WILDERNESS & ENVIRONMENTAL MEDICINE, **26,** 62–67 (2015)

BRIEF REPORT

# Injury Trends in Rock Climbers: Evaluation of a Case Series of 911 Injuries Between 2009 and 2012

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**Objective.**—Rock climbing is a widely performed sport. This prospective single-institution study evaluated the demographics of climbing-related injuries to improve our comprehension of current injury characteristics.

**Methods.**—During a 4-year period, 836 patients with a total of 911 independent climbing injuries were prospectively evaluated using a standard questionnaire and examination protocol.

**Results.**—Of all injuries, 833 were on the upper extremities, 58 on the lower. Seventeen injuries were Union International des Associations d'Alpinisme (UIAA) grade 1 injuries, 881 were grade 2, and 13 were grade 3. No higher UIAA graded injuries occurred. Overall, 380 were acute injuries (359 were seen in clinic, 21 were seen through the emergency department), and 531 were overstrain injuries (all seen in clinic). Finger injuries accounted for 52% of all injuries, the shoulder being the second most frequent location. Pulley injuries were the most frequent finger injuries. Of 20 injured young climbers under the age of 15 years, 14 had an epiphyseal fracture (all epiphyseal fractures: mean age 14 years, range 12 to 15 years). Male climbers were significantly older ($P < .05$), had more climbing years ($P < .05$), and were climbing at a higher climbing level ($P < .01$). Older, more experienced climbers had significantly more overstrain injuries than acute injuries ($P < .05$).

**Conclusions.**—When comparing this study with our previous study from 1998 to 2001, there are some notable differences. Although pulley injuries are still the most common climbing injury, there are now more A4 pulley injuries than A2. Shoulder injuries are becoming more common, as are epiphyseal fractures among young climbers. It is important to understand current patterns of climbing injuries so that health providers can target interventions appropriately.

*Key words:* rock climbing, finger injuries, sport climbing, pulley injury, mountaineering, sports injuries

## Introduction

Rock climbing is a widely performed sport, and over the past 20 years much research has been done to analyze the injuries, injury distribution, and injury risk involved. Most overstrain injuries are found on the upper extremities and are caused by performing a hard move.[1] Most acute trauma, however, involves the lower extremities and is caused by a fall.[1] A wide variety of studies have focused on upper limb injuries or on the various rock climbing subdisciplines: outdoor sport climbing and rock climbing, indoor climbing, and competition climbing.[1,2] Severe injuries during well-bolted sport climbing, indoor, or competition climbing are rare, but do happen.[1,2] Injuries from outdoor alpine climbing are more frequent and more serious.[1,2] One specific problem with some of these studies is that most are performed retrospectively with a bias (eg, patient selection bias), and the injury collection, grading, and anatomical presentation is inconsistent.[3] Acknowledging this fact, the Medical Commission of the International Mountaineering Association (UIAA MedCom) proposed a coherent injury score and further guidelines for injury analysis.[3]

In a previous study from 1998 to 2001, we prospectively clinically examined 604 climbing injuries and published an injury analysis and distribution.[4,5] In addition, we and many others gave lectures to trainers, parents, and doctors, and wrote articles and books to

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increase the awareness of climbing-specific injuries in an effort to reduce their frequency. As the sport becomes more professionalized, injury patterns are changing and require continued follow-up. Follow-up allows us to assess the effectiveness of preventive measures and to identify the changing injury patterns—for example, the number of epiphyseal injuries among young climbers.[6] To reevaluate injury demographics, distribution, and severity in our clientele, we conducted a prospective clinical follow-up study.

## Methods

During a 4-year period from January 1, 2009, to December 31, 2012, we prospectively evaluated patients with climbing injuries. All athletes were seen in our hospital and evaluated with a standard questionnaire and examination protocol. The evaluation included two kinds of patients: patients making elective visits to our outpatients sports medicine clinic (which is part of our department of trauma and orthopedic surgery), and patients who came to our hospital, Klinikum Bamberg (a 24-hour level 1 trauma center within Germany's largest climbing area, the Frankenjura, in which V.S and D.P. are consultants to the orthopedic and trauma surgery department). The trauma surgical resident in charge of the emergency department kept us informed about any climbing patients and presented case information such as body weight and height, as well as information about how long the patient had been climbing and the climbing level.

The UIAA metric scale[3] was used to evaluate the climbing level. It was graded according to the hardest redpoint route (climbing without artificial aid and without rest) within the last 2 years. Acute injuries were defined as a single trauma with a sudden onset that led to an injury. Chronic injuries were defined as overstrain injuries with no specific acute trauma. For injury distribution, the Orchard Sports Injury Classification System 10 (OSICS 10) was used in accordance with the UIAA MedCom recommendations.[3] Injuries were graded using the UIAA MedCom score.[3] Pulley injuries were diagnosed using a 13 MHz linear transducer (Sonosite, Bothell, WA) with forced flexion, following our previous recommendations. If an exact diagnosis could not be obtained, an additional magnetic resonance imaging scan was performed with the hand in a crimp position. Pulley injuries were graded and treated according to the score of Schöffl et al.[4] When possible, the results of the prior 2003 study were included in the table of the results.[4,5] The Internal Ethical Commission of our institution accepted the study; external Institutional Review Board approval was not sought.

Statistical analysis was performed using Microsoft Excel for data collection and SPSS (SPSS Inc, Chicago, IL) for analysis. The statistical analysis was performed by an independent statistician. All measured values are reported as means and standard deviations. The Kolgomorov-Smirnov test was used to check for normal distribution. Homogeneity of variance was investigated using the Levene F test. Normally distributed variable differences within and between groups were assessed with paired and unpaired *t* tests. All tests were 2-tailed,

**Table 1.** Patient injury distribution and grading 2009 to 2012 compared with 1998 to 2001

| *Patients (n = 836)* | *2009–2012 (n = 911)* | *1998–2001 (n = 604)* |
|---|---|---|
| Age, years | 34.1 ± 11.1 (11–77) | 28.3 ± 12.4 (13–52) |
| Climbing level[a] | 8.8 ± 1.2 (5.0–11.3) | 8.6 ± 1.1 (5.3–11.0) |
| Climbing years | 13.3 ± 10.1 (0.3–64) | 7.3 ± 5.8 (2–35) |
| Injury distribution | | |
| Upper extremity | 833 (91.4) | 405 (67.1) |
| Lower extremity | 58 (6.4) | 77 (12.7) |
| Other | 20 (2.2) | 122 (20.2) |
| Injury grading | | |
| UIAA 1 | 17 (1.9) | 4 (0.6) |
| UIAA 2 | 881 (96.7) | 584 (96.7) |
| UIAA 3 | 13 (1.4) | 9 (1.5) |
| UIAA 4 | None | 7 (1.2) |
| UIAA 5-6 | None | None |
| Injury type | | |
| Acute | 380 (41.7) | 308 (51) |
| Overstrain | 531 (58.3) | 296 (49) |

Values are mean ± SD (range) or *n* (%).

[a] Union International des Associations d'Alpinisme (UIAA) metric.

**Table 2.** Injury distribution according to body area, 2009 to 2012 and 1998 to 2001

| *Body area*[a] | *2009–2012 (n = 911)* | *1998–2001 (n = 604)* |
|---|---|---|
| Finger | 474 (52) | 247 (41) |
| Shoulder | 157 (17.2) | 30 (5) |
| Hand | 119 (13.1) | 47 (7.8) |
| Forearm and elbow | 83 (9.1) | 81 (13.4) |
| Lower leg/foot | 35 (3.8) | 55 (9.1) |
| Knee | 19 (2.1) | 22 (3.6) |
| Trunk and spine | 17 (1.9) | 43 (7.1) |
| Pelvis | 4 (0.4) | 0 (0) |
| Other | 3 (0.3) | 79 (13) |

Values are n (%).
[a] Anatomical locations are specified as given by Schöffl et al[4] to enable a comparison with the prior study.

and a 5% probability level was considered significant. Cross table analysis with Pearson's $\chi^2$ test was performed for group analysis. The 4 most frequent OSICS locations (P = hand, finger, thumb; S = shoulder, clavicle; E = elbow; and W = wrist) were further analyzed.

## Results

From 2009 to 2012, we treated 836 patients (630 [75%] male, 206 [25%] female) with a total of 911 independent climbing injuries (Table 1). Sixty-three patients had 2 diagnoses, 11 had 3, and 1 patient had 5 different diagnoses. Of all injuries, 380 were acute (359 were seen in clinic, 21 were seen through the emergency department), and 531 were overstrain injuries (all seen in clinic). Tables 2 and 3 show the distribution of injuries, and Table 4 shows the 10 most frequent injuries. The most frequent injuries were pulley injuries, followed by tenosynovitis of the finger flexor tendons and capsulitis of the finger joints. Six of the 10 most frequent injury locations were hands and fingers. Of 140 pulley injuries, 103 were diagnosed through ultrasonography examination. In 37 cases, an additional magnetic resonance imaging scan was performed. Overall, finger injuries accounted for 52% ($n = 474$) of all injuries. The most frequent finger injury, with 140 cases, was a pulley injury; Table 5 provides a comparison of the distribution of pulley injuries. As seen in Table 6, there were more than 20 different diagnoses of finger injuries.

The statistical analysis showed that the male climbers were significantly older ($P < .05$), had been climbing for more years ($P < .05$), and were climbing at a higher level ($P < .01$) than female climbers. Older, more experienced climbers had significantly more overstrain injuries than acute injuries ($P < .05$). There was no significant association between a climber's redpoint level and the development of overstrain or acute injury.

**Table 3.** Injury distribution of anatomical sites according to Orchard Sports Injury Classification System 10

| *Main Grouping* | *Category* | *OSICS Designation* | *(n = 911)* |
|---|---|---|---|
| Head and neck | Head/face | H | 0 (0) |
| | Neck/cervical spine | N | 4 (0.4) |
| Upper limbs | Shoulder/clavicle | S | 157 (17.2) |
| | Upper arm | U | 0 (0) |
| | Elbow | E | 70 (7.7) |
| | Forearm | R | 12 (1.3) |
| | Wrist | W | 69 (7.6) |
| | Hand/finger/thumb | P | 528 (57.1) |
| Trunk | Chest (sternum/ribs) | C | 0 (0) |
| | Thoracic spine | D | 0 (0) |
| | Trunk, abdomen | O | 0 (0) |
| | Lumbar spine | B | 11 (1.2) |
| | Pelvis and buttock | L | 2 (0.2) |
| Lower limbs | Hip/groin | G | 4 (0.4) |
| | Thigh | T | 0 (0) |
| | Knee | K | 19 (2.1) |
| | Lower leg | Q | 3 (0.3) |
| | Ankle | A | 12 (1.3) |
| | Foot/toe | F | 20 (2.2) |
| Location unspecified | | X | 0 (0) |

Values are n (%).
OSICS, Orchard Sports Injury Classification System.

**Table 4.** Ten most frequent injuries, 2009 to 2012 and 1998 to 2001

| *Injuries 2009–2012 (n = 911)* | *n* | *%*[a] | *Injuries 1998–2001 (n = 604)* | *n* | *%*[a] |
|---|---|---|---|---|---|
| Pulley injury | 140 | 15.4 | Pulley injury | 122 | 20.2 |
| Capsulitis | 87 | 9.5 | Epicondylitis | 51 | 8.4 |
| Tenosynovitis | 80 | 8.8 | Tenosynovitis | 42 | 7.0 |
| SLAP tear | 51 | 5.6 | Strain finger joint capsule | 37 | 6.1 |
| Epicondylitis | 50 | 5.5 | Skin abrasions | 34 | 5.6 |
| Impingement (shoulder) | 40 | 4.4 | Back problems | 24 | 4.0 |
| Strain finger flexor tendon | 36 | 4.0 | Knee injuries | 14 | 2.3 |
| Dupuytren disease | 30 | 3.3 | Fractures | 14 | 2.3 |
| Strain finger joint capsule | 25 | 2.7 | Capsulitis | 13 | 2.2 |
| Ganglion finger flexor tendon | 19 | 2.1 | Ganglion finger flexor tendon | 11 | 1.8 |

SLAP, superior labral tear from anterior to posterior.
[a] Percentage correlated with all injuries (n = 911/n = 604).

**Table 5.** Pulley injuries, 1998 to 2001[a] and 2009 to 2012

| *Eras* | *D1* | *D2* | *D3* | *D4* | *D5* | *A1* | *A2* | *A3* | *A4* | *C1-3* | *A2/A3* | *A2/4* | *A3/4* | *A2/A3/A4* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1998–2001 (*n* = 122)[4] | 0 | 0 | 47 | 73 | 2 | 0 | 81 | 6 | 28 | 0 | 4 | 0 | 0 | 3 |
| 2009–2012 (*n* = 140) | 0 | 7 | 42 | 89 | 2 | 1 | 48 | 1 | 61 | 7 | 12 | 1 | 1 | 8 |

[a] From Schöffl et al.[4]

**Table 6.** Differential diagnoses of finger injuries, 2009 to 2012 and 1998 to 2001

| *Finger injuries 2009–2012 (n = 474)* | *n* | *%*[a] | *Finger injuries 1998–2001 (n = 247)* | *n* | *%*[a] |
|---|---|---|---|---|---|
| Pulley injury | 140 | 29.5 | Pulley injury | 122 | 49.4 |
| Capsulitis | 87 | 18.4 | Tenosynovitis | 42 | 17.0 |
| Tenosynovitis flexor tendon | 80 | 16.9 | Strain finger joint capsule | 37 | 15.0 |
| Strain flexor tendon | 36 | 7.6 | Capsulitis | 13 | 5.3 |
| Strain finger joint capsule | 25 | 5.3 | Ganglion | 11 | 4.5 |
| Ganglion finger flexor tendon | 19 | 4.0 | Strain flexor tendon | 7 | 2.8 |
| Collateral ligament injury | 17 | 3.6 | Fracture | 7 | 2.8 |
| Epiphyseal fracture | 16 | 3.4 | Osteoarthritis | 7 | 2.8 |
| Lumbrical shift syndrome | 15 | 3.2 | Dupuytren | 5 | 2.0 |
| Osteoarthritis | 14 | 3.0 | Soft tissue injury | 5 | 2.0 |
| Extensor hood syndrome | 7 | 1.5 | Tendon rupture | 4 | 1.6 |
| Lumbrical tear | 4 | 0.8 | Collateral ligament injury | 3 | 1.2 |
| Snap finger | 3 | 0.6 | Osseous tear fibrocartilago palmaris | 2 | 0.8 |
| Cartilage injury | 2 | 0.4 | Epiphyseal fracture | 2 | 0.8 |
| Flip phenomena | 2 | 0.4 | Lumbrical shift syndrome | 2 | 0.8 |
| Broken osteophyte | 1 | 0.2 | Phlegmonia/cellulitis | 1 | 0.4 |
| Avulsion fracture | 1 | 0.2 | Finger amputation | 1 | 0.4 |
| Flexor contraction | 1 | 0.2 | | | |
| Rupture connexus intertendineus | 1 | 0.2 | | | |
| Enchondroma | 1 | 0.2 | | | |
| Contusion | 1 | 0.2 | | | |
| Tendon rupture | 1 | 0.2 | | | |

Shoulder injuries were the second most frequent location (*n* = 157); see Table 7.
[a] Percentage of all finger injuries (*n* = 474/*n* = 247).

Climbing level, years of climbing, height, weight, sex, and age did not significantly influence the UIAA score. Acute injuries had a significantly higher UIAA score than overstrain injuries.

## Discussion

In our present study, we are trying to understand the dynamics of injuries associated with rock climbing. Ten years after our previous study,[4,5] we prospectively analyzed a similar group of athletes to see whether there was a major change in the demographics of climbing injuries. It is important to note that the cohort of climbers in this study is diverse. Most of our patients were climbing in the Frankenjura, Germany's largest sport climbing area. Although most injuries were related to bolted sport climbing, we also had patients from other climbing areas (eg, traditional climbing areas in the United States or the United Kingdom) who sought our advice as a second opinion as well as patients who traveled to see us after injuring themselves climbing in the Alps or other climbing areas.

Analyzing our patients, we found more male climbers were injured than female climbers, which is inconsistent with other climbing studies. For rock climbing injuries, Jones et al[7] found an odds ratio of 1.01 (95% CI: 0.32 to 3.20) for males, whereas Josephsen et al[8] found little or no influence of sex. To minimize selection bias, this study is best compared with our previous work where we found a similar gender distribution, with 70.1% male climbers and 28.9% of female climbers injured.[4,5] We believe that the sex difference is mainly a consequence of the higher number of male than female climbers within our region. Whether men are more risk prone than women cannot be answered using these data.

In our previous analysis, we found the average age of injured climbers to be 28.3 years,[4,5] whereas Nelson et al[9] reported the mean age for rock climbing injuries to be 26 years (95% CI: 24.9 to 27.1 years). In our present study, the mean age (34.4 ± 11.1) was higher. The climbing level (8.8 ± 1.2 UIAA metric) was similar to that in our study of 10 years prior (8.6 ± 1.1 UIAA metric). The statistical analysis in our present study shows that climbers of a higher age and with more climbing years had significantly more overstrain injuries than acute injuries. Climbing frequency and difficulty were also associated with the incidence of overuse injuries, according to Jebson et al[10] and Jones et al.[7]

Most injuries (91.4%) in our current study were of the upper extremity. In the prior study from 1998 to 2001, we found similar results; and so far, most research indicates that for non-alpine rock climbing, the upper extremity is the most injured body region.[4,5] That applies to most of our patients. In alpine terrain, longer falls are frequent and result in a higher number of lower limb injuries.[1] But as stated above, most of our injured climbers come from a bolted sport climbing area, thus making upper limb injuries more likely due to performing hard moves.

The injury severity in our present study was mostly low, none being higher than UIAA grade 3, and that also represents the specifics of the local climbing area. However, it is still surprising that we did not find any higher grade injuries in our 4 years of research. In the previous study from 1998 to 2001,[4,5] 5 polytrauma cases were included (a total of 7 grade 4 injuries). Our hospital, Klinikum Bamberg, is one of three level 1 trauma centers covering Germany's largest climbing area, the Frankenjura. From press reports, we know that there were higher grade injuries and fatalities in the respective time frames. These polytrauma patients are distributed to various trauma centers through a regional control center, which dispatches in accordance with current operative availability, flight time, National Advisory Committee for Aeronautics (NACA) score, geographic region, and so forth. Hence, the number of polytrauma patients is biased, as there is always the possibility that whenever there was a polytrauma climber, we may have already been busy with one or two other polytrauma patients. However, the low injury severity in our study is consistent with various previous studies in the literature that show an overall low injury severity for sport climbing and bouldering.[1,7,8]

When comparing our present study with the prior study 1998 to 2001,[4,5] we found some differences. Although pulley injuries were the most common injury in both studies, we found that pulley injuries are now more common to the A4 instead of to the A2 pulley. This finding reflects a tendency we have seen over the last years and may be explained by the biomechanics of grip techniques used. More shoulder injuries also occurred in the present study (Table 7). There are two reasons for

**Table 7.** Distribution of diagnoses in shoulder injuries

| *Injury (n = 157)* | *n* | *%* |
|---|---|---|
| SLAP tear | 51 | 32.5 |
| Impingement | 40 | 25.5 |
| Shoulder sprain | 17 | 10.8 |
| Dislocation, Bankart lesion | 16 | 10.2 |
| Supraspinatus tendonitis | 7 | 4.5 |
| Instability (non-Bankart) | 7 | 4.5 |
| Tendinosis of long biceps tendon | 5 | 3.2 |
| Rupture of long biceps tendon | 5 | 3.2 |
| Rotator cuff tear | 5 | 3.2 |
| Acromioclavicular joint injury | 3 | 1.9 |
| Pulley injury | 1 | 0.6 |

SLAP, superior labral tear from anterior to posterior.

this: first, shoulder injuries are rising among rock climbers;[1] and second, we specialize in sports medicine shoulder surgery, which makes for a sample bias.

The number of epiphyseal fractures has also been rising in comparison with the previous study.[4,5] This increase also has been described by Bayer et al.[6] In our previous study, we saw 2 cases of epiphyseal fractures, which calculates to an incidence of 0.3%; in the present study, we found 16 cases, for an incidence of 1.8%—a gain of 600%. This incidence increase becomes even more alarming looking at adolescent climbers only. Our present study included 20 young climbers (13 male, 7 female) who were less than 14 years of age. Sixteen of these had symptoms of finger pain after and while climbing, with finger joint swelling but no acute trauma. Of these 16 climbers, 14 had an epiphyseal fatigue fracture on magnetic resonance imaging, 1 bilaterally. Thus, 14 of 20 injured young climbers (70%) up to age 14 had an epiphyseal fracture, making that fracture by far the most common climbing injury among young climbers. These numbers are alarming and need to be acknowledged by the national and international climbing bodies. Precautions need to be instigated, and prophylaxis increased. Campus board exercises are known to be one risk factor for epiphyseal fractures in young climbers, but others still need to be detected. One example for possible prophylaxis is the campus board recommendation published through the British Mountaineering Council (https://www.thebmc.co.uk/campus-boards-guidance-on-use) in cooperation with UIAA MedCom. Even though it may seem as if our previous work and that of others on prophylaxis and knowledge transfer may not have influenced this specific epidemiology, we now see these injuries at an earlier, and thus more treatable, stage. Increased public awareness will lead to better treatment options and better outcomes in the future.

## STUDY LIMITATIONS

Our study has several limitations. The cohort of climbers in this study is diverse, with most of them coming from the local sport climbing area, others from farther away. The kind of climbing mostly performed in the area certainly influences the injury profile. Our questionnaire also had the limitation of not giving specific details about the injury cause, such as the exact climbing activity (subdiscipline) and environmental location. There is also selection bias with polytrauma patients, as discussed. The main bias of the current study, however, is the authors themselves. We are very active in treating finger and shoulder injuries of climbers, and therefore, the patient selection is certainly biased. Nevertheless, this bias also existed in the previous analysis;[4,5] therefore, we think a reevaluation of our clientele is important, as it shows trends in injury development and reassesses the effects of preventive measures.

## Conclusion

After analyzing our climbing patients over approximately 10 years, we still find that finger injuries are the most common. Shoulder injuries are also becoming more frequent, as well as epiphyseal injuries among young climbers. More educational efforts are needed to ensure early detection of these young climbers' injuries, thereby avoiding long-term consequences. For further analysis and evaluation of fatality risk, a prospective, closed-cohort study is necessary.

## Acknowledgments

The authors thank Professor Dr Sighard Roloff for performing the independent statistical analysis, and Mss Inge Perkins and Kelsey Shumate for English language support.

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