

Overuse injuries in the elite rock climber

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ABSTRACT

ROHRBOUGH, J. T., M. K. MUDGE, and R. C. SCHILLING. Overuse injuries in the elite rock climber. *Med. Sci. Sports Exerc.*, Vol. 32, No. 8, pp. 1369–1372, 2000. Closed rupture of the flexor tendon sheath has been known to occur in the elite rock climbing population. However, only one study has investigated the prevalence of this entity. **Purpose:** To examine an elite climbing group in this country for the prevalence of pulley rupture and report on other commonly occurring injuries in the hand and elbow. **Methods:** 42 elite rock climbers competing at the U.S. national championships were evaluated by an injury survey and concentrated examination of the hand and elbow. Manual testing for clinical bowstringing was done for each finger, by the same examiner. **Results:** 11 subjects (26%) had evidence of flexor pulley rupture or attenuation, as manifested by clinical bowstringing. Injury to the PIP collateral ligament had occurred in 17 subjects (40%). Other commonly occurring injury syndromes are described. **Conclusion:** Our results and others suggest that closed traumatic pulley rupture occurs with significant frequency in this population. In addition, all subjects with this injury continued to climb at a high standard and reported no functional disability. **Key Words:** ROCK CLIMBING, FLEXOR PULLEYS, A2 PULLEY, BOWSTRINGING

Elite rock climbing places extreme forces on the upper extremity. These unusual stresses appear to be associated with a unique subset of injuries to the hand and upper extremity. Despite a growing number of reports addressing this association, there is relatively little clinical research to substantiate these discussions.

Before 1986, the English literature on rock climbing injuries consisted of reports of trauma sustained in falls or studies on the effects of altitude (1,8,10,12,13,19,23). Several authors have since recognized the trend toward overuse injuries. Various questionnaire studies have shown that the majority of overuse injuries occur in the upper extremity, particularly in the proximal interphalangeal joint (PIP joint, or PIP) region of the hand (2,3,11,14,16,24). In 1990, two separate case studies documented a previously unreported injury: closed traumatic rupture of the A2 pulley (4,25). Both injuries exhibited dramatic clinical bowstringing of the flexor tendons across the PIP joint (see below). Bowers (7) has since reported on nine patients with closed traumatic pulley rupture, recommending surgical reconstruction.

The flexor tendon sheath in the hand is a continuous structure that includes a series of thickened fibrous tunnels, or pulleys. These pulleys keep the flexor tendons adjacent to the skeleton throughout the range of finger motion. Rupture or loss of a significant portion of the pulley system can result in “bowstringing” (4,7,17,25). This refers to the sep-

aration of the tendon from the bone during resisted finger flexion, just as a bowstring is drawn away from a bow when the bow is bent. The flexor pulley system includes five annular pulleys, referred to as A1–A5, with attachments starting at the distal metacarpal and continuing out to the distal interphalangeal joint (DIP). The most important pulleys to prevent bowstringing have been thought to be A2, which attaches to the proximal phalanx, and A4, which attaches to the middle phalanx (4,7,17,25).

Closed pulley rupture in climbers has been discussed in the French literature since 1985. Cartier et al. (9) presented several climbers with acute pain over the A2 pulley, and hypothesized a large force against the A2 pulley during certain hand positions. Moutet et al. (20) reported on 12 cases of A2 pulley injury without bowstringing in elite climbers, treated conservatively with good results.

Bollen has found variable amounts of bowstringing across the PIP joint in 26% of 67 male competition climbers (6). Several other upper extremity problems have been seen with frequency in the competitive population, including epicondylitis at the elbow, chronic shoulder pain, chronic collateral ligament injury, and fixed flexion contractures at the PIP joint (5,6). Lewis et al. (15) published a case of acute carpal tunnel syndrome in a rock climber secondary to overuse and suggested a possible predisposition for this condition in climbers.

The reports of closed pulley rupture in this unique population raise questions regarding the true prevalence, recommended treatment, and possible prevention of this entity. Only one study has investigated its prevalence in a group of elite athletes (6). The purpose of this study is to examine an elite climbing group in this country for the prevalence of

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pulley rupture and to describe other injury syndromes occurring commonly in this population.

METHODS

Forty-two contestants of the 1995 American Sport Climbing Federation National championships were evaluated by an injury questionnaire and hand and upper extremity examination. An informed consent was provided to all participants. By using climber's terms, frequency and difficulty level of climbing were characterized.

Injuries of the upper extremities were recorded by location on a detailed diagram. The following characteristics were recorded: nature and location of the pain, type and difficulty of the move that caused the injury, and duration and intensity of the pain. Injuries sustained in a fall were not included. Any contact with a health professional for the injury, as well as recommendations and treatments received, were recorded.

Each subject received the same physical exam, by one examiner, which was recorded on a standard form. Pathology specifically tested for included bowstringing at the PIP joint and proximal phalanx, PIP collateral ligament laxity and tenderness, competence of the flexor digitorum superficialis (FDS) and flexor digitorum profundus (FDP) tendons, loss of active PIP extension, flexor tendon nodules, and triggering. If specific history implied symptoms of carpal tunnel syndrome, epicondylitis, or chronic shoulder pain, examination of these areas was done.

Data were analyzed in the following fashion. The subjects with each given injury were compared against the remainder of the study group in regard to several variables. Age, total years climbing, top difficulty level climbed (see below), and years climbing at an elite level were all evaluated statistically to see if significant relationships could be demonstrated. Levene's test for equality of variances, and the *t*-test (for equality of means) were used for this purpose. In addition, gender was evaluated across all injury types using chi-square and Fisher's exact tests.

Due to the wide variation of ability in a rock climbing population, it is important to include a relative measure of climbing ability among subjects. Because all climbs are

TABLE 1. Yosemite decimal system.

Beginner	Intermediate	Advanced	Expert
5.1	5.8	5.10d	5.12a
5.2	5.9	5.11a	5.12b
5.3	5.10a	5.11b	5.12c
5.4	5.10b	5.11c	5.12d
5.5	5.10c	5.11d	5.13a
5.6			5.13b
5.7			5.13c
			5.13d
			5.14a
			5.14b
			5.14c
			5.14d

The difficulty grading scale used in the U.S. Essentially every rock climb has been given a difficulty grade. Charts comparing scales of other countries are readily available. Reprinted by permission of the publisher from Dr. Joel Rohrbough, "Radiographic osteoarthritis in the hands of rock climbers," *Am. J. Orthoped.* 27(11):734-738, 1998, by QUADRANT HEALTHCOM INC.

TABLE 2. Upper extremity injuries encountered (prevalence in parentheses).

Injury	N (%)
Collateral ligament injury	17 (40.5)
Shoulder pain	14 (33.3)
Bowstringing	11 (26.2)
Flexor unit strain	11 (26.2)
A2 pulley pain	10 (23.8)
Tendon nodule	10 (23.8)
Medial epicondylitis	9 (21.4)
Lateral epicondylitis	4 (9.5)
Musculotendon junction pain	3 (7.1)
Wrist undercling injury	3 (7.1)
Carpal tunnel syndrome	3 (7.1)

given a difficulty grade, the rock climbing scale is a useful and accurate way to compare the difficulty levels at which subjects are climbing. In general, the higher the difficulty level the higher the stress loads to which the upper extremity is subjected. Including this information facilitates comparison between groups (22). A chart of the difficulty scale used in this country, the Yosemite Decimal System, is given in Table 1 (18,22). The difficulty level of subjects in this study is presented below.

RESULTS

Forty-two climbers participated in the study. The mean age was 25 yr (range 13-40). There were 7 female and 35 male climbers. Male and female climbers' ages did not differ significantly. The mean difficulty level of our athletes was 5.13b (range 5.12a-5.14a, see Table 1); all climbers were climbing at an elite level. The average time climbing at an elite level (5.12a or higher) was 4.52 yr (range 0.2-15 yr).

The total number of injuries recorded were 126. Of these, 79 (63%) were in the hand, and 46 (37%) were elsewhere in the upper extremity. Only one athlete did not report any injuries. The specific injuries encountered and their prevalence are presented in Table 2. In some cases, commonly occurring syndromes were assigned a new diagnosis; these are explained further in the discussion section. We found no association between the number of injuries and the climbers' ages or ability levels.

Flexor tendon nodules could be palpated in the palm of several climbers. No climber reported a history of trigger finger. A diagnosis of carpal tunnel syndrome was not given unless previously confirmed by an orthopaedic surgeon or by electromyography or in cases where a positive history was combined with a positive Phelan's and Tinel's test at the time of examination. Both flexor tendons were intact in all cases.

Climbers suffering from A2 pulley pain ($N = 10$) were significantly older than those who were not (mean age of 30.7 ± 8.2 yr vs 22.6 ± 5.9 yr, respectively, $t = 3.10$, $P = 0.004$). A history of medial epicondylitis occurred in a significantly more experienced climbing population: subjects with this complaint had been climbing for 12.8 ± 3.8 yr (mean \pm SD), whereas those without had been climbing 7.6 ± 5.0 yr ($t = 4.3$, $P < 0.0005$). Interestingly, we were not able to demonstrate any other significant relationships

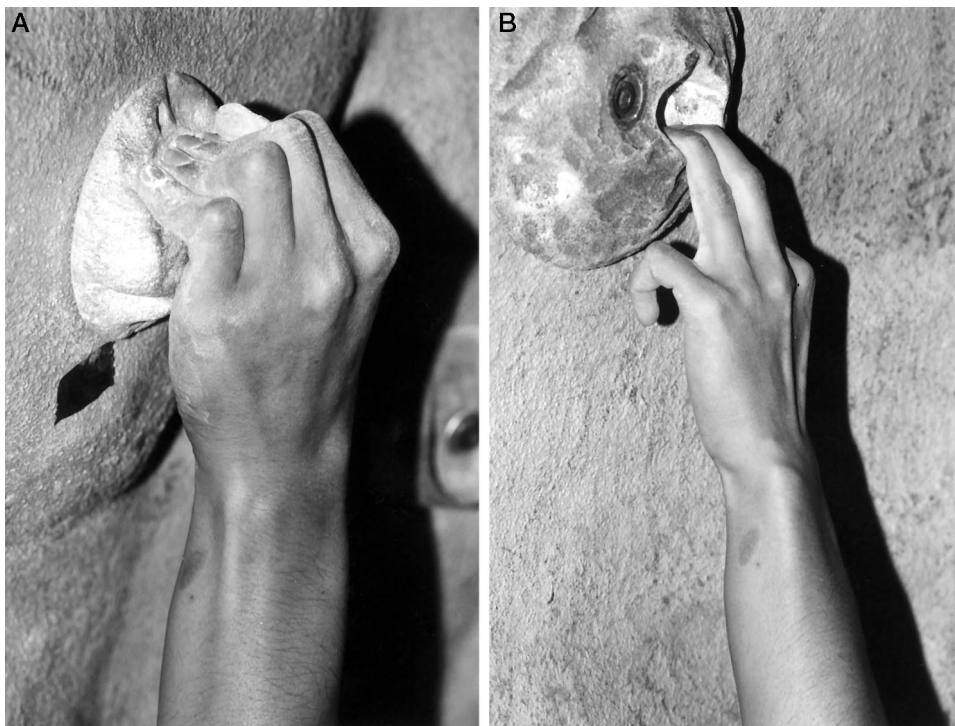


Figure 1—There are a relatively small number of hand positions used in climbing. Two of the most common types are shown here (22). A, Typical crimp hold. Note hyperextension of the distal interphalangeal joints, with relative flexion of the proximal interphalangeal joints. B, Typical pocket hold. Distal interphalangeal joints are in flexion, while the proximal interphalangeal joints are relatively extended.

between specific injuries and number of years climbing, difficulty level climbing, or years climbing at an elite level. In addition, evaluation of age and gender across all injury types failed to yield any significant relationships other than those mentioned above.

DISCUSSION

Our results suggest a specific cluster of acute and chronic overuse injuries that can be expected in the elite rock climber. Some of these, such as collateral ligament strain, medial and lateral epicondylitis, and carpal tunnel syndrome, are familiar to the sports medicine physician. Others, such as pulley rupture (manifested by bowstringing), strain of the musculotendinous junction, and what we have called flexor unit strain, are relatively new entities. Of these, frank bowstringing provides the clearest diagnosis. It should be palpable and asymmetric to the opposite side. These findings are associated not only with A2 rupture, but A3 and A4 as well (17). A typical history includes an audible “pop” and swelling during sudden forced extension of the finger. Twenty-six percent of our competition climbers exhibited this injury. This is consistent with previous findings (Bollen and Gunson (6), 26.8%) in a similar population.

A significant number of subjects had experienced severe pain over the A2 pulley, but did not exhibit bowstringing. A recent cadaver study suggests these injuries probably represent isolated rupture of the A2 pulley; clinically evident bowstringing was not seen until rupture of all three pulleys (17). This is supported by Bower’s surgical findings, in which all patients had rupture of A2, A3, and A4 at the time of surgery (7). Isolated rupture of the A2 pulley is supported by the clinical history of our subjects, which included pain,

swelling, and often an audible “pop” at the proximal phalanx.

Flexor unit strain is the term we used to describe a severe pain that begins at the proximal phalanx or distal palm and travels through the entire flexor system to the insertion at the medial epicondyle. The history was specific and the injury fairly common, occurring in 11 subjects (26%). Each of these climbers could recall the precise move on which this injury occurred; 10 of 11 had occurred on a “pocket” type hold (Fig. 1B). Many of these injuries had a prolonged recovery time.

Musculotendinous junction strain is a characteristic pain over the distal forearm near the junction of the middle and distal third. It can be appreciated by attempting resisted flexion of the long finger while keeping the ring finger straight. It probably corresponds to strains or tears within the common muscle belly of the FDP, as fingers are used in isolation under great stress (21). Collateral ligament injury of the PIP joint was the most prevalent injury, occurring in 17 subjects. These are typically accompanied by ecchymosis along the side of the joint and variable swelling, if seen acutely. Chronic injuries have residual pain over the collateral ligament and variable amounts of varus/valgus instability of the proximal interphalangeal joint.

Most of the subjects who chose to seek medical advice for their injuries felt the health professional had no appreciation for the stresses involved in climbing, and were not helpful in providing a working diagnosis or treatment guidelines. Many climbers sustaining injuries of this type are elite athletes with dedicated and extreme training techniques. The injuries are usually soft tissue injuries and respond well to appropriate conservative treatment. In most cases limited climbing can be done while still providing adequate rest.

At this time there is disagreement in the literature regarding treatment of a closed flexor pulley rupture in an elite rock climber. Tropet et al. (25) felt a climber would not be able to resume his sport with the weak grip resulting from such an injury and recommended repair. However, the moment arm of the tendon across the joint is increased during bowstringing. Theoretically, this would not be consistent with a weaker grip. Instead, digital range of motion, and possibly flexion contracture, have been the concerns historically regarding loss of the annular pulleys. In Bowers et al.'s series (7), the presenting complaint in most patients was flexion contracture. Release of the sheath scar corrected the contracture, and pulley reconstruction was recom-

mended. However, the one patient who refused surgery was successfully treated by a ring pulley support splint. In this study, climbers with this injury have continued to climb at a high standard and reported no difficulties with hand tasks during activities of daily living. This suggests the natural history of closed pulley rupture may be more benign than previously thought.

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