Evaluation of Injury and Fatality Risk in Rock and Ice Climbing

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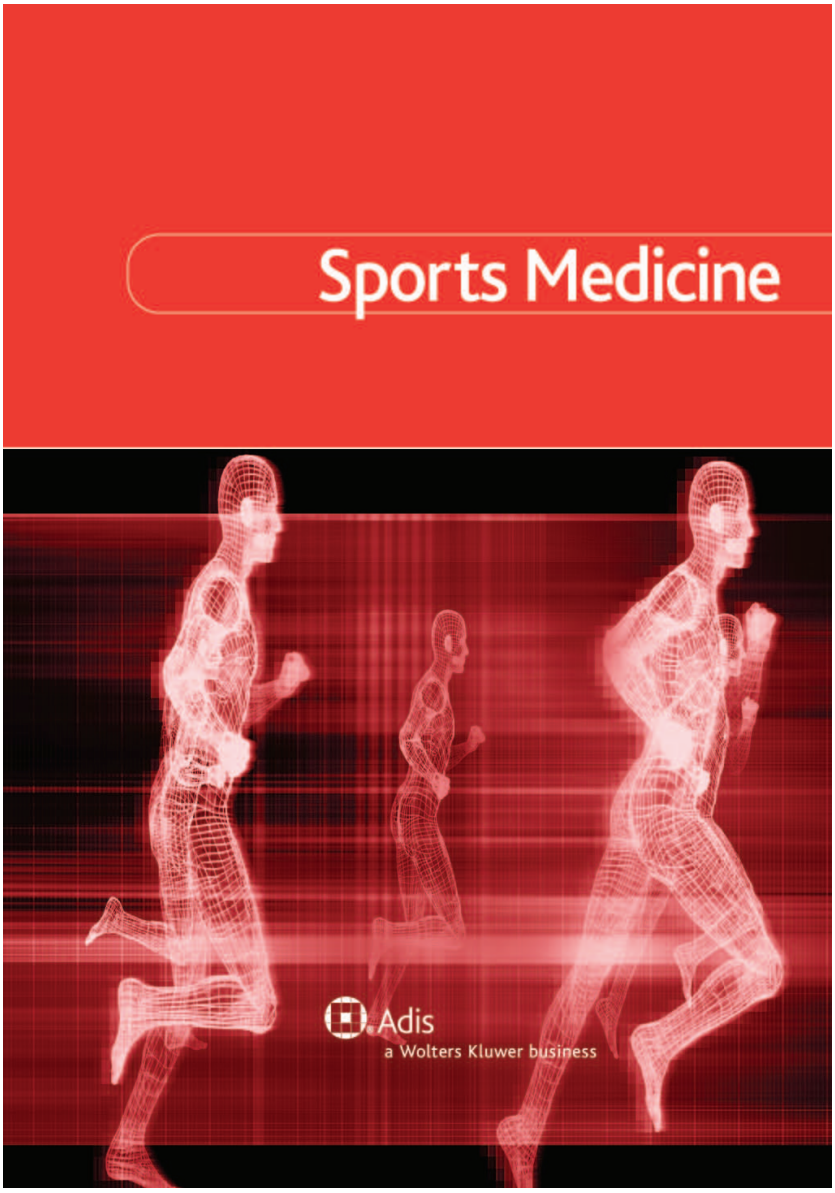

REVIEW ARTICLE

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Evaluation of Injury and Fatality Risk in Rock and Ice Climbing

Volker Schöffl,[1,2,3] *Audry Morrison*,[3] *Ulrich Schwarz*,[4] *Isabelle Schöffl*[5] and *Thomas Küpper*[3,6]

1 Department of Sportorthopedics, Orthopedics and Trauma Surgery, Klinikum Bamberg, Bamberg, Germany
2 Department of Trauma Surgery, Friedrich Alexander University Erlangen-Nuremberg, Erlangen, Germany
3 Medical Commission of Union Internationale des Associations d'Alpinisme, Bern, Switzerland
4 Private Practise, Oberstdorf, Germany
5 Department of Anatomy 1, Friedrich Alexander University Erlangen-Nuremberg, Erlangen, Germany
6 Institute of Occupational and Social Medicine, RWTH Aachen Technical University, Aachen, Germany

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Abstract

Rock and ice climbing are widely considered to be 'high-risk' sporting activities that are associated with a high incidence of severe injury and even death, compared with more mainstream sports. However, objective scientific data to support this perception are questionable. Accordingly, >400 sport-specific injury studies were analysed and compared by quantifying the injury incidence and objectively grading the injury severity (using the National Advisory Committee for Aeronautics score) per 1000 hours of sporting participation. Fatalities were also analysed. The analysis revealed that fatalities occurred in all sports, but it was not always clear whether the sport itself or pre-existing health conditions contributed or caused the deaths. Bouldering

(ropeless climbing to low heights), sport climbing (mostly bolt protected lead climbing with little objective danger) and indoor climbing (climbing indoors on artificial rock structures), showed a small injury rate, minor injury severity and few fatalities. As more objective/external dangers exist for alpine and ice climbing, the injury rate, injury severity and fatality were all higher. Overall, climbing sports had a lower injury incidence and severity score than many popular sports, including basketball, sailing or soccer; indoor climbing ranked the lowest in terms of injuries of all sports assessed. Nevertheless, a fatality risk remains, especially in alpine and ice climbing. In the absence of a standard definition for a 'high-risk' sport, categorizing climbing as a high-risk sport was found to be either subjective or dependent on the definition used. In conclusion, this analysis showed that retrospective data on sport-specific injuries and fatalities are not reported in a standardized manner. To improve preventative injury measures for climbing sports, it is recommended that a standardized, robust and comprehensive sport-specific scoring model should be developed to report and fully evaluate the injury risk, severity of injuries and fatality risk in climbing sports.

Rock climbing originated as a skill practice for difficult sections of a mountaineering ascent in the 1960s and was practiced by a small group of dedicated climbers. By the mid-1980s its popularity spread globally and diversified to include new categories such as ice climbing (climbing iced rock faces and frozen waterfalls),[1] bouldering (ropeless climbing to low heights), speed (competition climbing where two climbers climb simultaneously on identical routes against each other) and aid climbing (climbing with artificial aid and gear).[2,3] In 1991, only a few countries participated in the first World Championships but by 2005, some 500 athletes from 55 countries competed.[2-4] The International Federation of Sport Climbing is currently seeking recognition as an Olympic sport.[3,5,6] All of these climbing activities are regulated by national and international climbing organizations to promote safe participation, competitions[2,3,7] and to meet the needs of the rapidly rising club memberships.

Learning to climb has never been easier with the advent of indoor artificial climbing walls found in many cities.[8] In some schools it forms part of the sport curriculum.[4,5] Rock climbing participation is accessible to all ages, toddler to pensioner,[4-7] and is enjoyed by many over a lifetime. There is little doubt that climbing as a sport has both diversified and grown in popularity, and has even become a spectator sport. However, with any sporting participation, there will be some risk of injury that must be weighed against the benefits of this exercise. To date, no known study has demonstrated that rock or ice climbing are high-risk sports, a commonly held perception.

Epidemiological analysis of sport-specific injuries helps to provide preventive measures that can target the incidence and reduce their severity. Extensive studies on injuries in general rock climbing,[4,9-22] indoor climbing[8,10,23] and competition climbing[5] exist, including analysis of the injury risk per 1000 hours. Severe injuries during indoor or competition climbing are rare, but do happen.[5,8,10,12,16,17,19,21-33] Most injuries in rock climbing occur on the upper limbs, notably the fingers, and generally result from overstraining rather than acute injuries.[28,31,34-39] To date, no known study has objectively demonstrated that ice or rock climbing are high-risk sports, or that those climbing higher grades are more prone to experience severe injuries compared with those climbing lower grades. Nevertheless, the media's lurid depiction of elite rock and ice climbers has helped to create a perception of climbing as being a hazardous and high-risk sport.[1,40] For example, a 1999 *Time Magazine* cover featured a sport climber with the headline ''Why we take

risks'' with a subtitle stating ''From extreme sports to day trading thrill seeking is becoming more popular.''[40] Other 'thrill seeking' activities cited in this magazine's feature article included having unprotected sex when AIDS was prevalent.[41] UK government statistics from around this time counter such titillating journalism by calculating the annual risk of death as a consequence of climbing to be 1 in 320 000 climbs, 1 in 200 000 dives if scuba diving, and 1 in 116 000 flights for hang gliding.[42]

Many European accident and disability insurance policies either limit or exclude rock and ice climbing participation. In contrast, an established British policy[7] offers global coverage for different forms of climbing. This suggests that both the popular public and professional assessment of the actual risks associated with climbing may not be fully informed.

To objectively analyse and compare injuries from different sports, a common scoring system for the grading of injuries is essential. In general, when assessing whether a sport presents a high risk of injury or death, a distinction between overstrain (overuse) injuries and acute injuries or accidents should be made. The reasons being, overstrain injuries are generally less severe and can generally be avoided with informed training, whereas an examination of the injury rate for acute sport-specific injuries, especially their severity, is crucial. In any case, an analysis of both overuse and acute injuries in climbing has been presented in this review.

Although many studies and alpine clubs have recorded climbing accidents and injuries for over 100 years, two studies around 1990[20,21] pioneered the use of a scoring system (Injury Severity Score [ISS]) to grade registered climbing injuries and calculated the injury risk in correlation to climbing days[21] or climbing time.[20] However, this ISS score showed a weak validity for injury self recall,[43] and so future studies used the National Advisory Committee for Aeronautics (NACA) score[44] (see table I) for grading.[1,45] The NACA score is the most commonly used emergency score in Germany and is also part of the nationwide standard pre-hospital emergency physicians report form.[46] It is also recommended and used internationally for alpine trauma evaluation.[47]

Table I. The National Advisory Committee for Aeronautics (NACA) scoring system[44]

Patient status	Score level
Not an acute life-threatening disease or injury	1
Acute intervention not necessary; further diagnostic examination needed	2
Severe but not life-threatening disease or injury; acute intervention necessary	3
Development of vital (life threatening) danger possible	4
Acute vital (life threatening) danger	5
Acute cardiac or respiratory arrest	6
Dead	7

Therefore, this review sought to objectively compare different sports for their sport-specific injury risk by quantifying and grading the injury severity, and fatality rates per 1000 hours of sporting participation. The question as to whether any, or all, climbing activities should be considered high-risk sports was also examined.

1. Retrospective Data Collection and Climbing Participation Time Calculation

An electronic PubMed search was conducted using the following search terms: 'rock climbing' (138 hits), 'ice climbing' (10 hits), 'mountaineering' (1821 hits), 'sport injuries risk' (5021 hits), 'sport fatalities' (243 hits), 'epidemiology sport injuries' (5102 hits) and 'NACA score' (13 hits). All studies on rock climbing and ice climbing were gathered and completely analysed. For mountaineering, all the abstracts were read and, if relevant, the full paper was accessed. A similar method was used for the other search terms once the relevant abstracts were identified. Additional information was sought by personal communication (with the German Alpine Club Safety Commission) and by an Internet search to obtain alpine club publications from Germany, Canada and America.

From 400+ studies on climbing, mountaineering and other sports that supplied detailed information on sport-specific injuries, the injury risk per 1000 hours was either extracted directly

or calculated from the data of the selected study. If climbing days were reported and not the injury risk per 1000 hours of sports performance, a single rock climbing day was calculated using 4 hours for sport climbing, 8 hours for alpine climbing, 2 hours for indoor climbing,[5,8] 6 hours for ice climbing[1,5,8] and 16 hours for an expedition day. The rock climbing ability grade was transferred into the Union Internationale des Associations d'Alpinisme (UIAA) scale and then into the metric scale.[48] The injury definition and grading from the selected studies were initially evaluated by the independent analysis of the injuries using the NACA injury scoring system followed by a complete re-evaluation of these injuries in an identical manner by the consensus of three experienced trauma surgeons or sport physicians who were also experienced climbers. The fatality rate and case fatality were also analysed. In order to compare climbing with other sports, the injury risk per 1000 hours of sport participation was either given or calculated.

2. Description of Rock Climbing Sub-Disciplines

Rock climbing is a multi-disciplined sport. Depending on the sub-discipline examined, the climber's experience and skills, grade of route difficulty, equipment, climbing surface (type of rock or ice, artificial indoor wall, scree), remoteness of location, altitude and weather will implicate different levels of risk. In addition to these variables, many climbers regularly participate in more than one climbing sub-discipline. Designing scientific studies that can accurately reflect all these injury variables exclusively for outdoor climbing is difficult,[49] as many of these variables are common to anyone who engages in outdoor activity. Injuries at indoor climbing walls have more controlled sport-specific variables and are better documented.[5,8,23] Another variable considered when analysing climbing literature was careful interpretation of the origin of the study and geographical climbing area, as climbing terms and conditions differ among the continents (i.e. rock type, climbing grades, likely equipment used – especially in older studies, likely climbing sub-disciplines practiced), and this was reflected in tables II–V. Therefore, some climbing sub-disciplines will be briefly described, followed by an analysis of injury data for climbing and other sports.

2.1 Sport Climbing

Sport climbing (figure 1) or free climbing requires gymnastic-like strength, flexibility, finger strength and strength endurance when climbing each unique and graded route. The climbing is slightly prescriptive as the climber ascends towards mostly permanently fixed anchors, such as bolts to clip their rope into for protection. The route length can range from 10 to 100+ m with fixed anchors generally around 2–5 m apart. Falls are frequent, trained for and are mostly harmless.[11] Physical hazards (rock fall, weather changes etc.) are small and the neglect of wearing a climbing helmet is widely accepted.[4,64] In contrast, fixed anchors will be very minimal when 'free climbing' and a helmet is recommended.

2.2 Bouldering

Ropeless climbing involves a short sequence of powerful and technical moves to complete the graded route on large rocks, occasionally up to 10+ m high.

Bouldering (figure 2) can be done without a partner and with minimal equipment (climbing shoes and crash pad). Falling onto one's feet or body is a normal part of bouldering, whether a route is completed or not.

2.3 Traditional (Alpine) Climbing

Traditional (alpine) climbing (or trad climbing) emphasizes the skills necessary for establishing routes in an exploratory fashion outdoors. The lead climber typically ascends a section of rock while placing removable protective devices where possible along the climb. Falls can therefore be longer than those experienced when sport climbing. Unreliable fixed pitons may occasionally be found on older established routes. As physical hazards are likely, the use of a helmet is considered mandatory.[65] Above approximately

Table II. Injuries and fatalities in traditional and sport climbing

Study (year)	Type of climbing (geographical location)	Study profile	Cause of injury; body location	Injuries per 1000 h sport performance	Injury severity	Fatality	Risk evaluation
Bowie et al.[21] (1988)	Traditional climbing, bouldering some rock walls 1000 m high (Yosemite Valley, CA, USA)	Data collection in the ER of the central hospital within the area	Mainly lead climbing falls; mostly lower extremity	37.5[a]	Majority of minor severity using ISS score; 95% ISS <13; 5% ISS 13–75	13 of 220 subjects had severe injuries, of which 11 were fatal (5.9%); case fatality rate 6%	Bias of injuries presented may reflect more serious injuries requiring ER treatment
Addiss and Baker[22] (1989)	Mountaineering and traditional climbing, includes snow and ice (US National Parks; includes snow and ice terrain)	127 rock climbing injuries that were reported to US National Park services (1981–2)	75% falls	NS	28% NACA seven (fatal)[b]	36 (28%); injuries on snow and ice were more likely to be fatal	Potentially high-risk activity
Schussmann et al.[20] (1990)	Mountaineering and traditional climbing (Grand Tetons, WY, USA)	Data collection through National Park registration from 1981 to 1986, representing 43 631 climbers, 108 accidents for all mountaineering activities	More mountaineering accidents than rock climbing	0.56 for injuries; 0.13 for fatalities; incidence 2.5 accidents/1000 mountaineers/y or 5.6 injuries/10 000 h of mountaineering	23% of the injuries were fatal (NACA 7)[b]	25 fatal, 23% case fatality rate; fatality rate 0.13/1000 h	Author concluded mountaineering was of a higher risk than pure rock climbing; climbing education and experience were considered preventative factors in accidents and injuries
Rooks et al.[18] (1995)	Recreational rock climbers, (GA, USA)	39 recreational climbers	Six climbers climbing beyond the sport level sustained a major injury from a fall, 35 sustained at least one significant injury; mostly to upper extremity	NS	NS	Six (15%) had a major injury from a fall	NS
Paige et al.[19] (1998)	Traditional climbing, sport climbing (NS)	94 rock climbers completed a retrospective questionnaire on overstrain injuries by mail, in person and via the Internet	Mainly lead climbing, falling when alpine climbing, injuries from hard moves in sport climbing; upper extremity, fingers especially affected	NS	NS	None as retrospective questionnaire	No major difference between alpine and sport climbing

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Table II. Contd

Study (year)	Type of climbing (geographical location)	Study profile	Cause of injury; body location	Injuries per 1000 h sport performance	Injury severity	Fatality	Risk evaluation
Rohrbourgh et al.[31] (2000)	Competition rock climbers at US National Championships (NS)	42 elite rock climbers; only overuse syndromes were studied	Mostly in upper limbs	NS	NS	None	No significant relationship between overuse injuries and years of climbing or difficulty level
Schöffl et al.[15] (2003)	European climbers (NS)	604 injured climbers were seen prospectively over 4 y	Upper extremity 67%	NS	Mostly NACA 1–2, only 0.8% severe injuries (NACA 4 or 5)	None	Severe injuries were rare
Logan et al.[29] (2004)	Rock climbers, (UK)	545 members of the Climbers Club of Great Britain completed a questionnaire, which examined the prevalence of hand injuries		NS	Mostly NACA 1 and 2[b]	None reported as it was a retrospective survey on hand injuries	Climbing intensity score higher in injury group (including overstrains) ($p < 0.05$) although paper said intensity, grade is what is meant and clearer
Gerdes et al.[16] (2006)	Rock climbing (NS)	1887 subjects completed an anonymous Internet survey. There was a total of 2472 injuries, which included overuse syndrome injuries	Upper extremity 57.6%	NS	20% no injury; 60% NACA 1; 20% >NACA 1[b]	None reported as it was a retrospective survey	Traditional ($p < 0.01$) and solo climbing ($p < 0.01$) had more injuries (acute and overuse injuries). Injuries were fairly evenly distributed between indoor and outdoor climbing
Smith[12] (2006)	Review on alpine climbing injuries, (NS)	Review	Falls are the most frequent injury cause	NS	NS	NS	Falling injuries are more severe in alpine climbing
German Alpine Club[50] (2006)	All climbing disciplines (NS)	Reports on all climbing accidents were reported to the DAV insurance cover provider (2004–5)		NS	NS	NS	12% of all accidents in mountain sports are from rock and ice climbing: 48% of these from alpine climbing, 29% sport climbing, 9% indoor climbing, 6% ice climbing, 1% bouldering
Josephsen et al.[51] (2007)	Bouldering, indoor and outdoor (CA, USA)	Prospective, cross-sectional cohort study ($n = 54$) of 152 subjects who completed the year-long study		NS	NS	None	Few differences between injuries experienced between indoor and outdoor bouldering

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Table II. Contd

Study (year)	Type of climbing (geographical location)	Study profile	Cause of injury; body location	Injuries per 1000 h sport performance	Injury severity	Fatality	Risk evaluation
Jones et al.[52] (2007)	Rock climbers, indoor and outdoor (NS)	Retrospective cross-sectional study of 201 rock climbers	10% acute through falls, 33% overuse injuries, 28% acute through strenuous move	NS	NS	None reported as it was a retrospective study	Climbing frequency and difficulty are associated with incidence of overuse injuries
Nelson and McKenzie[53] (2009)	Rock climbing injuries, indoor and outdoor (NS)	846 cases treated at US NEISS hospitals were collected and 40 282 injuries for the US were estimated from 1990 to 2007	Lower extremity mostly affected	Measures of participation and frequency of exposure to rock climbing are not specified	Mostly NACA 1–2[b], 11.3% hospitalization	None reported as it was a retrospective study	Over-exertion injuries more likely on the upper body

a Injuries/fatalities per 1000 h calculated by the authors according to the information given in the study.

b NACA score graded by the authors according to the information given in the study.

DAV = German Alpine Club; **ER** = emergency room; **ISS** = Injury Severity Score; **NACA** = National Advisory Committee for Aeronautics; **NEISS** = National Electronic Injury Surveillance System; **NS** = not specified.

2500 m, physiological altitude-induced adaptations must also be factored into the climbs.

2.4 Indoor Climbing

Indoor climbing (figure 3) is performed on artificial structures that try to mimic climbing outdoors but in a more controlled environment. As physical hazards are almost totally eliminated, such climbing became an extra-curricular sport in many countries.[6] National and international competitions are held on such walls and involve three major disciplines: lead climbing (i.e. sport climbing), speed and bouldering. Bouldering is performed above thick foam mat flooring.

2.5 Ice Climbing

Ice climbing (figure 4) normally refers to roped and protected climbing of features such as icefalls, frozen waterfalls, and cliffs and rock slabs covered with ice refrozen from flows of water. Equipment includes ice axes for hands and crampons for feet. Physical hazards such as avalanches, rock and icefalls are present.

3. Injury and Fatality Risk

3.1 Traditional, Sport Climbing and Bouldering

Very few climbing injury studies differentiate between the sub-disciplines[51] of outdoor rock climbing, and many climbers participate in a few sub-disciplines, so traditional, sport climbing and bouldering will be examined together. Unfortunately, a high number of scientific climbing articles present case studies of common hand injuries[11,13-15,28,38,66-72] and are therefore not suitable for injury risk analysis, but they help to inform of overuse injury trends and preventative training. Nevertheless, most studies agree that the most (58–67%)[15,16] injured body region is the upper extremities.[15-19]

In contrast, in their hospital and emergency room study based in the Yosemite Valley, USA, Bowie et al.[21] found that the lower extremity was most affected. The Yosemite area is famous for its 1000 m high walls, few bolts and mostly traditional climbing. Falls here can be quite long and may result in rock-hit trauma[4,27,73] as the

Table III. Injuries and fatalities in indoor and competition climbing

Study (year)	Type of climbing (geographical location)	Study profile	Cause of injury; body location	Injuries per 1000 h sport performance	Injury severity	Fatality	Risk evaluation
Limb[23] (1995)	90 indoor climbing walls (England, Wales and Scotland)	Postal survey of climbing walls; 55 accidents reported with 1.021 million visits	Mostly upper limb	0.027[a]	All >NACA 1[a]; none NACA 7	None	Climbing walls seem to be associated with a very low injury rate; injury rate not related to any identified wall design or safety feature
Schöffl and Winkelmann[8] (1999)	Indoor climbing walls (Germany)	Prospective study of 25 163 registrants to indoor climbing walls		0.079	3 NACA 2; 1 NACA 3	None	Indoor climbing is a very low risk sport for acute injuries
Wright et al.[10] (2001)	Overuse injuries in indoor climbing at World Championship (Munich, Germany, 1999)	Semi-supervised questionnaire for 295 spectators and competitors	44% had overuse injuries; mostly fingers	NS	NACA 1–2[b]	None	Climbing harder routes was correlated to overuse injuries ($p < 0.01$)
Schöffl and Küpper[5] (2006)	Indoor competition climbing, World Championships (Munich, Germany)	443 climbers (273 M; 170 F) from 55 countries	18 acute injuries of which four were significant	3.1	16 NACA 1; 1 NACA 2; 1 NACA 3	None	Indoor rock climbing has a low injury risk and a good safety profile
Josephsen et al.[51] (2007)	Bouldering, indoor and outdoor (CA, USA)	Prospective cross-sectional cohort study n = 54 of 152 subjects who completed the year-long study	Overuse injuries	NS	NS	None	Few differences between indoor and outdoor climbing
German Alpine Club[50] (2006)	All climbing disciplines (NS)	Reports on all climbing accidents reported to the DAV insurance cover provider (2004–5)		NS	NS	NS	12% of all accidents in mountain sports are from rock and ice climbing: 48% of these are from alpine climbing, 29% sport climbing, 9% indoor climbing, 6% ice climbing and 1% bouldering
Jones et al.[52] (2007)	Rock climbers, indoor and outdoors (NS)	Retrospective cross-sectional study of 201 rock climbers	10% acute through falls; 33% overuse injuries; 28% acute through strenuous moves	NS	NS	None	Climbing frequency and difficulty are associated with incidence of overuse injuries

a Injuries/fatalities per 1000 h calculated by the authors according to the information given in the study.

b NACA score graded by the authors according to the information given in the study.

DAV = German Alpine Club; **F** = females; **M** = males; **NACA** = National Advisory Committee for Aeronautics; **NS** = not specified.

Table IV. Injuries and fatalities in ice climbing

Study (year)	Type of climbing; (geographical location)	Study profile	Cause of injury; body location	Injuries per 1000 h sport performance	Injury severity	Fatality	Risk evaluation
Mosimann[45] (2006)	Ice climbing (Switzerland)	Outcome of 46 ice climbers rescued by Swiss mountain rescue service over 6 y	Most frequent injury causes were falls (55%), but no fatal injuries were sustained through falls	NS	31% NACA 0; 42% NACA 2–3; 8% NACA 4; 6% NACA 5; 13% NACA 7	Case fatality rate 13%	Fatality rate in ice climbing is higher than in mountaineering and rock climbing
Schöffl et al.[1] (2008)	Ice climbing (international)	Retrospective questionnaire of 88 experienced ice climbers who evaluated their injuries over previous 3 y	95 injuries, overuse syndrome	4.07 for NACA 1–3	2.87/1000 h NACA 1; 1.2/1000 h NACA 2/3; none >NACA 3	None reported as this is a retrospective study	Ice climbing is not a sport with a high risk of injury; 61% of injuries occurred while leading, 24% while following
American Alpine Club[54] (2006)	All climbing accidents (US)	Alpine club records from 1951 to 2003 reported 6111 accidents (5931 unharmed) from 11 089 mountaineers		NS	53% NACA 0[a]; 12% NACA 7[a]; 4% NACA[a] accidents on ice	1373 fatal accidents	NS
German Alpine Club[50] (2006)	All climbing disciplines (NS)	Reports on all climbing accidents reported to the DAV insurance cover provider (2004–5)		NS	NS	NS	12% of all accidents in mountain sports are from rock and ice climbing: 48% of these are from alpine climbing, 29% sport climbing, 9% indoor climbing, 6% ice climbing and 1% bouldering
Canadian Alpine Club[55] (2005)	All climbing accidents (Canada)	Alpine club records from 1951 to 2003 reported 958 accidents involving 2003 mountaineers; 715 injured, 163 occurred on ice		NS	NS	Of 292 fatal injuries, 30 were fatal ice climbing injuries, which occurred over a 30 y period	NS

a NACA score graded by the authors according to the information given in the study.

DAV = German Alpine Club; **NACA** = National Advisory Committee for Aeronautics; **NS** = not specified.

Table V. Injuries and fatalities in mountaineering

Study (year)	Type of climbing; (geographical location; includes snow and ice terrain)	Study profile	Cause of injury; body location	Injuries per 1000 h sport performance	Injury severity	Fatality	Risk evaluation
Addiss and Baker[22] (1989)	Mountaineering and traditional climbing (US National Parks)	127 rock climbing injuries that were reported to US National Park services (1981–2)	75% falls	NS	28% NACA 7 (fatal)[a]	36 (28%) injuries on snow and ice were more likely to be fatal	Mountaineering was potentially a high-risk activity compared with rock climbing
Schussmann et al.[20] (1990)	Mountaineering and traditional climbing (Grand Tetons, WY, USA)	Data collection through National Park registration, 108 accidents	More mountaineering accidents than rock climbing	0.56 for injuries; 0.13 for fatalities	23% of the injuries were fatal (NACA 7)[b]	25 fatal cases; fatality rate 23%	Author concluded mountaineering was of a higher risk than pure rock climbing; climbing education and experience were considered preventative factors in accidents and injuries
Malcom[56] (2001)	Mountaineering (Mt Cook, New Zealand)	Fatality analysis of deaths on Mt Cook		NS	NS	0.12 for fatalities[a] or 1.87/1000 mountaineering days	Mountaineering was associated with a high risk compared with other leisure activities
Stephens et al.[57] (2005)	Unknown (Washington State Park, USA)	Retrospective, recreational injuries		NS	NS	Hiking was the most common activity during time of death with 58% fatalities. Mountaineering was 26%	NS
Monasterio[58] (2005)	Mountaineering and alpine rock climbing, maximum altitude 4000 m (New Zealand)	Prospective questionnaire regarding injuries over 4 y among 44 mountaineers (40 M; 4 F)		NS	NS	5 NACA 7 (fatal) [8.7%]; one death was unrelated to climbing, two fell into crevasses, two died by climbing misadventure (one climber was climbing alone)	Mountain climbing was associated with a high risk of serious injury and mortality; baseline climbing experience was 5–7 y

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Table V. Contd

Study (year)	Type of climbing; (geographical location; includes snow and ice terrain)	Study profile	Cause of injury; body location	Injuries per 1000 h sport performance	Injury severity	Fatality	Risk evaluation
Firth et al.[59] (2008)	Mountaineering (mountaineers, Sherpas and climbers attempting to climb Mt Everest, 8850 m, highest point in the world)	Search of Himalayan database and other records from 1921 to 2006; analysis of mortality among n = 28 276 where 192 deaths occurred	113 died from objective falls or hazards; 52 non-traumatic (sudden death, altitude illness, hypothermia); 27 body never found	NS	NS	Mountaineers had a mortality rate of 1.3%	Debilitating symptoms of high altitude pulmonary oedema associated with descent from the summit; subsequent deaths were commonly associated with late arrival times to summit and profound fatigue
German Alpine Club[50] (2006)	All climbing disciplines that were covered by the insurance provider for the German Alpine Club	Reports on all climbing accidents reported to the DAV insurance cover provider (2004–5)		NS	NS	NS	12% of all accidents that occur in mountain sports are from rock climbing: 48% of these are from alpine climbing, 29% sport climbing, 9% indoor climbing and 1% bouldering
American Alpine Club[54] (2005)	All climbing accidents (US)	Alpine club records from 1951 to 2003 reported 6111 accidents (5931 unharmed) from 11 089 mountaineers		NS	53% NACA 0[b]; 12% NACA 7[b]; 4% NACA[b] accidents on ice	1373 fatal accidents	NS
Canadian Alpine Club[55] (2006)	All climbing accidents (Canada)	Alpine club records from 1951 to 2003 reported 958 accidents involving 2003 mountaineers; 715 injured, 163 occurred on ice		NS	NS	292 fatal injuries; 30 fatal ice climbing injuries occurred over a 30 y period	NS

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Table V. Contd

Study (year)	Type of climbing; (geographical location; includes snow and ice terrain)	Study profile	Cause of injury; body location	Injuries per 1000 h sport performance	Injury severity	Fatality	Risk evaluation
Hearns et al.[60] (2006)	Mountaineers who were patients at a specialist spinal hospital (Scotland)	Retrospective study; 21 of 1400 patients identified with spinal injuries from mountaineering over 10 y; the 21 patients were followed up with questionnaires	Four rock climbing, six winter climbing, one other	NS	NS	No fatalities reported. Study was of survivors with spinal injuries from mountaineering	Incidence of spinal cord injury was less than in the overall group of spinal injury patients. Most of the 21 patients studied had other significant and potentially distracting injuries
McIntosh et al.[61] (2007)	School teaching outdoor training and wilderness skills taught at the National Outdoor Leadership School (Lander, WY, USA)	Retrospectively evaluated medical incidents and evacuations from National Outdoor Leadership School from 2002 to 2005; mean age of participants was 22 y		0.071 NACA 1[a]; 0.074 NACA 1–3[a]; 0.0056% NACA 2–3[a]	92% NACA 1[b]; 7.6% NACA 2–3[b]; none >NACA 3[b]	None	NS
McIntosh et al.[62] (2008)	Mountaineering (Mt McKinley [or Mt Denali] in Alaska, 6194 m)	Retrospectively reviewed fatalities from 1903 to 2006		0.063 for fatalities[a]	NS	3.08/1000 summit attempts, or 100/ 1 million exposure days on Mt Denali	Fatality rate is declining
McLennan and Ungersma[63] (1982)	Mountaineering (Sierra Nevada, Columbia; peaks up to 5700 m)	Retrospectively reviewed 5 y of accidents and their possible causes when climbing Class V routes	215 mountaineering accidents; 94 involved ankle and lower tibia, 17 deaths mostly involved head injuries	NS	NS	17 deaths, mostly from head injuries	Poor acclimatization with acute mountain sickness and hypothermia found in 104 patients, resulting in poor judgemental errors

a Injuries/fatalities per 1000 h calculated by the authors according to the information given in the study.

b NACA score graded by the authors according to the information given in the study.

DAV = German Alpine Club; **F** = females; **M** = males; **NACA** = National Advisory Committee for Aeronautics; **NS** = not specified.

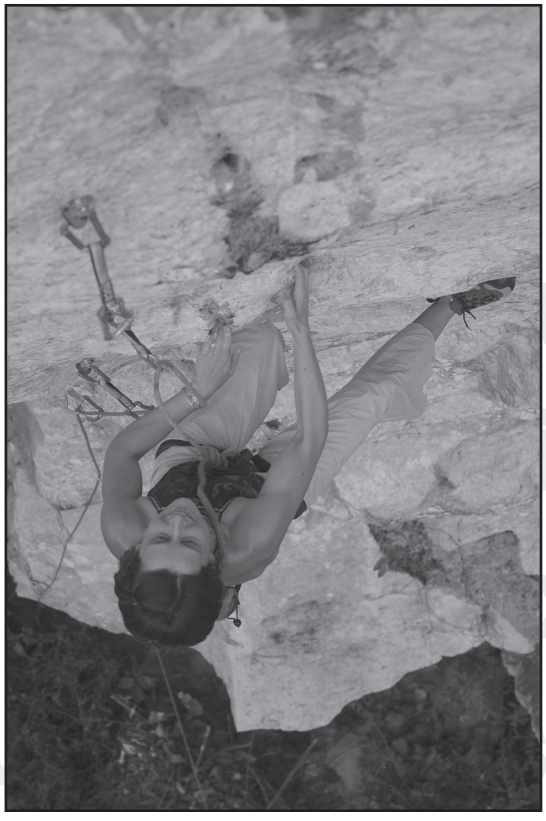

Fig. 1. Modern sport climbing, protected with bolts.

body swings into the wall with outstretched legs typically absorbing the impact.[4] More recently, Nelson and McKenzie[53] analysed American hospital emergency room records from 1990 to 2007 using data from the National Electronic Injury Surveillance System (NEISS) of the US Consumer Product Safety Commission. These reviewers also found that most of the climbing injuries were located on the lower extremities. However, this study was unable to determine what style of climbing, time of year (i.e. winter vs summer) or where exactly the accident took place (i.e. big walls). The falls were coded by mechanism (i.e. felt a 'pop', overexertion, sprain), by any descriptive narrative of the accident if available, and by whether the fall was ≤6 m or ≥6 m. Therefore, the bias of this study may report more falls ≥6 m where lower extremity injuries are more likely to result from big swings into the wall or big falls. The authors claim that the discrepancy between their finding of mostly lower extremity injuries and most other studies finding mostly upper extremity injuries may be partially explained by the minor nature of many rock climbing related injuries recalled by participants in the other surveys. Another study using a similar NEISS analysis[74] on American golf cart injuries from 1990 to 2007 found significantly more golf cart injuries resulted in emergency room admissions than from climbing – an estimated 147 696 injuries versus 40 282, respectively. The NEISS data do not permit access to information regarding patient outcomes over time, or more personal data. Addiss and Baker[22] and Schussmann et al.[20] combined data from rock climbing and mountaineering when analysing injuries in US National Parks. Both studies found mountaineering to be of a higher risk than pure rock climbing. Addiss and Baker[22] also found that falls on snow or ice were longer than falls on rock, and injuries on snow or ice were more likely to be fatal. The injury rate per 1000 hours can only be found in two studies and varied markedly from 37.5[21] to 0.56.[20]

For alpine climbing (traditional climbing), a death rate (fatality rate) was documented by Bowie et al.[21] – 13 from 220 injured climbers died – a case fatality rate of 6%. This case fatality rate was much smaller than older US records

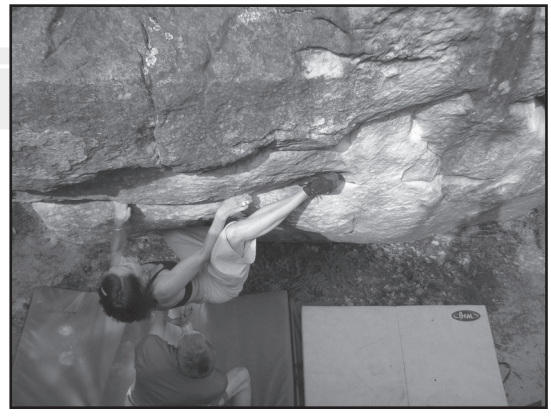

Fig. 2. Boulderer and protection (for protection a spotter [who works to direct the climber's body toward the crash pad during a fall, while protecting the climber's head from hazards] and a bouldering mat [crash pad] is used).

Fig. 3. Indoor bouldering.

from 1951 to 1960 that recorded 41%,[75] 19% for the Grand Tetons[20] in 1982 and 8% for Sierra Nevada.[63] Schussmann et al.[20] calculated an incidence of 2.5 accidents/1000 mountaineers/year or 5.6 injuries/10 000 hours of mountaineering. The 25 fatalities calculated to a fatality rate of 0.13/1000 hours or a case fatality rate of 23%. The Yosemite results from Bowie et al.[21] are in accordance with the results of Hubicka[76] for European climbing areas. As most of the analyses performed in these climbing injury studies were conducted retrospectively through questionnaires, the fatality rate is frequently biased. The 'older' studies (20 years ago)[20-22] reported the most severe injuries and the highest fatality rates, while recently, a prospectively conducted study on bouldering[51] reported no fatalities. The few bouldering injuries recorded in this latter study,[51] also found few injury differences between indoor and outdoor bouldering, which is in accordance with the data by Gerdes et al.[16]

In summary, Schussmann et al.[20] already concluded in 1990 that rock climbing has a lower injury risk than football and horse riding, but with the obvious difference that latter sports rarely result in fatalities – although this is a negotiable argument concerning horse riding.[77] Climbing frequency and difficulty were associated with the incidence of overuse injuries[29,52] in some studies, while others could not find an association.[31] Most injuries occur when lead climbing,[12,19,21,22] with falls being the most common source of acute injuries.[12,19,21,22,53] Performing hard moves was the most common cause for overuse injuries.[52] In traditional climbing, falls lead to the most injuries, while in sport climbing performing strenuous moves tended to be the cause.[16,19] Overall, the majority of all injuries in these climbing studies was of minor severity (NACA 1 and 2),[15,16,18,20-22,29,53] with a fatality rate ranging from 0% to 28%.[22,51] The vast span in between these numbers must be further evaluated through ongoing studies, and may reflect the bias of injuries recorded in the study.

3.2 Indoor Rock Climbing

Several studies explored injuries and injury rates in indoor and indoor competition climbing. Wright et al.[10] evaluated the frequency of overuse injury during the indoor 1999 World Cup Championship (n = 295) where 44% of the respondents had sustained an overuse injury, 19% at more than one site. Wright et al.[10] found

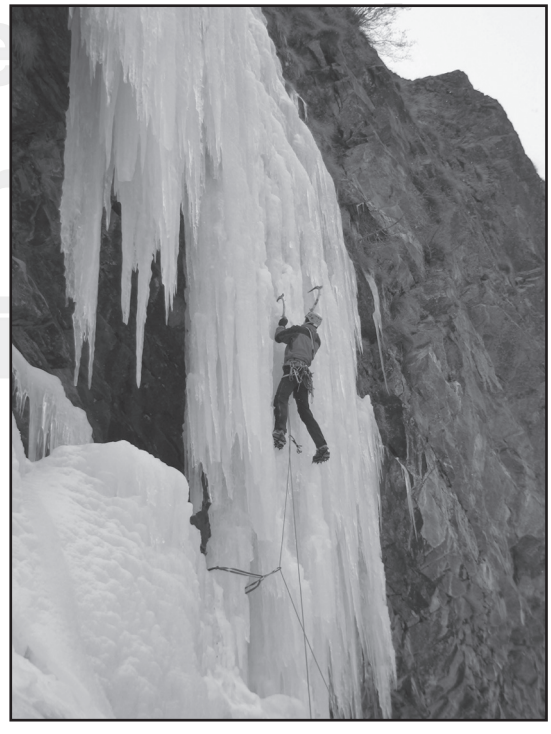

Fig. 4. Ice climbing.

an independent correlation to increased injuries ($p < 0.01$) when (i) climbing harder routes; (ii) bouldering or leading versus top rope climbing; and (iii) climbing for more than 10 years. Multivariate analysis removed the effect of sex as an independent predictor.

Jones et al.[52] similarly found increased numbers of overuse injuries or injuries caused by strenuous moves and less from fall-related injuries than in traditional and outdoor sport climbing.[12,19,21,22] Two large-scale studies[8,23] analysed indoor climbing injuries. Limb[23] reported 55 accidents from 1.021 million climbing wall visits and no fatalities. Schöffl and Winkelmann[8] prospectively surveyed 25 163 registrants at ten climbing walls. Only four significant injuries (NACA 3) were found and no fatalities; the injury risk per visit was 0.016% or 0.079 injuries/1000 hours of performance.[8] A higher injury risk rate of 3.1/1000 hours was found at the 2005 World Championships,[5] where 18 acute medical problems were treated (including 13 cases of skin bruising (see table VI).

In summary, these indoor climbing studies demonstrated a very minor injury risk and severity compared with traditional climbing and various other sports.[5,8,23] Overuse injuries were commonly reported in upper limbs, with the finger most affected.

No study reported a fatality rate, even though fatalities do occur when climbing indoors. Causation of these rare fatalities need to be addressed in future studies to distinguish whether climbing misadventure or pre-existing co-morbidities contributed most to any death.[50]

3.3 Ice Climbing

Although ice climbing is a popular sport, very little data on injuries and accidents exist. Schindera[99] reported on general 12 general glacier injuries where six patients fell into glacial crevasses and the other six slid down a glacier ice field. Patterson[100] reports about ice climbing in prose style. Mosimann[45] evaluated 46 rescued ice climbers for a non-peer-reviewed journal *Bergundsteigen*, a risk-management magazine for the German, Swiss and Austrian Alpine Clubs. Schöffl et al.[1] evaluated 88 ice climbers using a retrospective questionnaire where both ice-climbing frequency and risk behaviour were evaluated, and injuries and accidents were rated using the NACA score. In these latter two studies, most of the injuries were of minor severity. Schöffl et al.[1] found mainly open wounds (55.2%) and haematomas (21.9%), 71% were NACA 1, and no injury scored above NACA 3. The injury incidence was 4.07/1000 hours for NACA 1–3 with 2.87/1000 hours in NACA 1, and none in NACA 4–7.

Of 46 ice climbers rescued over 6 years, Mosimann[45] found 31% had no injury (NACA 0), 42% had NACA 2–3 injuries, 8% had NACA 4, 6% NACA 5, and 13% (6 climbers) had a fatal injury (NACA 7). The most frequent cause of injury was falls (55%), although no fatal injury was caused by a fall. The percentile death risk (fatality rate), which the author defined as the percentile portion of deaths in reference to the sum of all known emergencies, was reported as 13% for ice climbing. The author claimed the fatality risk was higher for ice climbing than in mountaineering (8%), ski mountaineering (7.5%) and rock climbing (4%), but gave no reference for these data.

Since 1951, the American[54] and Canadian Alpine Clubs[55] recorded details of all mountain accidents in their respective climbing areas up to 2005. The American Alpine Club report[54] recorded 6111 mountaineering accidents. The Canadian Alpine Club[55] recorded 958 accidents and then separately analysed ice-climbing accidents over a 30-year period to reveal 92 mountaineers were injured while ice climbing, 30 were fatal. The German Alpine Club recorded ice-climbing accidents that were reported to their insurance cover provider. From 2004 to 2005, 150 climbing accidents were recorded, with 12% of all accidents occurring in mountain sports.[50] Alpine mixed climbing was recorded in 8% of all accidents, water ice-climbing was 6%.

In summary, these studies demonstrated a small percentage of accidents had occurred on ice terrain. The limited data specifically on ice-climbing injuries showed a minor injury risk and some fatalities.

Table VI. Injury risk per 1000 hours of sport performance of various sports

Sport	Type of athlete studied	Injuries per 1000 hours	References
Rugby	Amateurs, competition	283	78
Rugby	Professionals, competition; summer/winter	150/52	79
Ice hockey	Professionals	83	80
Rugby	Youth	57	81
Handball	F, competition	50	82
Soccer	M, competition/training UEFA Champions League	31.6/3–5	83
Traditional climbing 20 y ago	NS	37.5	21
Motorbike	Competition, professionals – race course, cross, trial	22.4	84
American football	German first league	15.7	85
Handball	M, competition/training	14.3/0.6	86
Basketball	Professionals and amateurs, M and F	9.8	87
Soccer	M, professionals overall injury risk	9.4	83
Sailing	Yacht sailing, professionals, competition and training	8.8	88
Polo	Competition	7.8	89
Kite surfing	NS	7	90
Volleyball	School children, training	6.7	91
Ice climbing	NS	4.07	1
Soccer	F, German first league	3.1/1.4	92
Competition climbing	NS	3.1	5
Triathlon	NS	2.5	93
Boxing	Amateur and professionals	2	94
Mountain biking	NS	1	95
Ski/snowboard	NS	1	96
Nordic walking	NS	0.9	97
Mountaineering and traditional climbing	NS	0.56	20
Surfing	NS	0.41	98
Indoor climbing	NS	0.079	8
		0.027	23

F = female; **M** = male; **NS** = not specified; **UEFA** = Union of European Football Associations.

4. Comparison of Climbing to Mountaineering

As the collective skills of all forms of rock and ice climbing are required when mountaineering a comparison with mountaineering activities is important. Mountaineering may include hiking, expeditions and mixed and Alpine climbing, to climbing the highest point in the world – Mount Everest (8850 m). All these activities present different physiological demands and involve different risks – from altitude-induced illnesses (beginning from around 2500 m) to diagnosing and managing all medical problems in the wilderness.[12,19-22,28,54,60,62,99,101-113] Most studies on mountaineering fatalities and accidents present the fatality/accident number per 1000 climbers or per 1000 summits, making direct comparison with sporting studies reporting injuries 1000 hours of sports performance difficult.

McIntosh et al.[61] evaluated medical incidents at a US outdoor/wilderness school. Injuries occurred at a rate of 1.18 per 1000 programme days. Only 5% of the injuries resulted from the programme's supervised rock climbing; 44% resulted from hiking with a backpack. Stephens et al.[57] similarly found hiking (58%) was the most common activity at the time of death in a fatality and 26% in mountaineering.

McIntosh et al.[62] also reviewed mountaineering fatalities on Mount McKinley, Alaska (6194 m). More recently, fatality rates have declined to 3.08 of

1000 summit attempts. McIntosh et al.[62] found this fatality rate to be 20 times higher than those given for trekkers hiking in Nepal by Shlim and Houston[113] and even higher than those for English and Welsh mountaineers.[114] McIntosh et al.[62] adjusted denominators to allow comparison and reported a fatality rate of 100/1 million exposure days on Mount McKinley, or a calculated fatality rate of 0.063/1000 hours.

Malcom,[56] reported mountaineering fatalities on Mount Cook in New Zealand and found it to be 1.87/1000 exposure days, or a calculated 0.12 fatalities per 1000 hours of mountaineering. This figure seems extremely high and may have been the product of estimated exposure days based on hut night stays, rather than actual climbing days.[62] Firth et al.[59] calculated a mortality rate of 1.3% when examining causes of mortality among those who climbed Mount Everest from 1921 to 2006 (n = 192 fatalities from 28 276). Altitude-induced illnesses with neurological dysfunction or co-morbidities may have contributed to fatal falls (n = 113) or body disappearances (n = 27), but could not be confirmed. Pollard and Clarke,[115] similarly found that at extreme altitude, 70–80% of mountaineering deaths were related to environmental factors.

Monasterio[58] prospectively surveyed 46 rock climbers/mountaineers over 4 years to determine the type and frequency of accidents. Monasterio[58] reported five deaths – one unrelated to climbing, two in avalanche and two from climbing misadventure. Unfortunately, neither Monasterio nor Pollard and Clarke reported climbing frequency during the study period.

When summarizing the comparison of rock and ice climbing to mountaineering, the latter showed a higher injury and fatality rate. On 8000 m peaks, ascent success rates declined with summit height, but overall death rates, and death rates during descent from the summit, increased with summit height.[59,105]

5. Injury Risk Compared with Other Sports

When comparing injury risk among different sports, the relative injury risk per 1000 hours of sport exposition is a useful and established parameter. Further subdivision within a specific sport can also reflect important injury risk factors. For example, the injury risk in soccer when competing was much higher than for training[83] (table VI). Similar results were reported for female soccer,[92] snowboarding,[116] handball (male and female)[82,86,117] and indoor climbing.[5,8,23] Sex differences also influence injury risk.[118] For example, the injury risk for soccer played by females was lower than for males when training versus competing.[83,92,118] In rugby, important differences exist between amateurs and professionals,[78,79] and between juniors and adults.[78,81] A comparison of the same disciplines performed either by school children or adults also shows significant differences.[119] Comparing not only the injury risk but also the seriousness of the injuries between different sports is difficult, as no standard score is present. Becker[92] evaluated all female soccer injuries or accidents, which resulted in a drop out of one playing or training unit and further assessed this injury time out according to <1, <3 or >6 weeks. An analysis of American Football injuries in the German First League graded an injury as minor if there was a competition or training dropout of up to 1 week; longer breaks or a hospital stay were graded as severe, and intensive care unit therapy or persistent neurological or orthopaedic damage was graded as fatal.[85,120] Other studies,[95,96,98] including the study by Neville et al.,[88] that evaluate injury risks in sport disciplines do not grade the injuries at all, even for combined injuries and diseases together.

Spinks and McClure,[121] reviewed 48 studies that quantified the risk of injury from physical activity in children aged 5–15 years. There was no consistency in the injury definition among studies and the wide variation in reported injury rates did not necessarily represent actual differences in injury risk between activities. It is difficult to compare studies directly where a standardized injury severity and rate per 1000 hours of sports performance or equivalent is lacking, although some insight into sport-specific injuries may be possible.

Fatality rates among sporting studies are even more difficult to compare as natural deaths and the influence of co-morbidities[122] on sporting fatalities are up to 30% and are not often explored.[122]

In soccer, a consensus statement on injury definition and data collection procedures was a greed under the auspices of FIFA (Fédération Internationale de Football Association) Medical Assessment and Research Centre.[123] A similar statement is desirable in other sports. In summary, Schussmann et al.[20] already concluded in 1990 that rock climbing has a lower injury risk than football and horse riding, but with the obvious difference that latter sports rarely result in fatalities which is a negotiable point when considering equine-related fatalities.[77]

6. Is Climbing a High-Risk Sport?

Another aim of this study was to objectively evaluate whether climbing was a high-risk sport. Meyers encyclopaedia[124] defines extreme sports as the performance of exceptional sport disciplines where the athlete deals with high mental and physical stress. If the sport contains an objective or subjective sensed risk of damage to health or life it is considered a high-risk sport. Meyer's definition is accurate but it does not define any real risk from the athlete's perspective, that is, an experienced and highly skilled athlete is more likely to take and successfully manage higher perceived sporting risks compared with a novice. Kajtna and Tusak[125] define high-risk sports as any sport where one has to accept the possibility of severe injury or death as an inherent part of the activity. In contrast, Backx et al.[91] characterized high-risk sports as those performed mostly indoors with a high jump or contact rate, as in volleyball or basketball.

Some authors substitute the terms 'high-risk sport' and 'extreme sports' or these terms interchangeably. Young[126] included climbing under the term 'extreme sports', together with inline skating, snowboarding, mountain biking etc. Young[126] stated that the category of extreme sports was fluid and the definition was inexact. In support of Young's view, it is not known what selection criteria were for an 'extreme sport' to be included in the popular media event called the X-Games, a commercial annual sports event in the US. Climbing was occasionally represented in this annual event.

Sport disciplines that are performed by a large population are subjectively considered harmless.[127] Therefore, more mainstream sports such as soccer, handball or rugby are not perceived or characterized as high-risk sports, even though they have a high risk of injury. A sport such as kite surfing reported a modest injury rate (7/1000 hours)[90] in a 6-month prospective study (n = 235). However, the injury incidence and severity rate was high and even recorded a fatality (124 injuries, 11 severe injuries and 1 fatal).[90]

When assessing whether climbing should be considered a high-risk sport it is obvious that each climbing sub-discipline implicates different levels and types of risk of injury and fatality. When climbing outdoors, there are objective dangers and physical hazards such as variable rock and ice quality, extreme weather conditions, weapon-like equipment (ice climbing), difficult approaches and high mental and physical stress. In mountaineering, additional environmental factors can sometimes directly influence injuries and fatalities (e.g. avalanches, crevasses, altitude-induced illnesses with neurological dysfunction) but these situations can still be avoided or sometimes successfully managed (e.g. using weather forecasts, training in alpine climbing/rescue skills, obtaining knowledge of local terrain, climbing permits, acclimatization and awareness of altitude-induced illnesses, access to helicopter mountain rescue). In contrast, with indoor and sport climbing, these objective and external dangers are greatly reduced but, nevertheless, a risk of a fatal injury is still given.

The vast majority of climbers manage the above inherent risks with their climbing experience and skills, thereby avoiding serious injuries and even fatality. Sport and indoor-climbing, including competitions, cannot be considered as high-risk sporting activities.

7. Limitations of the Analysis

The heterogeneity of the data collected in the various individual studies may limit the conclusions. In some studies, the narrative or data presented on injuries did not always distinguish whether the 'climbing accident' occurred while

actively climbing or perhaps when walking or hiking towards the route. Was the accident a result of equipment failure or climbing misadventure? It is mostly unknown whether any co-existing health morbidities contributed or caused many sporting accidents or deaths. There may also be an underreporting of climbing injuries, especially the deaths associated with the sport as no mandatory reporting is required and the studies are often based upon retrospective survey data. The survey-based studies may suffer from recall bias of the participants, as well as misclassification bias by the investigators. Other limitations include possible sampling bias of these investigators (possibly not incorporating all of the studies), and difficulties in abstracting and manipulating data reported in previous publications. The calculation of climbing days into hours may also contain miscalculations. Internationally, there is no standardized method of recording climbing accidents by representative climbing bodies or otherwise. Such limitations may have resulted in a more descriptive study being realized.

In addition, all the authors are experienced rock climbers. This may have resulted in a bias, but it was also important when interpreting data (i.e. the specific geographical location of the study will suggest climbing styles, the nationality of climbers may also suggest climbing styles and techniques). Many non-climbing people, including researchers, do not differentiate among the different climbing styles because they are unaware of such differences. Rock climbing is a multi-disciplined sport. Depending on the sub-discipline examined, the climber's experience and skills, grade of route difficulty, equipment, climbing surface (e.g. type of rock or ice, artificial indoor wall, scree), the remoteness of location, altitude and weather will implicate different levels of risk. In addition to these variables, many climbers regularly participate in more than one climbing sub-discipline. Such data need to be understood in climbing injury studies.

The present authors have all experienced injuries when rock climbing and have had friends die when climbing. We are also members of the International Medical Commissions for the UIAA providing advice to more than 7 million climbers in 76 countries (V.S., T.K., A.M.) and for the International Federation of Sport Climbing (IFSC) [V.S.], and the Safety Commission of the German Alpine Club (V.S.). We deal with climbing injuries and injury analysis on a regular basis both in document form, and even when medically treating patients (V.S., T.K.). We are obviously aware of the risks involved when climbing and wish to initiate a more comprehensive sport-specific reporting of such injuries and fatalities to objectively educate everyone about the real risks associated with climbing sports, and to promote evidence-based best practice with the sport itself.

8. Conclusions

Scientific epidemiological analysis of sport-specific injuries helps to inform preventative measures that can target the injury incidence and reduce their severity, even potential fatality. It may even provide the robust criteria desirable in an objective and standardized definition of a 'high-risk' sport, which is currently lacking. According to the above definitions, few sports would qualify as not being a high-risk sport, including basketball, mountain biking, handball, soccer (contact sports) and horse riding (danger of potential fatality). Sporting fatalities should also ideally be assessed to determine whether co-existing morbidities contributed or caused the death, as opposed to sporting participation.

Of all the sports objectively analysed, indoor climbing reported the fewest injuries per 1000 hours of participation, and no fatalities. Other climbing sub-disciplines similarly reported a low injury incidence relative to mainstream sports assessed, along with a low injury severity grade. However, overuse injuries of minor severity involving the upper limbs, notably the finger, are commonly reported in rock climbing studies. Nevertheless, a small number of fatalities do occur in all climbing disciplines, mainly in alpine and ice climbing. This must be further explored in future studies, both in terms of organized and individual sporting participation.

When determining the relative injury risk in any sport, we suggest using the NACA injury

severity scoring system, for accuracy and simplicity, to evaluate 1000 hours of sport exposition. However, it is a pre-hospital score and lacks information about patient outcome – specifically, did a fatality ultimately result from a patient with a NACA score of 4 to 6 during the hospital stay? Therefore, additional information on how an injury was sustained and the final outcome would add completeness to sporting risk assessment. An international consensus statement for climbing and mountaineering is currently being drafted by the Medical Commissions of the UIAA and IFSC.[2,3]

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Correspondence: Priv.-Doz. Dr.med. *Volker Schöffl* MHBA, Department of Sportorthopedics, Orthopedic and Trauma Surgery, Klinikum Bamberg, Bugerstr. 80, 96049 Bamberg, Germany.
E-mail: Volker.schoeffl@me.com