The effect of a thumb CMC splint on pain in the CMC joint and compensatory movement at the wrist: a pilot study

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For the Degree of
Master of Occupational Therapy

Title of Scholarly Project
“The Effect of a Thumb CMC Splint on Pain in the CMC
Joint and Compensatory Movement at the Wrist: A Pilot Study”

Submitted by
Andrea Sheibley

In partial fulfillment of the requirements for the degree
Master of Occupational Therapy

APPROVED

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Attachment: Abstract

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The Effect of a Thumb CMC Splint on Pain in the CMC Joint and Compensatory Movement at the Wrist: A Pilot Study

Andrea Sheibley

Department of Occupational Therapy

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Abstract

This pilot study investigated the effects of the Colditz thumb CMC splint on pain in the CMC joint and movements at the wrist during a common scooping occupation. In addition, effect sizes of the dependant variables and projected number of subjects needed in future studies were explored.

Four participants with left handed splints, three participants with right handed splints, and two participants with splints on both hands (N=11) completed the task of placing four scoops of drink mix into a cup two times according to the order they were assigned (splint, no splint; no splint, splint). While no differences were found between the splinted and non-splinted conditions for dorsiflexion, radial and ulnar deviation, and pain, participants did show significantly greater volar flexion with the splint off than on. A large effect was found for the variable of flexion, and a medium effect was found for deviation. The test for projected number of subjects found N estimates of 42 for dorsiflexion, 13 for volar flexion, 85 for ulnar deviation, and 67 for radial deviation.

The results of this study suggest that as the Colditz thumb CMC splint immobilizes the CMC joint, it also restricts a person’s ability to maximally volar flex his or her wrist. For those patients whose daily lives involve occupations that require a great deal of volar flexion, this could lead to stress on other proximal joints or problems with compliance. Additional research is needed to fully understand thumb CMC splint effectiveness. Future research should include a larger sample size and a variety of tasks. The small sample size and a large variability in movements and perceptions of pain in this study, as well as the use of a task that required little dorsiflexion or radial and ulnar deviation, made it difficult for significant results to be found.
The Effect of a Thumb CMC Splint on Pain in the CMC Joint and Compensatory Movement at the Wrist: A Pilot Study

With every passing year, the number of people treated with arthritis by occupational therapists increases. This is mostly due to the large aging population and the continuously increasing activity levels of this population (Moran, 2001). When the thumb carpometacarpal, or CMC, joint is affected, the functioning of the hand can be greatly decreased by pain and instability. A common treatment for thumb CMC pain and instability is splinting. It is important for occupational therapists to know what effects this type of treatment will have for the patient. Little research has been done concerning the effect of splints for the thumb CMC joint. Additional research will help occupational therapists understand how wearing a thumb CMC splint may stress the wrist joint. There is also a need for occupational therapists to understand the effect a thumb CMC splint has on pain experienced in the joint while using the hand in typical daily tasks. The purposes of this pilot study are to investigate the effects of using a thumb CMC splint on both perceived pain in the CMC joint and compensatory movements at the wrist compared to use of the free, or non-splinted, hand. In addition, this pilot study will examine effect sizes and projected subject numbers for these variables. This information will help occupational therapists determine the benefits and drawbacks of thumb CMC splints and will provide suggestions for future research in this area. The following literature review will describe arthritis, its effects on the thumb, and the prior research on thumb CMC splints.

Arthritis is a broad term that encompasses more than 100 different types of the disease. Two of the most common types of arthritis treated by occupational therapists are osteoarthritis and rheumatoid arthritis. Arthritis affects joints as a result of two main processes, inflammation and degeneration (Jones & Covert, 1996). These result in damage or destruction to the joint, and
the joint becomes weak and unstable. Pain often occurs as a result, which can interrupt the person’s ability to perform daily occupations.

Arthritis is a very common disease. According to the Center for Disease Control (2003), it is one of the most prevalent diseases in the country, affecting approximately 43 million Americans every year. The Arthritis Foundation (2003a, 2003b) estimates that 20.7 million of those affected have osteoarthritis, while an estimated 2.1 million have rheumatoid arthritis. In both types of arthritis, women are affected more often than men. The middle-aged and elderly populations are the most likely to be affected.

Osteoarthritis is a type of arthritis that results in degenerative changes in disarthrodial joints in the body. These changes occur when cartilage between the bones of a joint breaks down and wears thin, which causes the bones to rub together. Schlesinger (2001) reports, the loss of articular cartilage can then lead to secondary changes in the synovial tissue, ligaments, and muscles that move the joint. These changes further the instability of the joint.

Rheumatoid arthritis, on the other hand, is “a chronic inflammatory, systemic disease that produces its most prominent manifestations in the disarthrodial joints” (Goronzy & Weyand, 1997, p. 155). The synovium of the joint affected becomes severely inflamed, which causes the joint to become tender and swollen. According to Melvin (1989), this inflammation, over time, leads to weakening of the joint capsule, tendons, and ligaments and will eventually cause destruction of the cartilage and bone. Rheumatoid arthritis is characterized by recurring exacerbations, a period when symptoms are present, and remissions, a period when symptoms are not present.

Both types of arthritis can affect different joints in the body; however, joints with high synovium-to-cartilage ratio, such as in the hands, are the most frequently affected (Shanku,
2000). A particularly devastating area that is often affected is the thumb. The thumb is one of the most important digits in the hand. According to Swanson, Goran-Hagert and de Groot Swanson (1984), the thumb is responsible for 40 percent of all hand function. The joint that contributes the most to the function of the thumb is the CMC joint. The CMC joint is where the first metacarpal meets the trapezium carpal bone. Terrono and Horner (2000) state that it is this site that is behind the great strength and function of the thumb. The TS, or trapezioscaphoid joint, also contributes to the stability of the CMC joint and can be affected by CMC arthritis (Patterson, 1975). This joint is the articulation of the trapezium and scaphoid carpal bones. The CMC joint gives the thumb the ability to move in its three arcs of motion: flexion-extension, abduction-adduction, and opposition-reposition (Barron, Glickel & Eaton, 2000). These three motions allow the thumb to perform its many functions, including the ability to grasp and pinch.

The great amount of use and the forces placed on the CMC joint subject this joint to much stress in daily life. Wolock, Moore and Weiland (1989) report, the thumb CMC joint can endure compressive forces as high as 120 kilograms during strong grasp. This is why stability of this joint is vital to functioning. The bones, cartilage, joint capsule, synovial membrane, ligaments, and muscles that make up the CMC joint are what contribute to its stability. Arthritis can disrupt any or all of these components and can affect the quality of motion of the joint.

People who have osteoarthritis of the thumb CMC joint often report the most disabling symptom of the disease is the great amount of pain that occurs. Early on in the disease, the pain usually occurs with forceful, repetitive use of the hand that involves a lateral or chuck pinch, such as brushing the teeth, sewing, picking up books, turning a key, and opening drawers (Poole & Pellegrini, Jr., 2000). This pain is usually only relieved by either decreasing or avoiding these movements. This disuse causes weakening of the muscles and ligaments supporting the joint,
leading to instability of the joint, decreased strength, decreased extension, and subluxation or adduction contracture (Melvin, 1989). Therefore, the overall ability to move the thumb is affected. Poole and Pellegrini, Jr. (2000) also report that people who have osteoarthritis notice an increase in dropping objects and weakness of grip and pinch, as well as the appearance of a bony prominence at the base of the thumb. As the disease progresses, the functioning of the thumb, as well as the hand, becomes quite limited.

Rheumatoid arthritis also causes disability of thumb functioning. The inflammation that occurs with this type of arthritis causes pain, swelling, and weakening of the supporting structures of the CMC joint. Deformities at the CMC joint can occur. Problems from joint collapse and instability affect one’s ability to move the thumb (Wolock et al., 1989). As a result, the person experiences decreased range of motion, strength at the joint, tolerance for activity, and energy. Gross and fine motor skills of the thumb, such as grasping and pinching, become difficult (Shanku, 2000). The loss of stability at the joint affects the thumb’s ability to withstand forces. Daily occupations that require movement of the thumb for hand use, such as holding and gripping objects, become significantly decreased (Terrano & Horner, 2000).

The goal of occupational therapy in the treatment of arthritis is to help the patient manage the symptoms and increase his or her independence in daily occupations. One method commonly used to do this is splinting. Splints can be defined as “external supports applied to body parts” (Falconer, 1991, p. 81). When used for arthritis, they immobilize and/or support the affected joints. Splint use varies slightly for osteoarthritis and rheumatoid arthritis.

Splinting is often the initial form of treatment used for CMC osteoarthritis. The goals of splinting are to decrease pain and protect the joint (Terrono & Horner, 2000). In the case of the thumb CMC joint, splinting is also used to stabilize the joint and maintain the first web space
The thumb CMC joint is immobilized in the splint, which helps to relieve the pain caused by activity. The occupational therapist’s goal with splinting this joint is to decrease the pain in order to increase functioning and independence in occupations.

The use of splinting in rheumatoid arthritis can help to reduce symptoms; however, it is rarely used by itself (Jacobs, 2002). Splinting is often combined with other forms of interventions. The goals of splinting in rheumatoid arthritis are to decrease inflammation, to rest and support joint structures, to position joints properly, to minimize contractures of the joint, to provide stability, and to decrease pain in the joint (Fess & Philips, 1987). Splinting will protect the joint and decrease development of deformities. This will improve the person’s use of the thumb and hand.

Splints do not only affect the treated joint, but they can also affect the surrounding joints. Melvin (1989) describes what she calls compensatory stress as an increase in the involvement and stress in surrounding joints as a result of the immobilization of a joint. Stern (1991) first suggested that participants increased their use of more proximal joints to compensate for wrist immobilization. Bulthaup, Cipriani, and Thomas (1999) reported that significantly more motor unit recruitment was required in several shoulder and elbow muscles when healthy participants were wearing wrist orthoses than when using the free hand. While this suggests that the use of a thumb CMC splint may have an effect on compensatory stress of the wrist joint during hand use, no research has been done to document this phenomenon.

Most literature on thumb splints describes construction of custom made splints or reports, descriptively, on use of the thumb splints (Barbarioli, 2001; Casey & Kratz, 1988; Colditz, 2000; Galindo & Lim, 2002). Little research has been done regarding the effects of splints for the thumb CMC joint on performance. Four studies report on the effects of thumb splints on
variables such as pain, function, strength, stabilization, comfort and the need for surgery. These studies have been done using subjects with varying degrees of arthritis.

Berggren, Joost-Davidsson, Lindstrand, Nylander, and Povlsen (2001) investigated the influence of thumb splinting and providing accessories (assistive devices) on the need for thumb CMC joint surgery in treating arthritis. Their study was conducted on a group of 33 women with a mean age of 63 years. They all had osteoarthritis of the thumb CMC joint with no sign of adduction contracture. The subjects were randomly divided into three groups: a group treated with special fitted assistive devices only, such as bread knives, reachers, scissors, and potato peelers; a group treated with a semi-stable textile splint and the assistive devices; and a group treated with a non-stabilizing leather splint and the assistive devices. The subjects were followed for seven years, with assessments taken at seven months and seven years. The researchers found that 70 percent of the subjects were successfully treated using these conservative occupational therapy treatments. These subjects were satisfied with the results of the treatment and refused surgical treatments. The authors found no differences among the three groups at either time of assessment. They concluded that the use of conservative treatment including splinting and/or assistive devices can significantly reduce the number of patients who will require surgery for this condition. However, this study does not address splinting as a single modality.

Weiss, LaStayo, Mills, and Bramlet (2000) studied differences in the effects of the short and long opponens splint on the variables of pain, pinch strength, CMC stabilization, function, and preference. Five men and 21 women with the mean age of 57 years participated in this study. All subjects had osteoarthritis of the first CMC joint, with symptoms occurring a minimum of one year. The researchers used visual analog scales (VAS) to assess the dependent variables of pain, function, and splint preference. The subjects were randomly assigned to either
a short or long opponens splint and were asked to fill out a questionnaire both before and after wearing the assigned splint for two weeks. Pinch strength was measured using a custom made bolster containing a pinch meter. Stabilization was determined through radiographic measurements of the thumb CMC joint. These were done for all 26 subjects. The researchers later split the results of the subjects into groups according to stages of the disease. The results showed that both splints were effective at decreasing pain in the subjects regardless of stage. Pinch strength stayed the same after splinting for all subjects. The short splint was preferred over the long splint by all subjects for reasons such as increased function in daily occupations, cosmesis, comfort, and easier application. In addition, the researchers found that the subjects with earlier stages of the disease showed less subluxation of the first CMC joint than did those with later stages. The researchers concluded that both splints were successful at relieving pain and improving function in people with thumb CMC arthritis, while stability is improved only in those with earlier stages of the disease.

Buurke, Grady, de Vries, and Baten (1999) compared three different types of thumb splints used for the treatment of both osteoarthritis and rheumatoid arthritis pain of the thumb CMC joint. The subjects were 10 women with osteoarthritis and pain in the thumb CMC joint. The researchers compared the Sporlastic 07051, the Gibson ref. 6302, and the Uriel 25 splint on the variables of pain, hand function, comfort, cosmesis, pinch, grip, and use in daily life. The variables of pain, hand function, comfort, and cosmesis were evaluated based on VAS. A Preston Pinch Gauge was used to measure pinch, and the Green Test was used to measure grip using several different handgrips. To determine the splint’s use in daily life, the researchers interviewed each subject. The study was a counterbalanced design with subjects randomly assigned to a sequence of splint use. They found that the Uriel splint scored better in the
variables of comfort, function, and hand functioning, but the Sporlastic was preferred in the variable of cosmesis. No differences were found on the pinch test. The researchers concluded from this study that eight out of 10 subjects benefited from the use of the splints.

Finally, a research study performed by Swigart, Eaton, Glickel, and Johnson (1999) hypothesized that splinting was more effective in early stages of arthritis, but it could provide relief enough to avoid surgery regardless of stage of the disease. The long opponens splint was used in the study. Involved in the study were 125 women and men (141 total thumbs) with thumb CMC arthritis. The subjects had a mean age of 53.8 years. The subjects were measured using a mailed questionnaire regarding symptom improvement, including pain. The researchers found that those subjects with early stage arthritis showed more symptomatic improvement than those with later stages, but the difference was not statistically significant. They also found that splinting provided sufficient relief of symptoms to prevent or postpone surgery for all stages. The researchers concluded that splinting is an effective initial treatment of arthritis and may sufficiently relieve symptoms enough to allow the person to return to a normal level of function.

All of the previous studies provide support for use of various types of thumb CMC splints in treating arthritis; however, none investigate the effects of use of a thumb CMC splint on proximal joints. There is also no research investigating the Colditz thumb CMC immobilization splint (Colditz, 2000). The goal of this pilot study was to and extend the already existing research on thumb CMC splints by investigating the effects of a Colditz style thumb CMC splint on compensatory movements at the wrist, as well as its effect on pain at the thumb CMC joint. In addition, this pilot study aimed to investigate effect sizes of the dependent variables and projected number of subjects needed for future studies. Three hypotheses were investigated in this study. Due to little or no previous research, non-directional hypotheses were chosen. The
first hypothesis was the amount of dorsiflexion and volar flexion of the wrist will be different when wearing the thumb CMC splint than in the non-splinted hand. The second hypothesis was the amount of radial and ulnar deviation at the wrist will be different in the splinted hand than in the non-splinted hand. The third hypothesis was there will be a difference in the amount of pain reported by participants when wearing the splint than when not wearing the splint.

Method

Research design

The research design used was a repeated measures counterbalanced design. The participants were randomly assigned to one of two orders using a computer-generated number system. In order one, the participants first completed the task while wearing the thumb CMC splint and then with the free hand. In order two, the conditions were reversed. The advantage of this design was the subjects were compared to themselves, which minimized effects caused by individual differences.

Participants

One male and eight females participated in this study. Four participants had left handed splints, three participants had right handed splints, and two participants had splints on both hands (N=11). All participants had a medical diagnosis of thumb CMC osteoarthritis or rheumatoid arthritis from their rheumatologist or orthopedist and were referred to the Medical College Hospital’s Occupational Therapy Department for thumb CMC splint construction. Participants who have had surgical treatment on their thumb CMC joint were excluded from this study.

Instruments and Apparatus

A 66 by 48-inch (167.64 cm X 121.92 cm) table adjusted to 15 cm below each participant’s left elbow was used as the experiment’s surface. The items arranged on the surface
of the table included: a standard red plastic drinking cup, a small plastic scooping spoon, an aluminum canister holding the drink mix, and a Big Red Switch® marking the starting position. Small square pieces of masking tape were placed on the table to mark the midline of the table as well as the location of the front of the objects. A 46 cm by 46 cm square, centered with the midline of the table, was placed on the floor using masking tape to indicate where the participant should stand.

For right-handed participants, the plastic scooping spoon was centered on the midline of the table and was placed 14 cm from the front edge (see Figure 1 for items and locations). The spoon measured 5 cm in diameter and 3.3 cm tall. The handle was 2 cm long and was turned parallel to the front edge of the table to face the marked starting position. One full scoop of the spoon was equal to 53 ml. The task of scooping was chosen because it required a lateral or two-point pinch, which is stressful for the thumb CMC joint (Poole & Pellegrini, Jr., 2000). It was also a natural occupationally embedded task familiar to people, and it required use of the wrist as well as the fingers and thumb. The aluminum canister of drink mix was centered on midline behind the scooping spoon and placed 23 cm from the front edge of the table. The canister measured 15.5 cm in diameter and 16 cm in height. It was filled with crystallized drink mix to 8 cm, indicated by an indented line around the side of the canister. The drinking cup was placed 20 cm to the left of midline and 12.5 cm from the front edge of the table. The cup measured 10 cm in diameter and 12 cm in height. The red switch was placed 22.5 cm to the right of midline and 4.5 cm from the front edge of the table. For left-handed participants, the location of the objects was reversed. The computer, switches, and Biometrics K100 Base Unit were located at a separate table perpendicular to the experiment table.
Wrist movements were recorded with a Penny and Giles Limited Goniometer XM65 (Cwmfelinfach Gwent NP1 7HZ, United Kingdom), otherwise referred to as an elgon, on the dorsum of the hand and forearm of the preferred hand. The elgon was aligned with the third metacarpal and the midline of the forearm using two-sided and paper tape to hold it in place. The elgon’s data pack was attached at the back of the participant’s waist. The elgon’s leads were secured to the back of the participant’s shirt and run over his or her shoulder and down the arm to keep them from interfering with the tasks performed during the experiment. The elgon has a repeatability of better than ± 1º and an accuracy of 2º measured over a range of 90º as reported by the manufacturer. The elgon was used to record the amount of wrist flexion, extension, and radial and ulnar deviation that occurred in the participant’s wrist during each condition of the experiment.

The type of splint used in the study was a thumb carpometacarpal immobilization splint constructed and fitted by therapists at the Medical College Hospital Occupational Therapy Department following suggestions by Colditz (2000). The splint is a custom-molded thermoplastic splint. The Y-shaped pattern of the splint wraps around the first metacarpal, runs along the palmar surface, and wraps around the ulnar border of the hand. A strap is attached to the dorsoradial portion of the splint and runs across the dorsal surface of the hand. The splint covers the CMC joint and palm and is designed to avoid restricting movements in the other thumb joints, fingers, and wrist (see Figure 2).

The computer used in the data collection was a 200 MHz Gateway Pentium P5-200 desktop computer. A KPCMCIA-16AI analogue to digital acquisition card (Keithly; Cleveland, OH) with Testpoint data acquisition Software version 3.2B (Capital Equipment Corp.; Bellerica, MA) was used to obtain the data at a sample rate of 100 Hz.
A 10 cm visual analog scale, or VAS, was used to assess the amount of pain with 0 cm indicating no pain and 10 cm indicating pain as bad as it can be (Appendix A). This was in accordance with suggestions made in a study by Dixon and Bird (1981). Price, McGrath, Rafii, and Buckingham (1983) reported that visual analog scales were valid and reliable measurements of intensity and unpleasantness of human pain. Sim and Waterfield (1997) report, VAS scales are reliable in populations that do not have cognitive, perceptual, or language deficits. They also argue that VASs have poor content validity due to unidimensionality; however, content validity improves with two or more administrations of VASs to each participant.

Procedures

Following approval of the study by the Medical College of Ohio Institutional Review Board, patients receiving thumb CMC splints for treatment of arthritis that fit the inclusion criteria were informed of the study through presentation of a flyer by MCH occupational therapists (see Appendix B). Those interested in participating were scheduled for a data collection time in the motion analysis lab of Collier Building at the Medical College of Ohio.

Immediately prior to the participant’s data collection time, the researcher set up items of the experiment on the table in their correct locations. The VASs were prepared by marking three scales with a one, two, or three to indicate the order in which the scales would be given to the participant. In addition, the elgon was zeroed, and strips of paper tape were prepared for attachment of the elgon.

All participants were given an informed consent form to read and sign prior to beginning the experiment. The researcher answered any questions the participant had concerning the study prior to data collection. Those consenting to participate were then asked the questions on the data collection sheet (Appendix C). The participant was given the initial VAS to rate the level of
pain felt in the thumb. The scale was explained to the participants by stating, “This is a scale used to assess the amount of pain you are feeling in your thumb right now. The line indicates the amount of pain from no pain (point to portion of scale) to the worst possible pain (pointing to scale). Please mark a vertical line on the scale indicating the amount of pain you feel in your thumb at this time.” During this time, the participant’s number, gender, age and dominance were entered into the computer, and the order of conditions was displayed.

After the completion of the VAS, the experiment table was adjusted to the proper height and items of the experiment were double checked for accuracy. The procedure was explained to the participant by saying, “During this experiment, you will be asked to place four scoops of the drink mix from the large canister into the red drinking cup. You will start by placing your hand here, on the starting place (indicate by pointing) and will return your hand there when you are done. You will be asked to do this two times: one time with your splint on and another time with your splint off. I will be collecting information using the device on your wrist. You may use your other hand to hold the drinking cup on the table during the experiment, but please do not pick it up. You are not being timed during this experiment, so move at your natural pace. It is not necessary that you rush.” The participant was then offered a practice period of two scoops to familiarize himself or herself with the experiment’s objects. The participant was told, “Now I would like you to practice placing two scoops of the drink mix into the drinking cup.” The scoops of drink mix placed in the drinking cup during the practice period were dumped back into the canister.

The participant was then prepared for the first condition. If the participant was assigned to order one, he or she was asked to put on the splint. If assigned to order two, the participant was told to first complete the task without wearing the splint. The elgon was attached to the
participant, while briefly describing its components by stating, “This is a device that will measure your movements as you perform the experiment. It will be attached to your arm using double-sided tape and paper tape and shouldn’t hurt when it is removed. The information is sent to the computers over there (point). Please try to move as naturally as possible when performing the task.” If the participant was wearing the splint, the elgon was attached to the dorsum of the hand overtop the strap of the splint.

Once the elgon was attached, the participant began the first condition. The participant was told, “Please stand comfortably in the square. Put your hand on the starting place. When I say ‘begin’, you may start.” The data collection was signaled when “begin” was said and the participant’s hand was lifted from the starting place. Four scoops of drink mix were placed into the drinking cup (see Figure 2). Data collection ended when the hand was placed back on the starting place.

After the first condition, the participant was given a short rest period in which he or she was offered a chair. During this time, he or she was asked to respond to a second VAS with the instructions, “Here is another scale to fill out. Please mark this scale to indicate the amount of pain you felt in your thumb during this task.” The table was then wiped off and reset for the second condition of the experiment. The canister of drink mix was refilled to the correct amount. The elgon was removed, and the participant was asked to either put on or remove his or her splint according to the next assigned condition. The elgon was then replaced in the same location.

After the rest period, the participant repeated the exact procedures as previously performed using the second condition. When finished, he or she responded to the third VAS
with the same instructions as previously described. For those wearing the splints, the elgon and splint were removed. The elgon was then replaced on the arm without the splint.

The third condition involved recording range of motion measurements in the affected wrist. All participants were told, “I’d like you to move your hand like this.” The researcher demonstrated forward, backward and right to left movements. “Move as far as you can go in each direction. Place your hand on the red switch and lift it when I say begin. Please place your hand back on the switch when you are finished. Ready, begin.” The researcher performed the wrist movements along with the participant during the condition.

After the final condition, the elgon was removed from the participant’s arm, and he or she was offered additional ingredients, utensils and instructions necessary for completing the drink. Finally, the participant was presented with a $10.00 thank you gift certificate. The table was wiped off and reset for the next participant. The data were saved to the computer during the data collection.

*Data Analysis*

Descriptive statistics, including mean, standard deviation, range, and skewness, were calculated for all data gathered in this study. The data were tested for order effects using analysis of variance (ANOVA) to compare the data of the splinted condition in order one with the splinted condition in order two, and the data from the non-splinted condition in order one with that of order two. Intraclass Correlation Coefficients (ICC) were used to test interrater reliability of the VAS measurements.

Analyses were done on the data collected during the established time. Data were analyzed with parametric statistics. Multivariate analyses of covariance (MANCOVA) were used to analyze the data collected on wrist flexion, extension, and deviation with the maximum
range of motion measurements used as covariates. The VAS data were analyzed using MANCOVA with the first VAS used as a covariate to detect differences between pain ratings with and without the splint. An alpha level was set at 0.05. Cohen’s $f^2$ squared test was used to analyze effect sizes using the criteria small effect = 0.02, medium effect = 0.15, and large effect = 0.35 (Cohen, 1988). Motulsky’s test was used to determine projected subject number estimates with a power of 0.8 and the alpha level set at 0.05 (Motulsky, 1995).

Results

Participants

The mean age of the participants was 57.7 years, while the range was from 42 years to 74 years. The mean time since diagnosis of thumb CMC arthritis was 57.4 weeks, with the range being 3 weeks to 156 weeks (3 years). Participants reported the length of time of having their thumb CMC splints as ranging from “a few weeks” to one and one half years. Typical splint use, as described by participants, included wearing the splint at all times, during flare ups, at night, or while driving.

Movement data

Means and standard deviations for the extremes of range of motion measurements can be found in Table 1. The data were not skewed, and no order effects were found.

MANCOVA results for dorsiflexion and volar flexion produced statistically significant differences in degrees of movement between the splinted and non-splinted conditions ($F=3.957; df=2,18; p=0.038$). Follow-up univariate ANOVA tests for dorsiflexion and volar flexion found statistically significant differences between the splinted and non-splinted conditions for volar flexion. Table 2 presents the ANOVA results for dorsiflexion, and Table 3 presents the ANOVA results for volar flexion.
The MANCOVA results for radial and ulnar deviation showed no statistically significant differences in degrees of movement between the splinted and non-splinted conditions (F=1.346; df=2,18; p=0.285).

**VAS data**

Descriptive statistics for the VAS data can be found in Table 4. Inter-rater reliability for VAS measurements was excellent as determined by ICCs of 1.0 for the baseline, 0.99 for the splint scales, and 0.98 for the non-splint scales. The VAS data were not skewed, and no order effects were found. Results of the MANCOVA yielded no statistically significant differences in pain between the splinted condition and the non-splinted condition (F=0.077; df=1,9; p=0.788).

**Effect sizes and projected subject numbers**

Using Cohen’s criteria, the results yielded a large effect size for flexion (f squared=0.440) and a medium effect size for deviation (f squared=0.150) (Cohen, 1988).

Results of Motulsky’s test produced N estimates of 42 for dorsiflexion, 13 for volar flexion, 85 for ulnar deviation, and 67 for radial deviation (Motulsky, 1995).

**Discussion**

This pilot study examined the effects of the Colditz style thumb CMC splint on participant reported pain in the CMC joint and movements at the wrist. This study also sought to provide recommendations for additional studies through the examination of effect sizes and projected subject numbers. This study not only adds to occupational therapy’s existing knowledge on the effects of CMC splints, but also provides a starting point for research on such splints in the future. The results of this pilot study partially supported the hypotheses.

The first hypothesis predicted a difference between the amount of dorsiflexion and volar flexion of the wrist between the splinted and non-splinted hand. While the results indicated no
differences in dorsiflexion, a difference was found in volar flexion between the splinted and non-splinted conditions. Participants had significantly less volar flexion when completing the scooping task with the splint on than with the splint off. Based on this pilot study, it can be suggested that as the Colditz thumb splint immobilizes the CMC joint, it also restricts a person’s ability to maximally volar flex his or her wrist. This disagrees with Colditz’s (2000) suggestion that the Colditz thumb splint immobilizes the CMC joint while still allowing full movement and function of the wrist joint.

One reason for this decrease in volar flexion may be due to the splint’s design. While the proximal border of the splint running along the palm of the hand is designed to allow wrist flexion, it may also serve as a block against extremes of volar flexion at the wrist. Therefore, the participants may have been unable to obtain as much volar flexion while scooping the drink mix with the splint on as compared to scooping with the splint off. Another reason may have been due to different scooping styles used by the participants while wearing the splint as compared to not wearing it. The participants may have been accustomed to altering their movements when completing such a task to account for the splint. This could have caused them to naturally complete the task using different movements and range of motions at the wrist with the splint on than with the splint off.

The second hypothesis predicted a difference in the amount of radial and ulnar deviation at the wrist when comparing the splinted to the non-splinted hand. The results did not support this hypothesis. Radial and ulnar deviation movements when scooping the drink mix were similar when wearing the splint and when not. One reason for this may be due to the nature of the task. The scooping task in this pilot study required very little radial and ulnar deviation, which made it difficult to find significant differences between participants in such movements.
Another reason for this may be the difference in scooping styles between the participants. Each participant has a unique way of scooping. This may have caused such variability in radial and ulnar deviation measurements that differences could not be found.

Effect size and projected subject number results found in this pilot study suggest that future studies with larger sample sizes are needed to further investigate the variables examined here. The small subject number and large variability in both flexion and deviation movements, as can be seen by the means and standard deviations in Table 1, made it difficult for significant results to be found. Effect size and projected subject number results suggest that studies completed with more participants would provide more sensitive results, despite large variability in movements, in order to fully determine how wearing the splint effects wrist movements during the scooping task. This would provide a more complete look at the Colditz thumb CMC joint as use for the treatment of arthritis.

The third hypothesis of this study predicted differences in the amount of participant reported pain when wearing the splint compared to not wearing the splint. The results did not support this hypothesis as no differences in reported pain were found between the two conditions. This disagrees with studies by Buurke et al. (1999) and Weiss et al. (2000) which found that use of thumb CMC splints reduces pain felt in the CMC joint; however, differences between the means for the two conditions in this study show a trend in that direction. The mean of participant reported pain during the scooping task was higher when no splint was worn as compared to when the splint was worn. This indicates that the Colditz thumb CMC splint may have been useful in alleviating arthritis pain during the scooping task; however, the great deal of individual variability, as reflected by the large standard deviations in the VAS measurements,
and the small number of participants in this study made finding significant differences between the two conditions difficult.

A reason for the large variability in reported pain may have been due to the task being isolated and of low demand. Some participants indicated that they feel the most pain after using their thumb over longer periods of time or after tasks requiring more thumb strength. This study required participants to indicate pain levels in their thumb during the scooping task only. This scooping task may not have stressed the thumb enough for the participants to accurately decipher a difference in pain when wearing the splint and when not wearing the splint. Further studies with tasks that require more significant thumb use are needed to determine if the Colditz thumb CMC splint is useful in reducing the pain in the CMC joint during more demanding daily occupations.

**Implications for Occupational Therapy**

The results of this pilot study need to be interpreted with caution due to the small number of participants. However, they provide tentative information for occupational therapists concerning use of the Colditz thumb CMC splint. Faulkenburg (1987) emphasizes the importance for occupational therapists to consider a patient’s lifestyle and daily occupations when recommending a splint in order to encourage successful treatment results. The results of this pilot study suggest that use of the Colditz thumb splint could affect a person’s ability to complete occupations that require extremes of volar flexion. As a result, additional stress may be placed on more proximal joints to account for the decrease in ability to volar flex the wrist. As suggested in the study by Bulthaup et al. (1999), changes in wrist movements causes increased stress on proximal joints, which may lead to fatigue in those joints. In addition, a person’s willingness to comply with splint use during occupations that require volar flexion may
be affected, which could prevent him or her from reaching treatment goals. An occupational therapist should consider all such factors when suggesting the Colditz splint for the treatment of CMC arthritis.

Limitations

Because this was a pilot study and evaluated only eleven hands, one needs to use caution when interpreting the results. Another limitation was the unnaturalistic environment caused by the use of lab equipment. The attachment of the elgon to the participants’ arms and the presence of a computer and other devices may have caused the participants to be anxious or may have affected how they performed the task. It is also difficult to determine if participants moved differently during the scooping task in this environment as compared to completing the same task in their own kitchens. Another limitation was the placement of the elgon. While the same researcher placed the elgon on all participants, the placement may have varied slightly between conditions or participants.

Recommendations for future research

Additional research is needed to fully understand the effectiveness of thumb splints for the treatment of CMC arthritis. Future research should include a larger sample size and a variety of tasks. The small sample size and large variability in movements and perceptions of pain in this study, as well as the use of a task that did not require extremes of dorsiflexion or radial and ulnar deviation, made it difficult for significant results to be found. As suggested by results of Motulsky’s test, research with a larger sample size may provide additional power needed to find significant results for the variables investigated in this study. Additional research on the Colditz thumb CMC splint using a variety of tasks may offer a more complete look at how such a splint stresses the wrist joint. Further research may also choose to investigate the effects of the Colditz
splint on additional joints. In addition, new research is needed on a variety of thumb CMC splints.

Conclusion

Splinting is commonly used by occupational therapists in the treatment of arthritis. It is important, therefore, for therapists to understand the effects of splints when deciding which splint would work best for each patient. This pilot study sought to investigate the effects of the Colditz CMC on pain in the CMC joint and movements at the wrist while completing a common occupation and to estimate the number of participants needed in a larger study. Prior to this study, no research had been conducted on the Colditz thumb CMC splint as use for the treatment of arthritis. The results of this pilot study suggest that wearing this splint may affect a person’s ability to volar flex his or her wrist, which could affect his or her involvement in daily occupations that require such movement. This should be considered by the occupational therapist when recommending the Colditz splint, especially to those whose daily lives often involve tasks that require a great deal of volar flexion. Results of this pilot study lay groundwork for future studies in this area. Additional studies with larger sample sizes may be able to more fully evaluate the effects of the Colditz thumb CMC splint.
References


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Table 1
Descriptive Statistics for Extreme Ranges of Wrist Movements With the Splint and Without the Splint (degrees)

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dorsiflexion</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Splint</td>
<td>24.84</td>
<td>10.19</td>
</tr>
<tr>
<td>Non splint</td>
<td>22.2</td>
<td>7.8</td>
</tr>
<tr>
<td><strong>Volarflexion</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Splint</td>
<td>41.1</td>
<td>8.04</td>
</tr>
<tr>
<td>Non splint</td>
<td>51.71</td>
<td>11.57</td>
</tr>
<tr>
<td><strong>Ulnar deviation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Splint</td>
<td>6.1</td>
<td>35.73</td>
</tr>
<tr>
<td>Non splint</td>
<td>1.16</td>
<td>32.35</td>
</tr>
<tr>
<td><strong>Radial deviation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Splint</td>
<td>3.87</td>
<td>7.93</td>
</tr>
<tr>
<td>Non splint</td>
<td>2.23</td>
<td>9.12</td>
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N=11
Note: SD = standard deviation
<table>
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<tr>
<th>Source of Variation</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dorsiflexion</td>
<td>38.51</td>
<td>1</td>
<td>38.51</td>
<td>1.6</td>
<td>0.221</td>
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<tr>
<td>Error</td>
<td>457.73</td>
<td>19</td>
<td>24.091</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>13852.6</td>
<td>22</td>
<td></td>
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<td></td>
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</table>

N=11
Table 3
Univariate ANOVA for Extremes of Volar Flexion

<table>
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<tr>
<th>Source of Variation</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volar flexion</td>
<td>619.59</td>
<td>1</td>
<td>619.59</td>
<td>7.67</td>
<td>0.012</td>
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<tr>
<td>Error</td>
<td>1535.29</td>
<td>19</td>
<td>80.81</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>49979.96</td>
<td>22</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

N=11
Table 4
Descriptive Statistics for Visual Analog Scales at Baseline, With and Without the Splint (mm)

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>22.18</td>
<td>21.1</td>
<td>0</td>
<td>64</td>
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<tr>
<td>Splint</td>
<td>28.82</td>
<td>20.83</td>
<td>1</td>
<td>57</td>
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<tr>
<td>Non splint</td>
<td>32.73</td>
<td>34.39</td>
<td>2</td>
<td>82</td>
</tr>
</tbody>
</table>

N=11
Note: SD = standard deviation, Min = minimum, Max = maximum
Figure 1. Experiment items and locations
Figure 2. Participant performing the scooping task
Appendix A

Visual Analog Scale for Pain

No pain | Pain as bad as it could be
Thumb Splint Research

Would you like to help us learn more about your thumb splint? We are investigating how wearing your splint affects the pain you feel from arthritis and the movements of your wrist in a typical daily task.

Please consider taking part in a 30 minute research session in the occupational therapy department’s motion analysis lab here at the Medical College of Ohio’s campus (map on back). This research will help therapists to better understand the use of splints for treating thumb arthritis. As a thank you for participating, you will receive a $10.00 Meijer gift certificate.

If interested, please contact Andrea at (419) 868-8189 to schedule a time for your individual research session.
(If you get an answering machine, please leave a message and I will call you back.)
Appendix C

Data Collection Sheet
Researcher: Andrea Sheibley
Advisor: Julie Jepsen Thomas

Subject #___________

1. Hand dominance?  R or L

2. Male or Female?  M or F  
   Race or Ethnicity? ______________

3. What is your age? _____________

4. What is your diagnosis? ____________________________________________
   ___________________________________________________________________

5. How long ago were you diagnosed? ________________________________

6. How long have you had your thumb splint? __________________________
   ___________________________________________________________________

7. What is your typical splint use? (When do you wear it, how long do you wear it?)
   ___________________________________________________________________
   ___________________________________________________________________