient engages in occupations of daily living, the splint functions to support and protect the joint against further damage.

Both long and short opponens splints can support the CMC joint. The long opponens splint includes the wrist and typically the MCP joint. The splints come in a variety of materials and sizes. Splinting materials can range from soft neoprene to hard thermoplastic custom splints. The patient’s splint preference is a deciding factor in determining the best splint for the client; as the patients will be the ones using their splints daily. Factors such as comfort and even the cosmetic characteristics of the splint can be deciding factors. Client preference is the key to deciding on a splint, as all have advantages and disadvantages.

Swigart, Eaton, Glickel, and Johnson (1999) investigated whether splinting should be used as a conservative treatment of arthritis of the first CMC joint. They studied and
initially treated 114 men and women (93 women and 21 men) having CMC arthritis with splinting. Participants had an average age of 53.8 years. In all, the authors evaluated 141 thumbs. The study showed that of the 141 total thumbs, 130 were treated initially with thumb splinting only. The splint used was the long opponens thumb splint (i.e., long thumb stabilizer). The authors designed splints to eliminate motion of the wrist and thumb, but not to attempt to correct any deformity. The experiment’s data were collected over a three year span. Participants wore their splints for 3 to 4 weeks followed by another 3 to 4 weeks of weaning from the splint. The average time of follow-up was 54 months (range 30-74 months). Of the initial 130 thumbs, 25 thumbs (19%) required surgery. Researchers mailed the participants a questionnaire asking whether splinting of the thumb provided any relief from their symptoms. If yes, the researcher asked the participant to rate the percentage improvement immediately and 6 months after splinting. Results showed that participants with early stage arthritis had more symptomatic improvement than later stage participants. The results showed an improvement in the relief of symptoms to the point where surgery was either prevented or postponed for 12 of the 33 participants requiring surgery. Surgery was delayed up to seven years. The researchers concluded that splinting as a conservative treatment allows the participant to return to a normal level of function. A total of 22 participants did not tolerate wearing the splint and, subsequently, did not complete the trial. They cited driving, writing and sports as occupations that were too difficult to perform while wearing a splint.

The long opponens splint restricts the wrist and can be difficult to wear while performing certain occupations of daily living (ODLs). The Weiss, LaStayo, Mills and Bramlet (2000) objective, subjective, and radiographic assessment and prospective analysis of splinting the first CMC joint compared both the long opponens and short
opponens thumb splints. The subjects were 26 patients (five men and 21 women). The average age was 57 years (range 36-88 years). All had radiographic evidence of CMC osteoarthritis with pain at this joint. Each subject completed a questionnaire in order to assess the subjective responses associated with the wearing of the splints. A hand surgeon gave each patient the initial questionnaire before splinting and assessing the subject's pain level on a visual analog scale (VAS). The participants also documented the duration of their thumb pain. The patients graded their thumb pain after functional use (pinch). The authors randomly assigned patients to a long or short opponens splint to wear for one week. The short opponens immobilized the CMC joint only and left the MCP and wrist free. The long opponens splint immobilized the MCP, CMC, and wrist joints. The researchers asked the patients to rate pain during use on a VAS as well as to rate splint satisfaction on another VAS. Participants filled out a self-rating scale of 22 common ODLs and whether function with the splint was easier, the same, or more difficult.

Subjects were later split into two groups based on stage of disease. Both splints were effective in decreasing pain. The study showed that the short opponens thumb splint was preferred by all subjects due to increased ability to carry out ODLs. Other factors such as cosmesis, ease of application, and comfort yielded more positive feedback for the short opponens than the long opponens splint. Both splints showed a reduction in subluxation of the CMC joint in early stages. The researchers found that both splints reduced pain and improved function.

Weiss, LaStayo, Mills and Bramlet conducted another study in 2004 that compared two other types of splints. The splints tested in this study were a prefabricated neoprene splint (PFN) and the custom-made thermoplastic (CMT) short opponens splint. The main differences between the splints were the materials and joints involved. The
PFN splint was a soft neoprene material while the CMT was a hard plastic. In this study, the PFN splint immobilized the thumb MCP and wrist joints, while the CMT splint only immobilized the CMC joint, leaving the wrist and MCP free. Researchers measured both splints subjectively, objectively and radiographically after wear to assess effects on pain, pinch strength, CMC joint stability, function, satisfaction, and preference. The number of subjects was 25 (21 female and four male). Ten patients had stage one CMC -OA and 15 had stage two CMC -OA. Before splint assignment, each subject completed a VAS assessing the current pain level and duration of thumb pain. Researchers took tip-pinchoch strength measurements before splint application followed by VAS assessment of pain. The authors randomly assigned subjects to wear either the CMT or PFN splint for one week. The researchers instructed the patients to keep track of the amount of splint use throughout the day.

One week after splint wear, the authors assessed the patients on thumb pain via VAS, measurement of tip-pinchoch strength with the Greenleaf Solo System Pinchmeter, and a pain assessment while pinching with the assigned splint on. Another VAS was used to rate splint satisfaction and a self-rating scale of 22 occupations of daily living as to whether their performance while wearing the assigned splint was “harder”, “easier”, or “the same” as without the splint. Researchers also asked the subjects to choose the most preferable splint overall and to describe why they chose it. The authors recorded radiographic measures of CMC joint stability both with and without the assigned splints. First, the researchers took measurements with no splint, then in loaded fashion followed with the use of the PFN and finally the CMT splint at 70% maximal force. The loading occurred with use of the Greenleaf Solo System. CMC joint subluxation was measured under unloaded (no stress, no splint), loaded (stress, no splint), loaded (stress, PFN splint),
and loaded (stress, CMT splint) conditions. With this study, there was no significant difference in the average wearing time for each splint. Pain significantly decreased after wearing each splint and thumb pain was significantly less with the PFN versus CMT splint. Results showed that neither splint improved pinch strength. ODL reports with the CMT splint showed that patients reported 26% easier, 33% harder and 44% were the same, while the PFN splint reported 48% easier, 12% harder and 40% were the same. The PFN splint had a higher rating on satisfaction VAS. Seventy-two percent chose PFN over CMT with 20% preferring CMT and 8% saying either would be fine. These studies showed that these two types of splints reduced pain and provided stability, but neither splint greatly improved overall pinch strength. An increase in pinch forces was seen with the PFN, but neither improved measurements compared to forces generated without a splint. The CMT splint provided better stability, while the PFN decreased CMC joint subluxation to a greater extent.

Colditz (2000) described the design and biomechanics of a custom-molded thumb CMC immobilization splint that excluded the thumb MCP and wrist joints. The splint utilized the stability of the adjacent immobile second and third metacarpals as an anchor for the first metacarpal. This design also prevented the need to splint the thumb MCP, the wrist joint, or both which would limit hand function. The Colditz’ design allowed unrestricted thumb MCP and wrist motion. The Colditz design was used for protection following thumb CMC arthroplasty or as a base for thumb MCP or interphalangeal mobilization splinting. One of the areas that Colditz attributed to poor patient compliance in previous trials of CMC joint immobilization splinting was the limitation of hand function in the splint. The thermoplastic splint Colditz used left the MCP and wrist unrestricted thus improving hand function over other styles of splints. The only
restriction while wearing the splint was if a flat palm was needed (i.e., pushing up from the floor). Colditz’s rationale was that the muscles crossing the CMC joint created an imbalance of forces allowing excessive motion. The challenge in effectively immobilizing the first metacarpal without including the MCP and wrist joints was the difficulty in molding the splinting material circumferentially around the first metacarpal. The study showed that thumb CMC pain can be controlled without limiting movement of other joints if care is taken with positioning and molding during splint construction. The patient needs to report immediate reduction or elimination of pain with pinch to ensure that the splint is molded correctly. If the patient reports that pain cannot be controlled, inclusion of the thumb MCP or wrist joints may be necessary to control symptoms. The small size of the splint allows for more unrestricted movement than the long opponens style, is cost effective, and is an efficient treatment option for those patients who elect to postpone or exclude surgical reconstruction for thumb CMC arthritis.

Finally, a study conducted by Berggren, Joost-Davidsson, Lindstrand, Nylander, and Povlsen (2001) showed that splinting of the CMC joint in addition to the use of technical equipment (assistive technology) was beneficial in postponing surgery. The participants were 33 women with an average age of 63 years (range 46-80) with thumb CMC - OA. The authors randomized participants into three groups; the first group was assigned to unrestricted assistive technology use involving such devices as a bread saw, reacher, scissors, pen handle, potato peeler, and cheese cutter. The authors gave the other two groups splints in addition to assistive devices. The splints assigned by the researchers were a semi-stable textile splint and a non-stabilizing leather splint. The total length of follow-up was 7 years, with measurements after 7 months and then 7 years. Of the initial 33 subjects 23 (70%) no longer required surgery 7 months after occupational
therapy. After the 7 year span two more subjects elected to have surgery (4 of the remaining 23 died). The study showed that 6 months of conservative treatment by an experienced occupational therapist delayed or eliminated the need for surgery in the majority of study participants.

The previous studies demonstrated that splints can be effective in decreasing pain and increasing function to the point of postponing surgical treatment of first CMC joint OA. Researchers compared and contrasted different splints to see which is the most effective. The Swigart et al. (1999) study showed the value of the long opponens splint in reducing pain and in protecting the joint. The Weiss et al. (2000) study showed that the patients preferred the short opponens splint over the long version due to its size and freeing of the wrist and MCP joints. Weiss et al. (2004) compared the preferred short opponens custom-made splint against a prefabricated neoprene CMC splint. Results show both are effective in relieving pain and supporting the CMC joint; however, the neoprene splint was preferred for long term splint wear with neither splint improving pinch strength over measurements taken without a splint. Colditz (2000) showed efficiency in the use of a properly fitted and designed CMC splint, which is less cumbersome than other CMC joint splints. The Colditz design is capable of supplying appropriate support and protection efficiently for the patient. The goal of the current study is to investigate whether the Colditz designed custom-made thermoplastic CMC splints affect pain perception in the CMC joint, as well as to examine how the splint affects performance in occupations of daily living. The primary research question is as follows: does the custom made CMC splint reduce perceived pain in the CMC joint during stress loading of the joint compared to not wearing the splint? A secondary research question asks whether participants perceive daily occupations as easier or more
difficult to perform when wearing the Colditz designed CMC thumb splint.

Methods

Research design

The research design was a repeated measures counterbalanced design. The researchers used two separate orders for the procedures to counterbalance the protocol. The counterbalanced protocol compares the participants’ results to themselves which minimizes the effects of individual differences. The researchers used a follow up procedure that asks participants to complete and return a self-report survey after they have returned home.

Participants

The inclusion criteria for the study required that participants be at least 18 years of age or older. The participants needed to have diagnoses of arthritis and pain of the thumb CMC joint that required the services of the outpatient hand clinic for CMC splint fabrication and fitting. Participants who received a corticosteroid injection of the thumb CMC joint in the orthopedic clinic prior to their visit to the hand clinic were excluded from this study as such medication can independently mask the painful effects of stress loading through the CMC joint.

Instruments and Apparatus

The therapist recorded each participant’s demographic information on a data collection form (appendix A) including condition assignment, which therapist made the splint, date the splint was constructed, hand dominance, which hand needs to be splinted, age and gender.

Therapists used the Colditz (2000) y-shaped pattern design that immobilizes and protects the thumb CMC joint (figure 1). Occupational therapists at the outpatient hand
CMC Thumb Splint

Clinic fabricated and fit the custom molded thermoplastic splints which wrap around the ulnar border of the hand and first metacarpal, run along the palmar surface, and use a Velcro strap located on the dorsoradial side of the splint that runs across the dorsal surface of the hand. The Colditz (2000) design leaves the thumb metacarpal and interphalangeal joints, the wrist, and other finger joints unrestricted to allow for more hand function. Three occupational therapists with extensive splint fabrication experience made the CMC splints.

Participants quantified their perceived pain levels using visual analog scales (VAS). The VAS consists of one 10cm line with two anchors at either end. Zero cm indicates no pain whatsoever while 10cm indicates extreme pain (appendix B). Research has shown that visual analog scales are valid and reliable measurements of intensity and unpleasantness of human pain (Price, McGrath, Rafii, & Buckingham, 1983).

Two weeks after the occupational therapist constructed the splint, the participant completed a follow-up survey. The survey listed 22 common occupations of daily living that had the potential of creating a loading force through the CMC joint (appendix C). This survey was originally created by Weiss et al. (2000). The survey asks whether or not completion of the listed occupations while wearing the splint is harder, easier, or about the same compared to completing the tasks without the custom made splint. Participants were then able to indicate whether or not the custom made thermoplastic CMC wrap splint made completion of these tasks “harder”, “easier”, or “the same” as compared to completion of the task without the splint. The authors did not report reliability or validity data for the original survey. The option of writing in and rating other daily tasks not listed in the initial list of was also offered.

The therapists evaluated each participant in the hand clinic at a treatment table.
positioned approximately 28 inches from the floor. They asked participants to write their name and address with the affected hand (dominant or non-dominant) with a standard Bic Round Stic Ballpoint Pen on a single piece of 8 ½” x 11” white paper. The researchers asked the participants to write their name and address because the occupation of “handwriting” requires a tripod or three jaw chuck pinch to hold the pen. This pinch generates forces at the thumb CMC joint which typically results in pain for those with thumb CMC arthritis. This pain is often activity related, particularly after forceful pinch (Dias, Chandrasenan, Rajaratnam, & Burke, 2007).

Procedures

The study was approved by the University of Toledo Health Science Campus Human Subjects Institutional Review Board (#105679). Once approved, the treating occupational therapists informed the patients who met inclusion criteria of the research study. The occupational therapist gave persons interested in participating in the study an informed consent form to read and sign prior to data collection. The therapist recorded the participant’s subject number, age, sex, hand dominance, and hand to be treated on the demographic form (see appendix A).

The study had two orders of procedures to counterbalance for order effects (figures 2 and 3). Researchers prepared envelopes with all pertinent data forms (VAS, return addressed stamped envelope, ODL home survey form, gift card address form etc.) for each of the two orders of conditions. A computer generated random order list was used to randomly assign participants to the conditions. The therapist treating the participant picked up and opened the next envelope in sequence and followed the protocol for the designated condition.

In condition one the therapist completed the following steps. (see figure 2)
1. The therapist had the patient complete the first VAS. Every VAS contained within this study in both conditions was explained as, “this line represents the amount of pain you are experiencing in your thumb right now. This end (pointing) indicates extreme pain while this end (pointing) indicates no pain whatsoever. Please mark on this line the amount of thumb pain you have at this time.” The participant marked his or her current rating of pain on the VAS.

2. Once the initial VAS was completed, the therapist asked the participant to write his or her name and address with his or her affected hand without the use of a CMC splint. While engaging in the hand writing occupation, the therapist asked the patient to note his or her highest level of pain during the hand writing.

3. The therapist asked the participant to complete a second VAS rating perceived pain during the hand writing occupation using the same verbal instructions as in step one.

4. Next, the occupational therapist fabricated and applied a custom molded thermoplastic splint to support and protect the patient’s thumb CMC joint.

5. Once fitted, the therapist asked the participant to again assess his or her pain on a third VAS. The VAS protocol was the same as step one.

6. The occupational therapist asked the participant to re-engage in the occupation of “writing his or her name and address” while wearing the CMC splint.

7. The occupational therapist asked the participant to complete a fourth VAS assessing pain during the hand writing occupation with the splint using the same verbal instructions in step one.

8. Lastly, the therapist gave the participant the instructions for the follow-up home survey procedures. As a thank you for participating and as an incentive to return the follow-up survey, the therapist offered participants a $15 Kroger supermarket gift.
card (see figure 4).

In condition two, the therapist completed the following steps in order. (see figure 3)

1. The occupational therapist fabricated the splint and applied it to stabilize and protect the participant’s thumb CMC joint.

2. Once the splint was appropriately applied, the therapist asked the participant to fill out the first VAS which was the subject’s perception on his or her pain level after splint application.

3. After the first VAS, the therapist asked the participant to engage in the occupation of “writing his or her name and address” while wearing the CMC splint.

4. The therapist asked the participant to fill out a second VAS assessing his or her pain level during the hand writing occupation.

5. The occupational therapist removed the splint from the participant.

6. The occupational therapist gave the participant the instructions for the follow-up home survey procedures.

7. The occupational therapist asked the participant to fill out a third VAS to assess his or her pain without the splint.

8. The therapist asked the participant to engage in the hand writing occupation without the use of the splint.

9. The therapist administered a final fourth VAS as the participant assessed his or her pain while he or she completed the occupation of “writing his or her name and address” without the splint.

Results

Demographic Statistics
For this study, participants were diagnosed with CMC arthritis of the thumb. The sample included 23 participants. Three participants were male (13.0%), 20 were female (87.0%). The mean age was 54.4 years with a standard deviation of 11.7 years. The participants’ ages ranged from 24 to 83 years. Of the 23 hands splinted, 17 were dominant hands (73.9%) and 6 were non-dominant hands (26.1%). The number of left hands splinted was 11, (47.8%) and the number of right hands splinted totaled 12 (52.2%).

Data Analyses

Included within each of the two conditions of the study, participants were asked to rate their pain using a visual analog scales (VAS) four times (see table 1). Table 1 shows the VAS mean and median scores for perceived pain, the corresponding standard deviations as well as the standard errors. The VAS data were checked for order effects between the two orders of conditions. No order effects were found. Therefore, the data were combined for both orders and the remaining analyses were completed on the entire sample. All VAS skewness values were less than one.

The mean VAS data is visually presented in figure 5. Visual analog scale 1 is the free hand at rest without loading (pain range = 1 – 85). Visual analog scale 2 is the free hand with CMC loading through writing (pain range = 1 – 83). Visual analog scale 3 is the splinted hand at rest without loading (pain range = 0 – 80). Visual analog scale 4 is the splinted hand with CMC loading through writing (pain range = 0 – 78). An overall analysis of variance (ANOVA) was completed comparing the four VAS time periods (see table 2). There was a significant difference between the four VAS time periods (p = .000).

Multiple preplanned contrasts were developed with this experimental design. Because multiple contrasts could result in a type I error, a Bonferroni adjustment was
made to the alpha level. There were three preplanned contrasts comparing the baseline VAS findings with the remaining VAS findings resulting in a Bonferroni corrected alpha of .0167 (alpha of 0.05/ 3 contrasts = .0167). Two additional preplanned contrasts compared the perceived pain in the free hand with CMC loading with the perceived pain in the splinted hand at rest without CMC loading and the splinted hand with CMC loading resulting in a Bonferroni corrected alpha of .025 (alpha of 0.05/ 2 contrasts = .025).

The effect size (d) was calculated to determine the magnitude of the differences in the contrasts. According to Cohen (1988) a small effect size (d) is equal to or lower than 0.20, a medium effect size (d) is 0.50, and a large effect size (d) equals 0.80.

In order to analyze the primary research question, a series of preplanned contrasts were developed. First, the sample’s pain perception was compared between the unsplinted hand at rest (mean VAS = 31.09) and when writing or loading the CMC joint without the splint (mean VAS = 33.78). Even though there was an average increase in perceived pain with writing, the contrast analysis indicated that there was not a significant difference in pain perception between these two conditions [F = 1.843, (degrees of freedom = 1), p = .188]. The effect size for this contrast was 0.11 indicating a negligible effect.

Secondly, the sample’s pain perception was compared between the hand at rest, without the splint (mean VAS = 31.09) and when at rest with the splint on (mean VAS = 25.96). The contrast analysis showed that the application of the splint significantly reduced the average reported pain [F = 8.578, (degrees of freedom = 1), p = .008]. The effect size for this contrast was 0.22, which is a small effect size.
Next, the sample’s perceived pain was compared between the hand at rest, without the splint (mean VAS = 31.09) and when writing or loading the CMC joint with the splint on (mean VAS = 24.52). The means showed that the application of the splint during loading of the CMC joint reduced the average reported pain. However, the level of reduced pain was not statistically significant \([F = 5.494, (\text{degrees of freedom} = 1), p = .029]\). The effect size for this contrast was 0.27, which is a small effect size.

Two additional within-subject preplanned contrasts were also completed. First, the sample’s pain perception was compared between the free hand during CMC loading (mean VAS = 33.78) and the hand at rest with the splint on (mean VAS = 25.96). The analysis showed that the perceived pain was significantly reduced with the application of the CMC splint to the hand when the CMC joint was not loaded \([F = 8.907, (\text{degrees of freedom} = 1), p = .007]\). The effect size for this contrast was 0.32, which is a small effect size.

The final within-subject preplanned contrast compared the perceived pain in the free hand during CMC loading (mean VAS = 33.78) with the perceived pain in the splinted hand during CMC loading through hand writing (mean VAS = 24.52). The analysis showed that the perceived pain was significantly reduced in the splinted hand during loading of the CMC through a hand writing occupation \([F = 12.469, (\text{degrees of freedom} = 1), p = .002]\). The effect size for this contrast was 0.36, which is a small effect size.

**Survey data**

Fourteen of 23 participants returned the follow up survey for a 60.9% response rate. Of the 14 participants who returned surveys, eight persons received a splint for their dominant right hand and six persons received a splint for their non-dominant left hand.
Because of the mix of dominant and non dominant hands affected, only the 13 tasks on the survey that were bi-manual in nature were included in the analysis (see table 3). The research question asked whether or not the splint would make tasks harder, easier, or about the same to complete. Overall, the participants reported 44.4% of the tasks were rated as “harder” with the splint on, 39.4% of the tasks were rated as “easier” with the splint on, and 16.1% of the tasks were rated as “about the same” with the splint on. Since the responses to the surveys were nominal in nature, a Goodness of Fit Chi Square was completed on the results of the survey for occupations rated as “harder”, “easier”, and “the same” with the splint on (see table 4). With the degrees of freedom equaling two and the chi square equaling 24.71, the results showed a statistically significant difference among the three response categories compared to the expected frequencies.

Discussion

Hootman and Helmick (2006) state that by the year 2030, nearly 67 million United States adults will be diagnosed with arthritis, and therefore, the need for therapeutic intervention will be increased. This study sought to address one common problem found among those with arthritis, which is pain in the CMC joint of the thumb. The primary research question of this study asks whether or not the custom made CMC splint reduces perceived pain the CMC thumb joint during stress loading of the joint compared to not wearing the splint. The findings show a significant difference and average decrease in perceived levels of pain in individuals after application of a Colditz’ design custom fabricated thermoplastic CMC wrap splint in the outpatient setting. This study shows the benefit of utilizing CMC thumb splints in reducing perceived pain in individuals both at rest and during an occupation in which loading of the CMC occurs.
The decrease in perceived pain within the CMC joint during loading can be due to the increased stability and support the thermoplastic CMC wrap splint provides for the CMC joint during occupation. Participants reported an average lower perception of pain after splinting as measured by the VAS in comparison to perception of pain without the splint. These findings suggest that applying a Colditz’ design thermoplastic CMC wrap splint can reduce perception of pain in individuals with CMC arthritis.

Just as with the Swigart, Eaton, Glickel and Johnson (1999) study, splinting as a form of enforced rest may diminish pain due to the immediate increased biomechanical support and stability the CMC splint provides allowing for increased independence with less pain. The present study shows the immediate effectiveness of splinting the CMC joint. As perceived pain decreases with the application of the custom fabricated CMC wrap splint, individuals should be more capable of carrying out occupations of daily living with less pain.

It is important for the patients, physicians, and occupational therapist to realize that conservative treatment utilizing splints may be beneficial in decreasing pain. The longer the pain is present and in the later stages of CMC joint deterioration, occupations of daily living will be directly effected. Even sleep patterns can be disrupted if the pain is allowed to continue. A study by Swigart et al. (1999) showed that participants with early stage arthritis had more symptomatic improvement with splinting than later stage participants.

The second research question asked whether or not completion of typical daily tasks are easier, more difficult or about the same with the splint. The study by Weiss et al. (2000) compared the daily tasks completed with a short opponens splint versus a long opponens splint. Results of the Weiss et al. (2000) study survey responses for the short
splints revealed that participants reported 42% of the tasks as easier, 51% were the same, and 7% were harder to complete with the short CMC splint. The Weiss et al. (2000) survey results showed the short splint was preferred over the long splint in regard to completion of daily tasks in. Based on the results that the CMC splint is effective in reducing pain and the results of the Weiss et al. (2000) study, it would be expected that wearing the CMC splint during the completion of daily tasks was easier with the splint. This was not the case in the present study.

The present study revealed no significant generalizations with the survey of daily tasks results. The majority of respondents’ surveys showed that most tasks were either easier or harder to do with the splint on and many fewer were rated as about the same with and without the splint. Overall, the participants reported 44.4% of the tasks were rated as “harder” with the splint on, 39.4% of the tasks were rated as “easier” with the splint on, and 16.1% of the tasks were rated as “about the same” with the splint on. The results appear to show an individual reaction to tasks that is not consistent across the sample (see table 4). The mixed responses reflect the individuality in the participants’ preferences. For instance, seven individuals rated the daily task of “folding laundry” as “easier” to do with the splint on, while only three individuals rated “folding laundry” as “harder” to do with the splint on. For the task of “sewing” six individuals rated the task as “harder” to do with the splint on and only one individual rating the daily task of “sewing” as “easier” to do with the splint on. Significantly fewer felt tasks were “about the same” with and without the splint. Few tasks were clearly easier or harder to do with the splint on.

It is possible that the nature of all tasks listed on the survey does not apply to every individual requiring a CMC splint and may lead to some tasks on the surveys being
left blank. For example, sewing and yard work were left blank by five participants. If an individual does not sew or work in the yard, he or she may not rate the task on the survey. The frequencies for each daily task show that the results are individualized and may indicate that people differ in the tasks for which the splint is seen as helpful. A home maker may engage in many more of the bimanual daily tasks on the survey compared to an individual who works outside of the home who rarely engages in some of the bimanual tasks listed on the survey. These factors may have contributed to the mixed results found in the surveys.

*Interpretations*

Some results of the study require additional interpretation. The pre-planned contrast comparing perceived pain in the free hand without CMC loading versus the perceived pain in the splinted hand with CMC loading revealed a possible type II error. The participants rated their pain as less with the splint on than when free handed, but the means were not statistically different. The study had a relatively small sample size of 23 participants and that in combination with high variability in perceived pain, may have resulted in a type II error.

The present study yielded very high standard deviations (see figure 6). The variability in perceived pain ratings was large among the individual participants. For example, one individual reported almost no pain upon the initial VAS. A pain rating of one offered virtually no room for a decrease in pain creating a floor effect. Another participant indicated an initial pain perception of 85 offering much more room for a significant decrease in pain. The same pattern is seen in each of the pre-planned contrasts leading to highly elevated standard deviations. However, finding statistically significant results with such large standard deviations shows the effectiveness of how splinting
CMC Thumb Splint reduces pain given that large standard deviations make it difficult to find statistically significant differences.

The pre-planned contrasts compare the average perceived pain experienced during each contrast (see figure 5). If the mean perceived pain level of the unsplinted hand at rest (VAS #1) is compared with the mean perceived pain level of the unsplinted hand during CMC loading (VAS #2), an increase in overall pain is noted. This indicates that participants experienced an increase in pain with CMC loading, which would be expected.

The average perceived pain level in the unsplinted hand during CMC loading (VAS #2) compared with the average perceived pain level in the splinted hand at rest (VAS #3) shows a significant decrease in average pain after application of the CMC splint indicating that the splint decreases perceived pain. Similarly, the average perceived pain in the splinted hand at rest (VAS #3) compared with the average perceived pain in the splinted hand during CMC loading (VAS #4) shows a decrease in pain during CMC loading versus the splinted hand at rest. This indicates that the splint provides sufficient support to the CMC joint to prevent a spike in pain when the CMC joint is stressed.

Overall, the highest perceived level of pain was seen in the unsplinted hand during the CMC loading task of handwriting and the lowest average perceived level of pain was seen in the splinted hand during the CMC loading task of handwriting. The contrast shows that the splint was protective of perceived pain when loading the CMC joint during writing.

The study by Berggren, Joost-Davidsson, Lindstrand, Nylander, and Povlsen (2001) showed similar results in pain reduction by determining that splinting the CMC joint in addition to using assistive technology decreased pain and postponed surgery in
individuals with CMC arthritis. Their research showed that early intervention utilizing conservative treatment options, such as splinting, is useful restoring individual levels of daily performance by decreasing pain. If pain is decreased, individual performance and independence increases. The present study shows the effectiveness of the Colditz’ design custom fabricated thermoplastic CMC wrap splint in immediate reduction of pain.

**Limitations**

The first limitation was the small sample size of 23. A large factor in the determination of our sample size was one of the exclusion criteria established at the beginning of the research study. Individuals receiving any type of corticosteroid injection prior to their arrival to the outpatient hand clinic were excluded from the study as corticosteroid injections can independently mask the pain associated with loading through the CMC joint. The number of research participants with CMC arthritis would have more than doubled if we included the individuals who had received steroid injections, however, the results could have been confounded by the medication masking the true pain levels.

The prevalence of steroid injections may have limited the inclusion of those with more severe thumb pain in the sample. This would leave a larger proportion of those with less pain and consequently subject to the floor effect described earlier in the present study’s sample. If fewer persons had the injections, the sample may have included more individuals with higher levels of pain. Therefore, more room to show improvement with the splint could be possible. This may also increase the effect size or magnitude of the effect of applying the splint.

Another possible limitation was the take home survey. No psychometric data were available on the survey even though it has been used in other published studies
(Weiss et al., 2000). In addition to the reliability and validity of the survey, an uncontrollable 60.9% response rate reduced the numbers available for analysis, further reducing the power of the analysis.

The survey was a self-report and while self-report has been shown to be a reliable and valid measure, inspection of the individual surveys indicated a response pattern among a few participants. For example, one participant marked all tasks as harder to do with the splint on. Another marked all but two tasks as easier to do with the splint on. These response patterns could affect the results of the survey.

The survey asked whether tasks were easier or harder with the splint on but does not ask whether the tasks were more or less painful to complete with the splint on or off. It is possible that the splint could have made the task less painful, but the task could have also been harder to do with the splint on. The survey may have asked more about how the splint interfered with the normal, unsplinted use of the hand. In addition, the survey did not ask whether or not the person continued to wear the splint, even if a task was harder to do with the splint on. Perhaps people wore the splint for pain reduction regardless of whether or not it made the task easier or harder. These areas were not addressed by the survey used in the present study.

Finally, high standard deviations were calculated due to the elevated level in variability in personal perception of pain. This is evident in the large range of VAS scores. To control for this, it may be possible to only include subjects who initially report a minimum level of perceived pain on the baseline VAS. For example, a pre-determined level of perceived pain at baseline could be required for inclusion in the study. This minimum level of pain needed for inclusion would avoid a floor phenomenon and assure that all subjects would have the chance to show improvement in pain.
Future Research

Future studies are needed in the area of occupational performance displayed by individuals with splints showing the effectiveness of splints to reduce pain and enhance every day occupations. Further measuring perceived reduction of pain utilizing splints is also another area in which studies can be conducted. In future studies, the inclusion criteria can be altered to accommodate more participants, namely, participants that are status post corticosteroid injection. It would be valuable to know whether splinting in addition to steroid injections further reduces pain in the CMC joint. Setting up a separate condition to account for these participants may allow another analysis to be done that will measure all the response of those without and those with steroid injections in addition to the CMC splint. This would allow for a larger sample size and a more powerful research outcome. An inclusion criterion for baseline pain will be needed in order to show the largest possible decreases in pain resulting from application of the CMC splint. This will eliminate the floor effect seen in the present study.

A more specific survey is needed to identify whether tasks are more or less painful to do with or without the splint. The survey also needs to ask, not only whether tasks are easier or harder to complete with the splint on, but whether the participants continue to wear the splint when tasks are harder to complete. This will help to show, in a more clear fashion, just how the participants’ CMC splints affect the difficulty in completion of daily tasks with the splint on. The survey should also show whether or not participants feel the splint is convenient for everyday use. This factor could determine if participants continue to wear the splint for pain reduction when tasks become difficult, or to determine if the participants remove the splint in order to more easily complete daily tasks.
Conclusion

This study sought to investigate the effect of the application of a Colditz’ design custom fabricated thermoplastic CMC wrap splint on perceived reduction of pain and effectiveness of the splint in tasks of daily living. In terms of perceived pain reduction, the splint significantly reduced perceived pain in the CMC joint both at rest and during a handwriting occupation that applied a loading force through the CMC joint. As for the effectiveness of the splint in tasks of daily living, no generalizations could be made as the task ratings were rather evenly divided across the survey. Although additional issues need to be addressed during further investigation, increasing the sample size and subsequent statistical power of the design is recommended in order to more fully determine the effectiveness of splinting the CMC joint in individuals with arthritis and how it affects occupational performance.

Acknowledgements

I greatly appreciate my advisor Julie J. Thomas, PhD, OTR/L, FAOTA, for her guidance, hard work, and seemingly inexhaustible patience. I thank Kathy Collier, OTR/L, CHT, Mark Ruhe, OTR/L, and James Kessler, OTR/L, for their professional insight, skills as occupational therapy practitioners, and enthusiasm to pursue this study to completion. I thank Martin Rice, PhD, OTR/L, for his technical and statistical skills. I also thank the Arthritis Foundation for their financial support of this study.
References


Appendix A

Data Collection Form

Participant # ____________________

Condition 1 2 (Circle one)

Therapist’s Initials ________________ (Constructed splint)

Hand Dominance R L (Circle one)

Hand Splinted R L (Circle one or both if applicable)

Age ___________

Gender M F (Circle one)

Date splint constructed ______________________
Appendix B

Visual Analog Scale

No Pain                  Extreme Pain
----------                ----------
 (~10 cm)
Appendix C

Survey of Daily Tasks

Please fill in this survey on or about _________________ and mail it in the enclosed envelope. Be sure to include your Kroger gift card address form.

This is a list of daily tasks. Think about doing each task with your splint on your hand. Is it easier to do that task with your splint on? Is it harder to do with your splint on? Or is it about the same as with and without your splint? Put an “X” in the box that best describes how you feel.

<table>
<thead>
<tr>
<th>Task</th>
<th>Harder to do with splint on</th>
<th>Easier to do with splint on</th>
<th>Same with and without the splint</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open a jar</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cut meat</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carry groceries</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open a can of soda</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lift and pour milk</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hold a full cup</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peel/chop vegetables</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turn a faucet</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wring out a dishcloth</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wash and dry dishes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smooth and fold laundry</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brush and style hair</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brush teeth</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fasten buttons</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fasten zippers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Write</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use scissors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Make the bed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sew</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turn the car ignition</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perform your job</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do yard work</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>List other tasks you often do. Check whether or not they are easier, harder or the same to do with the splint on</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1

Mean, median, standard deviation, and standard error for each visual analog scale in millimeters

<table>
<thead>
<tr>
<th>Visual Analog Scale (scale number)</th>
<th>Mean</th>
<th>Median</th>
<th>Standard Deviation</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free hand without CMC loading (1)</td>
<td>31.09</td>
<td>25.00</td>
<td>24.43</td>
<td>5.09</td>
</tr>
<tr>
<td>Free hand with CMC loading (2)</td>
<td>33.78</td>
<td>23.00</td>
<td>26.12</td>
<td>5.45</td>
</tr>
<tr>
<td>Splinted hand without CMC loading (3)</td>
<td>25.96</td>
<td>18.00</td>
<td>22.85</td>
<td>4.76</td>
</tr>
<tr>
<td>Splinted hand with CMC loading (4)</td>
<td>24.52</td>
<td>14.00</td>
<td>24.79</td>
<td>5.17</td>
</tr>
</tbody>
</table>

Note: CMC is an abbreviation for the thumb carpometacarpal joint
Table 2

*Analysis of variance for visual analog scale data*

<table>
<thead>
<tr>
<th>Source</th>
<th>Sum of Squares</th>
<th>Degrees of Freedom</th>
<th>Mean Square</th>
<th>F</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual analog scale</td>
<td>1298.12</td>
<td>3</td>
<td>432.71</td>
<td>6.91</td>
<td>.000</td>
</tr>
<tr>
<td>Error</td>
<td>4130.63</td>
<td>66</td>
<td>62.59</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 3

*Frequency of ratings of 13 bimanual daily tasks*

<table>
<thead>
<tr>
<th>Task</th>
<th>Rating</th>
<th>Number of participants</th>
<th>Frequency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open Jar</td>
<td>Harder</td>
<td>6</td>
<td>42.9%</td>
</tr>
<tr>
<td></td>
<td>Easier</td>
<td>4</td>
<td>28.6%</td>
</tr>
<tr>
<td></td>
<td>Same</td>
<td>4</td>
<td>28.6%</td>
</tr>
<tr>
<td>Cut Meat</td>
<td>Harder</td>
<td>5</td>
<td>35.7%</td>
</tr>
<tr>
<td></td>
<td>Easier</td>
<td>5</td>
<td>35.7%</td>
</tr>
<tr>
<td></td>
<td>Same</td>
<td>3</td>
<td>21.4%</td>
</tr>
<tr>
<td></td>
<td>Missing Participant</td>
<td>1</td>
<td>7.1%</td>
</tr>
<tr>
<td>Open Soda</td>
<td>Harder</td>
<td>5</td>
<td>35.7%</td>
</tr>
<tr>
<td></td>
<td>Easier</td>
<td>5</td>
<td>35.7%</td>
</tr>
<tr>
<td></td>
<td>Same</td>
<td>2</td>
<td>14.3%</td>
</tr>
<tr>
<td></td>
<td>Missing Participant</td>
<td>2</td>
<td>14.3%</td>
</tr>
<tr>
<td>Cut Veggies</td>
<td>Harder</td>
<td>7</td>
<td>50.0%</td>
</tr>
<tr>
<td></td>
<td>Easier</td>
<td>5</td>
<td>35.7%</td>
</tr>
<tr>
<td></td>
<td>Same</td>
<td>2</td>
<td>14.3%</td>
</tr>
<tr>
<td>Wring Dishcloth</td>
<td>Harder</td>
<td>7</td>
<td>50.0%</td>
</tr>
<tr>
<td></td>
<td>Easier</td>
<td>4</td>
<td>28.6%</td>
</tr>
<tr>
<td></td>
<td>Same</td>
<td>3</td>
<td>21.4%</td>
</tr>
<tr>
<td>Wash Dishes</td>
<td>Harder</td>
<td>8</td>
<td>57.1%</td>
</tr>
<tr>
<td></td>
<td>Easier</td>
<td>5</td>
<td>35.7%</td>
</tr>
<tr>
<td></td>
<td>Same</td>
<td>1</td>
<td>7.1%</td>
</tr>
<tr>
<td>Fold Laundry</td>
<td>Harder</td>
<td>3</td>
<td>21.4%</td>
</tr>
<tr>
<td></td>
<td>Easier</td>
<td>7</td>
<td>50.0%</td>
</tr>
<tr>
<td></td>
<td>Same</td>
<td>4</td>
<td>28.6%</td>
</tr>
<tr>
<td>Button Clothes</td>
<td>Harder</td>
<td>6</td>
<td>42.9%</td>
</tr>
<tr>
<td></td>
<td>Easier</td>
<td>4</td>
<td>28.6%</td>
</tr>
<tr>
<td></td>
<td>Same</td>
<td>3</td>
<td>21.4%</td>
</tr>
<tr>
<td></td>
<td>Missing Participant</td>
<td>1</td>
<td>7.1%</td>
</tr>
<tr>
<td>Zip Clothes</td>
<td>Harder</td>
<td>5</td>
<td>35.7%</td>
</tr>
<tr>
<td></td>
<td>Easier</td>
<td>5</td>
<td>35.7%</td>
</tr>
<tr>
<td></td>
<td>Same</td>
<td>3</td>
<td>21.4%</td>
</tr>
<tr>
<td></td>
<td>Missing Participant</td>
<td>1</td>
<td>7.1%</td>
</tr>
<tr>
<td>Activity</td>
<td>Harder</td>
<td>Easier</td>
<td>Same</td>
</tr>
<tr>
<td>--------------</td>
<td>--------</td>
<td>--------</td>
<td>-------------</td>
</tr>
<tr>
<td>Make Bed</td>
<td>5</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sew</td>
<td>6</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Job</td>
<td>6</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yard Work</td>
<td>3</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Table 4

*Goodness of fit chi square*

<table>
<thead>
<tr>
<th>Rating</th>
<th>Observed Frequency</th>
<th>Expected Frequency</th>
<th>((O-E)^2) / E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harder with splint</td>
<td>80</td>
<td>60</td>
<td>6.67</td>
</tr>
<tr>
<td>Easier with splint</td>
<td>71</td>
<td>60</td>
<td>2.02</td>
</tr>
<tr>
<td>Same with splint</td>
<td>29</td>
<td>60</td>
<td>16.02</td>
</tr>
<tr>
<td>Chi square total</td>
<td></td>
<td></td>
<td>24.71</td>
</tr>
</tbody>
</table>

Note: Chi square \((df = 2) = 5.99\)
Figure 1

Colditz-designed thumb splint

Figure 2

Condition One

Referral

- **VAS #1**
  - Write without the splint

- **VAS #2**
  - Splint fabrication and application

- **VAS #3**
  - Write with the splint

- **VAS #4**
  - Discuss home survey procedure
Figure 3

Condition Two

Referral

- Splint fabrication and application
  - VAS #1
  - Write with the splint
  - VAS #2
  - Remove splint
  - Discuss home survey procedure
    - VAS #3
    - Write without the splint
      - VAS #4
Thank you for taking the time to participate in our research and for filling out our survey. As a token of our thanks for completing and mailing the survey back to us, we will mail you a $15 gift card to Kroger Supermarkets. Please fill out the address where you would like us to send the gift card. Mail this form in with your completed survey of daily tasks in the return envelope. Thank you again!

ADDRESS: ________________________________

CITY: ___________________ ZIP CODE: _________
Figure 5

Visual Analog Scale Means for Each Condition
Figure 6

Visual Analog Scales and Standard Deviations for Each Condition