Treatment and Prevention of Overuse Hand Injuries Related to Rock Climbing in Chattanooga and its Surrounding Areas

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Introduction

In any physical exercise, the risk of injury is always present and cannot be eliminated. Specifically, rock climbing subjects climbers to the dangers of cuts, abrasions, strains, and fractures in the least serious of injuries. Although rock climbers must be conscious of more serious injuries, such as death, they tend to ignore less minor injuries like overuse hand injuries. During rock climbing, the upper extremities are required to support unnatural weight loads for extended periods of time; therefore, they are the primary area for overuse injuries. The hands and fingers in particular are stressed and contorted more forcefully than any other part of the body. Over time, the ligaments and other soft tissues of the hand become stressed to their limits, and overuse injuries eventually develop.

This project will seek to find out which types of overuse injuries of the hand are the most common in Chattanooga and its surrounding areas. A literature review will be conducted to find acceptable professional treatments and preventative measures for these injuries. These treatments and preventions will then be compared to the self-treatment that climbers prescribe to see if this self-treatment has any validity. In order to accomplish this task, a questionnaire and interview of 25 local climbers was conducted. The questionnaire asked the climber his or her age, number of years climbing, frequency of climbing, level of climbing, types of injuries sustained, types of treatment received, and preventative measures taken after injury.

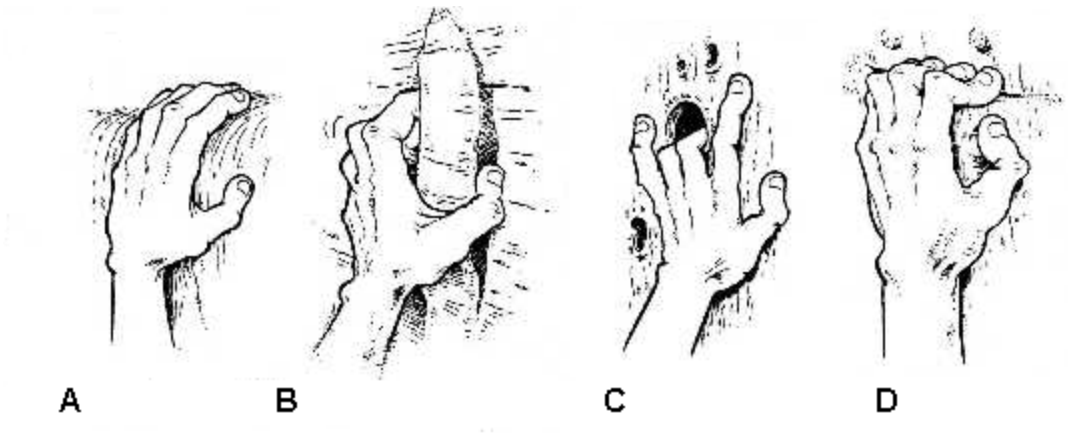
A personal interview with climbers served to clarify the responses on his or her questionnaire so that each particular injury could be identified.

Rock climbing can be divided into three distinct categories: traditional climbing, sport climbing, and bouldering. Traditional climbing involves climbing in cracks and placing gear for protection from falls as a climber ascends a route. According to Jebson and Steyers, traditional climbing can result in dislocated joints and digital avulsion amputations from sudden falls in cracks.[1] Sport climbing, in contrast, involves climbing on small edges, pockets, and bulges and clipping into bolts already placed in the rock. Klauser et al. [2] says that sport climbing allows climbers to test their limits because they are focused on climbing, not placing gear for safety. For this reason, sport climbers are more prone to overuse injuries than to traumatic injuries.[2] In a study conducted by Paige [3] comparing injuries in traditional and sport climbing, finger and hand injuries in sport climbing constituted 24% of the total number of injuries analyzed, while finger and hand injuries in traditional climbing constituted only 11%. Additionally, Paige found that the most commonly injured fingers were the middle and ring fingers for sport climbers and the middle finger for traditional climbers.[3] Bouldering, in contrast to both traditional and sport climbing, is climbing on large rocks up to 20 feet in height usually with no protection on the rock from falls. However, specially constructed foam mats are usually placed on the ground for protection from falls. Jebson and Steyers say that bouldering results in fewer hand injuries than traditional or sport climbing.[1] However, no conclusive studies were found that compare the rates of overuse hand injuries

between bouldering and other forms of climbing. Because bouldering is done on a wide variety of rocks with less significant risk for trauma, specific hand injuries for bouldering are more difficult to identify.

Overuse Hand Injuries Related to Rock Climbing

Overuse hand injuries in rock climbing can be categorized under one of the following headings: collateral ligament injuries, flexor tendon injuries, joint contractures, or carpal tunnel syndrome. These injuries occur when climbers repeatedly strain the soft tissues in the hand with their sport-specific grip techniques. Eric Horst [4], an accomplished climber and climbing instructor, identifies four grip positions in his Hypergravity Isolation Training (H.I.T.) workout for climbing: the open-handed grip, the pinch grip, the pocket grip, and the crimp grip. In both the open-handed grip and the pinch grip, the fingers and thumb are wrapped around a hold at varying degrees of flexion. When a climber uses a pocket grip, only one, two, or three fingers are used to support the climber's weight. Both the proximal interphalangeal (PIP) joint and the distal interphalangeal (DIP) joint are held at varying degrees of flexion. A crimp grip, on the other hand, requires a climber to hyperextend the DIP joint while flexing the PIP joint.[1] Not only is this grip the most painful and stressful grip in climbing, it is also the most common. Consequently, the crimp grip contributes to most of the overuse injuries suffered in rock climbing.



A. The Open-Handed Grip B. The Pinch Grip C. The Pocket Grip D. The Crimp Grip

Collateral Ligament Injuries

In a study conducted by Rohrbough et al. [5] of forty-two elite rock climbers, the most common overuse injury was collateral ligament injury of the PIP joint. The collateral ligaments act as stabilizing mechanisms of the PIP joints and the metacarpophalangeal (MCP) joints of the hands and fingers, supporting all of these joints medially and laterally. Jebson and Steyers describe collateral ligament injuries of the finger PIP joint occurring when a climber's fingers become trapped in a hold during a "dyno," a dynamic body movement in which the climber's body momentarily leaves the rock when going from one hold to another.[1] Holtzhausen and Noakes [6] describe the injury as a consequence of using the finger as a lever. This occurs when a climber's center of gravity rises above a hold, and he or she has to simultaneously pull in and push down on the hold. Injury to the ulnar collateral ligaments of the MCP joint of the thumb, on the other hand, is associated with the pinch grip.[6] Within

climbing, injury is usually restricted to the ulnar collateral ligament because it provides stability to the joint during adduction.

Joint Contractures

Another injury common in rock climbing is a joint contracture, or a fixed flexion deformity. According to Holtzhausen and Noakes, the DIP, PIP, and occasionally the MCP joint become frozen in a flexed position of about 10 to 15 degrees.[6] Holtzhausen and Noakes claim that the etiology of these contractures is unknown, but both Holtzhausen and Noakes and Jebson and Steyers suggest that fixed flexion deformities could be the result of repeated joint effusions and synovitis.[1, 6] Hunter et al. [7], on the other hand, suggests that these contractures could be the result of inflammation of the skin, joint capsule, collateral and retinacular ligaments, tendons, or the tendon sheaths.

Flexor Tendon Injuries

Flexor tendon injuries cover a wide number of overuse climbing injuries. In fact, 58 of the 79 hand injuries seen by Rohrbough et al. were related to the flexor tendon.[5] This is because the flexor tendons support the brunt of a climber's weight that is placed on the hands. On the palmar aspect of the hand, the flexor tendons attach the flexor digitorum superficialis (FDS) and flexor digitorum profundus (FDP) muscles to the fingers. The FDS muscle is responsible for the flexion of the PIP joint while the FDP muscle is responsible for the flexion of the DIP joint. Each tendon is

enclosed within a sheath that provides it with nourishment and a low-friction environment. At regular intervals along the sheath, there are thickenings called pulleys. These pulleys can be divided into two categories: annular and cruciate. While both types of pulleys function in keeping the tendon aligned with the bone, the cruciate pulleys collapse to allow complete flexion, and the annular pulleys prevent the tendon from bowstringing. When a climber's weight is transferred to his or her fingers, the result is a high amount of force on the flexor tendon and flexor tendon sheath. With repetition, this force can result in a variety of injuries. According to Jebson and Steyers, flexor tendon injuries can be placed under five different categories: flexor tendonitis and tenosynovitis, flexor tendon strain, tendon nodules, flexor tendon avulsion and rupture, and tendon pulley rupture.[1]

Flexor tendonitis and tenosynovitis are the consequence of repetitively placing stress on the flexor tendons. Jebson and Steyers state that these injuries cause pain along the palmar surface of the finger, which can extend into the palm or forearm and that swelling of the finger and palm may or may not accompany tendonitis.[1] Literally, flexor tendonitis is inflammation of the flexor tendon, and flexor tenosynovitis is inflammation of the flexor tendon and the synovial membrane surrounding the tendon. Flexor tendon strains are also the result of excessive force placed on the FDS tendon during climbing, but usually during a crimp grip. With this condition, Jebson notes that the patient may have digital swelling and enhanced pain with resisted PIP joint flexion.[1] If climbers suffer repeated flexor tendon strains, they may develop further injury such as a tendon nodule.

Rohrbough et al. observed ten climbers with palpable tendon nodules.[5] As described by Jebson and Steyers, tendon nodules are thought to be the result of repetitive flexor tendon strains.[1] After a flexor tendon strain, scar tissue can build up around the tendon. As the tendon passes through the tendon sheath, the tendon rubs against the tendon sheath, creating a "triggering" sensation.[1] These nodules only become problematic when they no longer pass through the digital pulley system. Jebson and Steyers describe this condition as a "locked finger" because it cannot be actively or passively extended.[1]

Flexor tendon avulsion and rupture occurs with an extreme overload on the tendon. With this injury, the patient lacks active flexion of either the PIP joint or the DIP joint, depending on if the FDS tendon or FDP tendon has been injured. Treatment for this type of injury requires surgical repair. Readers can find detailed post-operative therapy as described by Steinberg.[8] The primary treatment goals for flexor tendon avulsion are preventing tendon rupture, encouraging tendon gliding, and preventing flexion contractures.[8]

Perhaps the most distinctive overuse climbing injury is rupture of the tendon pulley. Rorhbough et al. claim that this injury can be distinguished by a loud "pop" when excessive stress is placed on the finger pulley system.[5] Also, Jebson and Steyers cite that rupture of the A2 pulley has been reported in 40% of professional climbers.[1] Many sources classify A2 pulley ruptures as being evident with visible bowstringing. However, detection of pulley ruptures is gradually becoming more debatable. For instance, Marco et al. [9] found that subtle bowstringing was evident

only with the rupture of two consecutive pulleys (either the A2 and A3 pulleys or the A3 and A4 pulleys). Bowstringing could not be seen in isolated A2 and A4 pulley ruptures. From the same study, he concluded that isolated rupture of the A2 pulley could not be determined through bowstringing alone. Advances in technology, such as magnetic resonance imaging (MRI), have been used to confirm isolated pulley rupture, as seen in the study conducted by Gabl et al.[10] Interestingly, though, clinical findings of bowstringing were cause for suspicion in all of Gabl's patients. Klauser et al., however, proposed a more accessible, less expensive alternative to MRI: high-resolution ultrasonography (US).[2] Klauser et al. found no significant difference between MRI and US for the detection of pulley ruptures.

Carpal Tunnel Syndrome

The final category of overuse hand injuries in climbing is carpal tunnel syndrome (CTS). In the study conducted by Rohrbough et al., CTS was evident in only 3 climbers.[5] But Holtzhausen and Noakes say that this injury is much more common in the top European climbers, affecting as much as 25% of this population.[6] As described by Lewis et al. [11], CTS occurs when a climber repeatedly flexes his or her wrist during a climb. However, Holtzhausen and Noakes cite that this syndrome is caused by an increase in the cross-sectional area of the FDS and FDP tendons.[6] Holtzhausen and Noakes also note that upon surgical release of the carpal tunnel, it was found that the flexor muscles actually extended into the area of the carpal tunnel, causing pressure in this area.[6]

Treatment of Collateral Ligament Injuries

Jebson and Steyers' protocol for treatment of PIP collateral ligament partial tears includes rest, icing, edema control, continued range of motion exercises, and "buddy taping."[1] Bach [12], however, suggests that treatment for incomplete collateral ligament injuries includes splinting the joint in full extension for 10 to 14 days. Holtzhausen and Noakes, on the other hand, recommend that the finger be splinted in 30 degrees of flexion for one to two weeks.[6] After splinting, Bach adds that the finger can be "buddy-taped" and range of motion exercises can be administered.[12] Holtzhausen and Noakes advise a week of enforced rest after which limited climbing can be done using only the open-handed grip.[6] They also promote finger taping but do not mention ROM exercises.

Treatment for partial tears or sprains of the thumb MCP joint ulnar collateral ligaments is more extensive than that of finger PIP joint collateral ligament injuries. Both Bach and Brown [13] recommend immobilization in a spica or thermoplastic splint between four to six weeks and three to six weeks respectively. Brown, however, provides the following extensive procedure for rehabilitation.[13] While the hand is in the splint, Brown recommends that active range of motion (AROM) is maintained in all joints in the upper extremity. The interphalangeal (IP) joint of the thumb should be focused on in order to prevent tendon adhesions from forming. During the fourth week of splinting, the splint should be cut to include only the hand and thumb, and AROM exercises of the thumb MCP joint should begin. In the fifth week, passive

range of motion (PROM) exercises of the MCP joint should be initiated and gradually progressed. Dynamic splinting can begin during the sixth week as needed. Since the joint will now be much weaker than it was before injury, strengthening should be performed in the lateral, tip, and three jaw pinch positions for approximately two weeks. Weeks 10 through 16 constitute unrestricted use of the joint, but Brown suggests that some patients may feel more comfortable taping the joint during sports activities.

Management of complete finger PIP collateral ligament tears has been debated for some time, but Bach recommends surgical intervention to reattach the ligament.[1, 12] In a study conducted by Morris et al. [14], five pairs of cadaver hands were stressed at the PIP joint until failure of the collateral ligament. Half of the ligaments were repaired using the Mitek Micro Arc Anchor and the other half were repaired using a traditional suture technique to other soft tissues such as the periostium. In order to position the Mitek anchor, a hole is drilled at the anatomic insertion point of the ligament, and the anchor is mounted into the bone. The ligament is then sutured to the anchor. Morris found no significant difference between this method and a traditional suture method.[14]

Some controversy of complete collateral ligament tears of the ulnar MCP joint has existed for some time as to the superiority of conservative treatment of surgical repair, but most authors recommend surgical repair.[15] Bach recommends surgical repair if the ligament has moved more than 2mm from its attachment site.[12] If surgical repair is to be preformed, then Bean et al. [16] suggest that the ligament be

sutured to its original attachment site. Bean et al. used eight male cadaver hands to test the ROM of attaching the MCP collateral ligament to different anatomic locations. In order to preserve the ROM of the MCP joint, it was found that the anatomic ligament attachments should be used for reconstruction.[16] Brown provides the following treatment program for postoperative MCP joint rehabilitation.[13] For the first six weeks, the same protocol as for incomplete tears should be followed, but all range of motion and strengthening exercises for the MCP joint should be postponed for approximately two weeks. This means that AROM exercises will be performed during the sixth week, PROM exercises will begin during weeks seven to eight, dynamic splinting will take place during weeks eight to ten, and strengthening exercises will be postponed until weeks ten to twelve. Unrestricted use can begin during week twelve and progress until week sixteen with suggested taping during sports activities. Firoozbakhsh, et al. [15], however, found that performing a tip pinch with cadaver hands generates a large amount of force on the UCL. Using 16 fresh, frozen, male cadaver thumbs, Firoozbakhsh, et al. tested the pinch and grip force of the hand and calculated the amount of force generated on the UCL. The strength of repaired UCL's of the MCP joint was also calculated. It was found that grip forces of 10 lbs or less generated no significant amount of force on the UCL.[15] However, a tip pinch of only 6 lbs generated a calculated 27 N on the UCL, which is greater than the measured strength of a repaired UCL.[15] For this reason, Firoozbakhsh et al. propose that more testing be conducted to determine whether or not using the pinch grip in UCL tears of the MCP joint are beneficial during rehabilitation.[15]

Treatment of Joint Contractures

In regard to treatment for joint contractures, both Holtzhausen and Noakes and Jebson and Steyers recommend rest, anti-inflammatory medication, stretching exercises, and post-exercise icing.[1, 6] Jebson and Steyers include dynamic splinting in treatment while Holtzhausen and Noakes promote pre-exercise warm-up, regular joint stretching, and resisted digital extensor muscle exercises as treatment additions.[1, 6] Chronic contractures may require surgical intervention according to Jebson and Steyers.[1] Stanley and Tribuzi [17] say that contractures should first be treated with joint mobilization so that normal ROM is obtained. After mobilization, passive stretching of the joint should be performed. Hunter et al. confirm these conservative treatments.[7] In this study, patients were treated with four main principles: controlled reduction of swelling, supervised ROM exercise, splinting of the flexor surface with a plaster of Paris or thermolabile splint, and eventually the use of dynamic extension splints. Of the 61 patients treated, no patients lost ROM, and only one patient did not improve ROM.[7] The average ROM before treatment was 24 to 67 degrees. After treatment, the average ROM improved to 8 to 98 degrees. Hunter et al. concluded that conservative treatment of fixed flexion deformities is an effective method of treating these injuries.[7] It was noted, however, that surgical intervention is required in some patients and that patients with malunion of fractures will not benefit from this type of treatment.[7]

Treatment of Flexor Tendon Injuries

Flexor tendonitis treatments recommended by Jebson and Steyers include rest, anti-inflammatory medication, and ROM exercises.[1] In a literature review conducted by Almekinders and Temple [18], only five of the nine prospective and placebo controlled studies on anti-inflammatory medication showed a decrease in pain. Additionally, no controlled studies were found regarding physical therapy for flexibility and strengthening of the flexor tendon.[18] In chronic tendonitis or tenosynovitis, Jebson and Steyers say that corticosteriod injections can be used only after all other treatments options have failed.[1] They add that these injections should be cautiously performed because intratendinous injections can result in rupture of the tendon.[1] Almekinders and Temple found that only three of eight prospective and placebo studies resulted in a beneficial effect and that corticosteroid injection is not clearly related to tendon rupture.[18] Also, there is little evidence to suggest that tendon overload is a major etiologic factor for tendonitis.[18] Since there is no clear etiology for tendonitis, Almekinders and Temple suggest that treatments for tendonitis need to be researched further.[18]

Treatment for flexor tendon strains includes rest, anti-inflammatory medication, and ROM exercises.[1] After complete range of motion has been restored, Jebson and Steyers suggest that climbers begin a gradual strengthening program, followed by a gradual return to climbing. A steady strengthening program can help prevent further injuries from occurring.[1] Another suggested preventative measure is

digital taping. Jebson and Steyers note that many climbers wrap their fingers to prevent flexor tendon injuries.

In order to relieve "trigger finger," an injection of cortidosteriod and lidocaine hydrochloride should be injected into the tendon sheath.[1] A surgical release should be performed if a second injection, given at least six weeks later, does not relieve "triggering" sensations.[1] Benson and Ptaszek [19] compared the effectiveness of local steroid injection versus surgical intervention in 102 patients with a total of 109 digits studied. While they found that surgical intervention might cost the patient more money, they conclude that the permanency of surgical intervention is preferred to further steroid injections. Turowski et al. [20] conducted a survey to find the effectiveness of surgical treatment for trigger finger. In a total of 75 patients, it was found that surgical intervention relieved symptoms in 97% of patients. For this reason, Turowski et al. recommend this procedure for trigger finger patients for whom conservative treatments have failed.[20] Ha et al. [21] describe a minimally invasive procedure for release of trigger finger. Using a specially constructed knife, the A1 pulley is sectioned to allow the tendon nodule free passage. This procedure was performed on 185 trigger fingers with satisfactory results in 93.5%. [21] As with Turowski et al., Ha et al. recommend this procedure for patients who have not had satisfactory results with conservative treatments.[21]

Over the years, many surgical techniques have been developed to repair ruptured flexor tendons. In the study conducted by Veitch et al. [22], the use of the double loop suture in tendon repair was assessed against the single loop and modified

Kessler sutures. Fifty-one fresh, frozen FDP and FDS tendons were used in this study. Each tendon was cut and repaired using one of the three techniques. In addition, all tendons received an epitenon suture around the circumference of the damaged area. Veitch et al. found the double loop method to be superior to both the single loop and modified Kessler methods with repair failures of 45.8 N, 31.5 N, and 26.0 N respectively.[22] Gill et al. [23] performed a similar study with forty cadaver flexor tendons. In this study, the modified Kessler, the single loop, the double loop 4-strand modification, and double loop 6-strand modification techniques were compared [23]. Again, the double loop techniques were found to be superior to the both the Kessler and single loop techniques. The average force at tendon failure for the Kessler, the single loop, the double loop 4-strand modification, and double loop 6-strand modification techniques were 22.0 N, 26.0 N, 45.9 N, and 49.0 N respectively. Gill et al. concluded that the double loop 6-strand modified technique provides enough strength to prevent tendon rupture after surgery in a more aggressive therapy program, but this study does not account for tendon healing in a living body.[23] Depending on the type of suture used, tendon healing can greatly increase or decrease.[23] For instance, a more complicated suture like the double loop 6-strand modified technique penetrates the tendon more than a less complicated technique such as the single loop suture and requires more healing time. Cetin et al. [24] observed seventy-four digits in a postoperative rehabilitation study. For this study, a combination of modified Kleinert and modified Duran techniques were used in the rehabilitation process. For the first seven days following surgery, controlled

mobilization of the involved hand was begun.[24] Patients were instructed to actively extend the involved digit(s) 10 times per hour and follow a routine of passive exercises 4 times daily. After week four, patients began active flexion exercises of the involved digit(s). Following the sixth week post-operation, patients were allowed to use the digit(s) in their daily routines. Resistance exercises could only begin after week eight. Cetin et al. found that 74% of the digit(s) yielded "excellent" results, and 24% of the digit(s) yielded "good" results.[24] As a result, it was concluded that this is an effective method of rehabilitation following post-operative repair of a flexor tendon rupture.[24]

Depending on the severity of bowstringing, both non-operative and operative treatments can be used for treatment of ruptured tendon pulleys.[10] Gabl et al. chose to first use non-operative treatment, after which patients would receive operative treatment only if the non-operative treatment failed.[10] Patients could only be considered for non-operative treatment if the bowstringing did not extend to the MCP joint of the affected finger. In this study non-operative treatment began with immobilization of the hand and forearm for two weeks. Next, the affected finger was placed in a soft cast with a consecutive finger for four weeks. During the sixth week, AROM exercises were initiated. Six weeks later, resistance training of the involved hand was begun and a custom ringbrace was formed to aid in supporting the pulley system. Climbing could begin again only after normal grip strength and pain-free range of motion had been obtained. In this case, the time period was six months. Average follow-up time for this study was 31 months. Although the non-operative

group had an average decrease in ROM at the PIP joint of 5.6 degrees and an average decrease in grip strength of 20 N compared to the non-involved hand, the amount of bowstringing in the patients had not increased. Post-operative therapy was identical to the non-operative therapy just described. Follow-up for this group resulted in an average decrease in ROM at the PIP joint of 4.0 degrees and an average decrease in grip strength of 12 N compared to the non-involved hand. Also, bowstringing was only visibly evident in one patient. All patients from both the non-operative and operative groups were able to return to their normal level of climbing. Holtzhasen and Noakes also describe a similar therapy program to Gabl et al. They do add, however, that subsequent taping of the affected finger is recommended for climbing.[6]

Treatment of Carpal Tunnel Syndrome

Both operative and non-operative measures can be used for the treatment of CTS. For acute CTS, conservative treatments such as rest, anti-inflammatory medications, the use of a splint at night, and avoided maximal wrist flexion while climbing were found to be effective by Lewis et al..[11] In a double blind study conducted by Ebenichler et al. [25], ultrasound was used to treat mild to moderate cases of carpal tunnel syndrome in 34 patients. In each patient, one wrist received active treatment while the other wrist received a "sham" treatment. The patients received 10 fifteen-minute treatments over the first two weeks of treatment and 10 subsequent treatments performed twice weekly over the next five weeks. Ebenbichler et al. found that 68% of the wrists treated with ultrasound treatment had satisfactory

improvement or complete remission of symptoms and compares these results with those of wrist splinting or steroidal injection.[25] At follow-up six months post-treatment, only nine of the actively treated wrists had an unsatisfactory outcome. Ebenbechler et al. conclude that ultrasound treatment is a good treatment option for short to medium-term effects in treating CTS; however, the combined use of ultrasound and other clinical techniques has not yet been researched.[25] If surgical release of the carpal tunnel is necessary, then the reduction of inflammation and pain are the primary post-operative treatment goals. In a study conducted by Hochberg [26], seventy-two patients were treated using traditional ice-therapy or controlled cold therapy (CCT) following surgical release of the carpal tunnel. Patients began therapy immediately after surgery and for 3 days post-operation. At the end of three days, the amounts of pain, edema, and medication used in the two groups were compared. It was found that the group treated with CCT had much greater reduction in all three categories.[26] As a result, Hochberg concluded that CCT is a superior treatment for post-operative carpal tunnel release compared to traditional ice therapy.[26]

Overuse Elbow Injuries and Their Treatments

Acute medial and lateral epicondylitis (ME, LE) are additional overuse injuries that can affect climbers. This is because the muscles that cause flexion and extension of the fingers originate at the medial and lateral sides of the humerus. Holtzhausen and Noakes discuss both ME and LE, or tendonitis of the medial and lateral forearm muscles.[6] For both of these conditions, Holtzhausen and Noakes

recommend icing, anti-inflammatory medication, physiotherapy modalities, and a gradual return to climbing over six weeks. Additionally, climbers should begin to strengthen both the digital flexor and extensor muscles instead of focusing only on flexor muscles. Holtzhausen and Noakes have also observed that ME is recurrent in climbers with lax collateral ligaments of the elbow. Newcomer et al. [27] conducted a randomized, controlled, double blind study to observe the effects of using a corticosteriod injection in conjunction with rehabilitation in early cases of LE. A total of 39 subjects were observed with 19 randomized to receive rehabilitation and a sham injection and the remaining 20 to receive rehabilitation and a corticosteriod injection. Newcomer et al. concluded that there was no significant difference in the outcome of these two groups.[27] For this reason, rehabilitation of LE should be the first treatment option for patients with acute symptoms. Another type of treatment for ME and LE is Low Level Laser Therapy (LLLT). Simunovic et al. [28] treated a total of 324 patients using the trigger points application technique, scanner application technique, or a combination of these two methods. It was found that LLLT completely relieved pain in 82% of acute cases. However, it was observed that over- or under irradiation can hinder the rehabilitation process. Simunovic et al. concluded that this study further confirms the advantages of the use of LLLT in treating ME and LE.[28]

Prevention of Overuse Injuries Related to Rock Climbing

In regard to prevention of specific injuries, no journal articles were found. Jebson and Steyers do suggest a gradual strengthening program and digital taping for the prevention of flexor tendon strains.[1] Additionally, Holtzhausen and Noakes suggest that climbers should perform pull-ups in the forearm-pronated position rather than the forearm-supinated position.[6] They also cautions that excessive pull-ups performed in this fashion may prompt LE. *Climbing Online* published an article on injury prevention for gym climbers. This article mentions some common prevention tips used by many climbers: warming-up, cooling-down, and yielding to pain.[29] There is, however, one method that few climbers use: preventative exercise. Preventative exercise strengthens specific areas of the body so that injury can be avoided. The exercise program published in this article includes strengthening and stretching exercises for the fingers, wrists, and back.[29]

Another preventative measure used by many climbers is digital taping. Taping, although used by numerous climbers, has not proven scientifically useful in relieving stress on the soft tissues of the fingers and hands. In a study conducted by Warme and Brooks [30], nine pairs of cadaver hands were taped and placed in a machine that simulated a crimp grip. With each pair of hands, the second and fourth fingers were taped on one hand over the A2 pulley, and the third and fifth fingers were taped on the other hand over the A2 pulley. After this, pressure was applied to each finger until mechanical or pulley failure. In comparison with the un-taped fingers, the taped fingers demonstrated no significant difference in mean load or

failure. As a result, Warme and Brooks do not recommend using digital taping alone to prevent tendon pulley injuries.[30] In a similar experiment conducted by Schweizer [31], it was found that taping over the A2 pulley decreased bowstringing by 2.8% and absorbed 11% of the force of bowstringing. In addition, taping over the distal end of the proximal phalanx was found to decrease bowstringing by 22% and absorb only 12% of the force of bowstringing. Schweizer concluded that circular taping has minimal effects in decreasing the force produced on the A2 pulley.[31] Retting et al. [32] conducted a study using professional and major college football players in which the grip strengths of taped and untaped fingers and wrists were compared. Both dominate and nondominate taped and untaped hands were compared in the study using a hand held dynamometer. Retting et al. concluded that there is no significant difference in grip strength between taped and untaped fingers and wrists.[32]

Methods

This project sought to determine which types of overuse hand injuries are the most common in Chattanooga and its surrounding areas due to rock climbing. A questionnaire was conducted to inquire of overuse hand injuries prevalent in the Chattanooga climbing population so that the treatments and preventions that rock climbers self-prescribe could be compared to clinically accepted techniques of treatment and prevention. In order to complete the questionnaire, the climber must have suffered at least one overuse hand injury due to climbing. Overuse hand injuries were defined as “injuries that result from repetative, strenuous forces exerted on the

hands during climbing" (Appendix I). Prior to completing the questionnaire, participants read and signed a participant consent form (Appendix I). The participants were asked to report his or her age, number of years climbing, the anatomic location of the injury, methods of treatment, and subsequent methods of prevention (Appendix II). Subjects included Chattanooga climbers who participated on a volunteer basis. They were either personally approached by the researcher at popular local climbing areas, or they completed the questionnaire at one of three locations: a local bouldering gym and two outfitter shops. If the questionnaire was not completed in the presence of the researcher, then the subject sealed the questionnaire in an envelope to keep their responses confidential. If there were any discrepancies with the answers on the questionnaire, then a personal interview was conducted with the climber. This project will hopefully serve as a basis for a future graduate project.

From the responses on the questionnaires, the averages of the climbers' ages, number of years climbing, the usual grade climbed, the most difficult grade climbed, and the days per week climbing were computed. Climbers responded to grades climbed using one of two scales. The first scale was the Yosemite Decimal System (YDS). This rating consists of the number "5" separated by a period from another number. This scale is used to rate climbing routes and ranges from 5.1 to 5.14 d. From the 5.10 rating and higher, a letter is added, either an "a," "b," "c," or "d," after the number to indicate increased difficulty. In order to find the average for the usual grades climbed and the most difficult grade climbed for the YDS, each grade was

converted to a number. The easiest grade was assigned the number 1, the next grade was assigned the number 2, and so on. The converted grades were then averaged, and the resulting number was converted back to its corresponding climbing grade. The second scale is the V-Scale. This scale is used to rate boulder problems and ranges from V0 to V15. In order to find an average for this scale, the "V" was dropped and the remaining number was used.

In order to derive the particular injuries suffered, the information from the literature review in regard to anatomical location, causes, and symptoms were correlated with the answers for questions 6, 8, and 14 (Appendix I). If the information from the questionnaires was not adequate to point to a specific injury, a short personal interview with the climber was conducted at a later date via telephone. Also, if the injury did not result from overuse or if it was not related to the hand, the injury was not considered in the results or the questionnaire was not included in the project. The results of the injuries, however, are less reliable because the researcher is not trained in diagnosing injuries.

Results

A total of 25 questionnaires were collected over a period of four months. The average age of the climbers was 24.9 years, and the average number of years climbing was 5.8 years. When asked to respond to the average grade that they climbed, the climbers responded in three separate combinations. Most climbers responded with a rating from the YDS. Other climbers responded with a rating from the V-Scale.

However, some climbers responded using both scales. The averages of the usual grades climbed were found to be 5.11 b and V6, while the averages of most difficult grades climbed were found to be 5.12 c/d and V7. In addition, the average of days per week climbing was 3.32 days.

	Age?	Number of years climbing?	Usual grade climbed?	Most difficult grade climbed?	Days per week climbing?
Average	24.88	5.77	5.11 b and V6	5.12 c/d and V7	3.32

The most common sites of injury were the ring and middle fingers, and the most common injuries were pulley injuries and flexor tendon strains. In fact, all of the pulley injuries reported occurred in either the middle or ring fingers, and most of the flexor tendon strains also occurred in the middle or ring fingers. The average time off of climbing due to injury was 30 days, and this time ranged from 0 to 6 months off of climbing. It was also found that the most common therapeutic techniques used that were not recommended by a health care professional were resistance training, finger massage, and finger taping. In addition, the most common source for therapeutic techniques was found to be fellow climbers. Finally, the most common preventative measures used post-injury were found to be finger taping, adequate warm-up, and finger stretching.

Discussion

From the self-ratings reported by the climbers, this particular group of climbers can be considered to range from advanced to elite in skill. Also, given that the average number of years climbing was 5.77, it can also be said that this group is fairly experienced in the sport. Because only previously injured climbers were allowed to complete the questionnaire, there is no way to propose a correlation between the level of climbing and frequency of injury or frequency of climbing and frequency of injury. However, it would be interesting to see if there is a correlation between the previously injured climbers and uninjured climbers in regard to level of climbing and frequency of injury.

Since the middle and ring fingers are used more frequently in climbing than the index and fifth fingers, it is not surprising that this was found to be the most common location for overuse injuries. In addition, considering the amount of force generated on the flexor tendon and its pulley system, it is not surprising that pulley injuries and flexor tendon strains were the most prevalent injuries. Except for collateral ligament injuries, Rohrbough et al. also found pulley injuries and flexor tendon strains to be the most prevalent overuse hand injuries. In contrast to Rohrbough et al., this project found collateral ligament injuries to be the least prevalent overuse hand injury. It is possible, however, that collateral ligament injuries are more frequent in more experienced climbers than the ones included in this project.

Overall, only five climbers received any kind of treatment from a health professional, and twelve climbers referenced a fellow climber as a source for therapeutic techniques. Therefore, it can be said that the Chattanooga climbing community relies upon its fellow members for information about treating climbing injuries. Although this could be problematic, the most common recommendations for therapy were conservative in nature: resistance training, self-massage, and finger taping. In several studies mentioned earlier, conservative treatment was found to be effective in curbing the effects of injuries. Specifically, in the study conducted by Gabl et al., patients treated with conservative treatments for pulley injuries had no increase in the amount of bowstringing.[10] There is no conclusive evidence, then, to say that the Chattanooga climbing community is putting itself "at risk" by not seeking medical attention for overuse injuries if conservative treatments are applied.

In regard to the prevention of injuries, finger taping is the only controversial response presented by a significant number of climbers. Although Warme and Brooks [30] conclude that finger taping does not increase the strength of the pulley system, it is evident that many climbers apply this routine to their injuries. For this reason, it is possible that finger taping provides either a placebo effect and/or a decrease in pain perception. Also, Warme and Brooks' study was conducted on frozen cadaver hands, a process which denatures the original state of the tendon and the tendon pulleys. For this reason, this study may not apply to healthy flexor tendon pulleys in a living body. Schweizer found that circular digital taping has minimal effects in decreasing the amount of force produced on the A2 pulley.[31] Although the

reduction in force may be minimal, there is no widespread alternative preventative measure to take at this time.

Several improvements can be made to this project. First of all, a pilot survey should have been conducted using a questionnaire such as the one used for this project. This pilot survey would include both previously injured and previously uninjured climbers. In addition, it would inquire of both therapeutic and preventative techniques used by the climber and used by fellow climbers for overuse hand injuries. Using the most common responses, the information from this survey would then be used to re-construct the short-answer questionnaire from this project into a multiple-choice questionnaire. Naturally, there would also be a choice labeled "other" for participants to fill in, if needed. This should be beneficial in receiving more complete answers from the climbers and also eliminate discrepancies involved in reading handwritten answers. Every question except for numbers 1, 2, 6, and 14 would be converted to multiple-choice. This reconstructed questionnaire would also include a list of symptoms for participants to circle as applicable to their injuries. Hopefully, this would decrease problems in diagnosing injuries and decrease the number of personal interviews required. Additionally, the participants would be asked to rate the success of the therapeutic and preventative techniques that they used so that there would be a basis for gauging the effectiveness of these techniques. Finally, acquiring a greater number of questionnaires would aid in collecting more statistically significant results.

Conclusion

One purpose of this project was to examine the self-treatments of rock climbers in the Chattanooga climbing population in respect to clinically acceptable treatments. It was found that all of the injuries were acute, and the most common methods of treatment used were conservative in nature. Since the literature only calls for invasive treatments in extreme or chronic injuries, there should be no alarm from these results. However, it was observed that many climbers were unaware of the exact injury that they had suffered and not all of the climbers applied appropriate treatments for their specific injury. Additionally, it was found that climbers rely heavily upon fellow climbers for information regarding treatment of overuse hand injuries. For these reasons, educating at least part of the climbing community about the symptoms and appropriate treatments for each type of injury should prove useful in spreading these techniques to other climbers. This task would be best accomplished through a series in a climber-friendly magazine or website such as *Climbing* magazine or ClimbXmedia.com.

Another purpose of this project was to examine the preventative techniques that climbers use with clinically accepted techniques. Of the most common preventative techniques, finger taping proved to be the only controversial method. Finger taping, however, does not place the climber in any danger. Also, another question does arise from these results: if overuse injuries are caused by a gradual overload of the soft tissues of the hand, what benefit, if any, would finger-specific resistance exercises provide in preventing overuse hand injuries? For example, many

climbers use “finger boards” or “rock gyms” to strengthen their fingers for climbing seasons. However, many climbers end up injuring themselves before the climbing season ever begins.[29] There have been no studies found to confirm that a gradual, controlled finger-strengthening program contributes to or inhibits overuse hand injuries due to climbing.

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Appendix 1

Participant Consent Form

Participant Consent Form

Title of Study: Treatment and Prevention of Overuse Hand Injuries Related to Rock Climbing in Chattanooga and its Surrounding Areas

Principal Researchers: John Gannaway, pre-physical therapy student, 406 Westview Avenue, Chattanooga, TN 37411, (423) 698-3108. Randy Walker, Ph.D., P.T., University of Tennessee at Chattanooga, Department of Physical Therapy, 529 Oak Street, Chattanooga, TN 37403, (423) 425-4747.

Dear Participant,

We are conducting a study to find the most prevalent overuse hand injuries due to rock climbing in Chattanooga and its surrounding areas. We will be comparing the methods that you used for recovery to clinically accepted methods of therapy for your injury. Any prevention techniques that you now use in your climbing routine will also be examined in the same manner.

If you agree to participate in this study, first provide your contact information (your name and a telephone number or e-mail address) on the provided index card and seal in the small envelope. Then please fill out the attached questionnaire in its entirety. Seal all materials in the large envelope. In order to participate in this study, you must have suffered at least one (1) overuse hand injury. Overuse hand injuries are injuries that result from repetitive, strenuous forces exerted on the hands during climbing. Overuse hand injuries usually involve, but are not limited to, the tendons and ligaments of the hand and do not include injuries suffered from a fall, cuts, scrapes, or bruises.

Participant Authorization

All individual data collected and used will be kept strictly confidential. In the event that a questionnaire requires further inquiry, the researchers will use the contact information that you provide to contact you. No one other than the principal researchers of the study will see your responses to the questionnaire. If you agree with the following statements, please sign below:

I certify that my answers to the questions will remain truthful.

I understand that I am participating as a volunteer, which means that I will receive no collateral for my participation in this study.

I certify that the researchers may use the contact information that I provide (either a telephone number or email) to contact me, if need be.

I understand that I may choose to discontinue my participation in this study at any time.

I certify that I am at least eighteen (18) years of age. If I am not eighteen, then I will have my legal guardian sign below.

I understand that I may contact the researchers at any time if I have questions about the study.

_____ _____

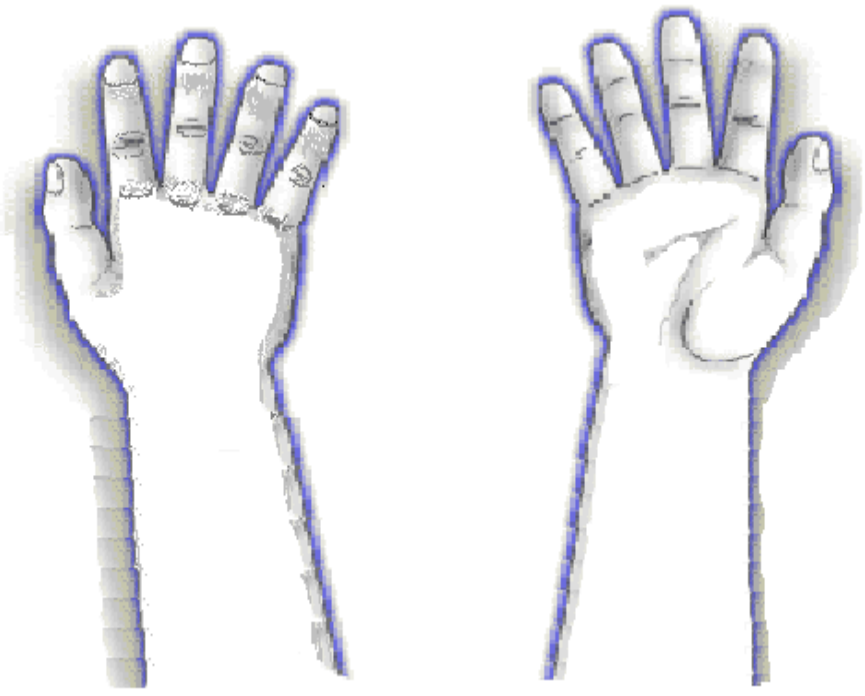
Signature of Participant (or Legal Guardian) **Date**

Appendix 2

Participant Questionnaire

Treatment and Prevention of Overuse Hand Injuries Related to Rock Climbing in Chattanooga and its Surrounding Areas Questionnaire

1. Age:
2. Number of Years Climbing:
3. How many days per week (on average) do you go climbing?
4. What is the average grade that you climb?
5. What is the most difficult grade that you have climbed?
6. Please shade the area(s) where you have had overuse injuries:



7. How many times has each area been affected in this way?

8. Have any of your injuries caused you to stop climbing? If so, how long did you wait to begin climbing again?

9. Were you treated by a medical doctor for your injuries?

10. Were you treated by either a physical or an occupational therapist for your injuries?

11. Did you use any therapeutic techniques that were not recommended to you by a health care professional? If so, please describe them in detail.

12. If you answered "yes" to the previous question, who recommended these techniques to you?
    a. a fellow climber
    b. a parent
    c. other (please specify)_____

13. Please list any preventative measures that you now apply to your climbing routine:

14. Please describe how your injury occurred (Use the back of this sheet if necessary).

Appendix 3

Human Subjects Proposal

The University of Tennessee at Chattanooga

Research Protocol For Review By Human Subjects Committee

I. Objectives of Project:

This project will seek to find out which types of overuse hand injuries are the most common in Chattanooga and its surrounding areas. Then the treatments and preventions that rock climbers self-prescribe will be compared to clinically accepted techniques of treatment and prevention to see if this self-treatment has any validity.

II. Subjects:

Subjects will be local climbers that will participate on a volunteer basis. They will either be personally approached by the researcher at popular local climbing areas, or voluntarily complete the questionnaire at a location where a large volume of climbers frequently visit (e.g. Rock Creek Outfitters, The Adventure Guild, etc.). If the questionnaire is not completed in the presence of the researcher, then the subject will seal the questionnaire in an envelope.

III. Methods or Procedures:

A literature review will be conducted to find acceptable professional treatments and preventative measures for these injuries. Research materials for this project will be obtained through the Lupton Library and the Erlanger Hospital Library and will include texts, journals, and medical databases. These treatments and preventions will then be compared to the self-treatment that climbers prescribe. In order to accomplish this task, a questionnaire and interview of at least 20 local climbers will be conducted (Please see attached). This questionnaire will require the subject to provide contact information so that the subject can be contacted via telephone or e-mail in order to clarify the responses on his or her questionnaire.