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OVERVIEW OF CLIMBING INJURIES

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ABSTRACT

Over the past two decades, climbing has become a sport of rising popularity. It encompasses various types of indoor and outdoor disciplines, including lead climbing, bouldering, and speed climbing. A particularly significant increase in interest was observed after introducing this sport at the 2020 Tokyo Olympics. Simultaneously, a greater number of climbing-related traumas have occurred.

This review aims to improve our comprehension of injury characteristics and to summarize epidemiology, mechanisms, and prevention of such injuries. Literature evidence demonstrates that the lower and upper extremities were most frequently affected as opposed to the spine and head (Buzzacott, 2019). Fractures, sprains, and strains accounted for the largest share of injuries. Overuse injuries predominantly involve the upper extremities, while acute traumatic injuries are more frequently sustained in the lower extremities (Lutter, 2020).

Due to a lack of standard procedures for evaluating climbing performance, further studies should prioritise the standardization of research methods. Furthermore, developing evidence-based preventive strategies and accounting for diverse risk factors for climbing-related injuries, such as eating disorders and neglecting the warm-up, are crucial to enhancing patient care.

KEYWORDS

Climbing, Bouldering, Injuries, Overuse, Risk Factors, Prevention

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Introduction

Over the past two decades, climbing has evolved from a relatively specialized activity into a widely practiced activity with a rising international following. This growth has been stimulated by numerous factors, including the diversification of sport's disciplines, such as lead climbing, bouldering, and speed climbing, ensuring every participant, regardless of age or skill level, discovers a niche that suits their needs and preferences. Climbing's increasing visibility through competitive events and synchronous media coverage led to the rapid development of indoor climbing facilities, broadening accessibility and enabling year-round participation. Notably, the incorporation into the program of the 2020 Tokyo Olympic Games marked a significant milestone in global recognition (Gibson-Smith,2020). The significant rise in engagement has not only attracted a new, wide range of individuals but has also accelerated further investment in climbing infrastructure, coaching programs, and safety initiatives.

Moreover, with the escalating levels of participation, there has been a parallel rise in climbing-related injuries, drawing growing/increasing attention from sports medicine researchers. The expanding diversity of climbing disciplines has also introduced new patterns of injury, reflecting the unique biomechanical and physiological demands of each type.

Despite the growing body of literature on climbing injuries, inconsistencies in research methodology remain, including differences in methodologies, populations, and definitions of injury. As a result, making direct comparisons appears problematic and challenging. Understanding the mechanisms and risk factors underlying climbing injuries is crucial for enhancing climbers' long-term health and performance.

Therefore, the present study aims to provide a comprehensive overview of climbing-related injuries, examining their distribution across different demographic groups and climbing disciplines, while identifying key risk factors and potential preventive approaches.

Methods

This systematic literature review was performed by searching major biomedical databases, including PubMed, Google Scholar, and ResearchGate. The research strategy utilized keywords such as "climbing injuries", "bouldering injuries", "overuse climbing injuries ", "protective strategies", and "injury surveillance".

This paper specifically focused on differences between injury patterns across various climbing disciplines. Furthermore, examining a wide range of studies that report on climbing injury trends in adults and children, preventative strategies, risk factors for men, women, and both genders simultaneously, was crucial for forming a comprehensive overview. Inclusion criteria prioritized peer-reviewed articles such as observational studies and systematic reviews. The collected data were then analyzed and synthesized to create a comprehensive review.

Risk Factors

In the literature, a diverse group of factors increasing the probability of climbing injuries has been identified, highlighting the multifaceted interaction of physiological, behavioral, and training-related components.

Climbing without a proper warm-up is a common risk factor, as it reduces muscle readiness and thereby increases the likelihood of strains and tendon injuries (Schweiz, 2001); similarly, warming up with activities unrelated to climbing has been linked to a higher overall risk of injury (Chen, 2025).

Findings regarding body mass index (BMI) as a risk factor for climbing-related injuries are inconsistent. Lion et al report that BMI over 21 constitutes a significant risk factor for such injuries, whereas other studies, including Hochholzer (2003, *One Move Too Many*, Lochner), found no such correlation. Moreover, Kovářová (2024) suggests that individual factors, including BMI, sex, and age, do not significantly affect either the frequency or severity of injuries across different climbing disciplines. On the other hand, we cannot neglect the importance of sustaining the body's metabolic demands, when insufficient dietary fat intake or overall under-fueling occurs, a predisposition to injuries rises (Hochholzer T, 2003, One Move Too Many, Lochner). Importantly, physiological and nutritional issues such as eating disorders and amenorrhoea can impair recovery and bone health, further predisposing athletes to overuse injuries (Chen, 2025).

Individuals who pursue more advanced levels of climbing and those training primarily to improve overall fitness face an elevated risk of injury, regardless of their present performance level (Grønhaug, 2024). Surprisingly, lack of participation in sports other than climbing is also associated with climbing injuries. (Chen, 2025). A study conducted by Grønhaug et al suggests that athletes who engage in multiple climbing disciplines demonstrate greater susceptibility to injury, in comparison to those who specialize in a single discipline.

Performing bouldering, a climbing subdiscipline characterized by short, high-intensity climbs, is also widely recognized as a risk factor for climbing injuries due to its explosive nature (Chen, 2025). Additionally, campus board exercises are known to be one risk factor for epiphyseal fractures in young climbers (Schöffl, 2015). Interestingly, while regular hangboard training is often used to improve finger strength, it may also increase the risk of tendon-related injuries (Chen, 2025).

The effects of mobility or flexibility-focused training remain debated, with no clear consensus in the literature on whether it heightens the risk of climbing injury (Chen, 2025). Therefore, additional studies are needed to assess whether these potential risk factors remain significant after adjustments are made for other relevant variables, including specific climbing-related factors, particularly style, frequency, and environmental conditions. Such analyses assist in determining whether the observed relationships are independent or influenced by confounding factors.

While considering key determinants of injury risk in climbing, we cannot omit human factors, particularly diminished concentration and fatigue. Cognitive fatigue impairs a climber's ability to accurately assess holds, judge distances, and execute specific movements, increasing the likelihood of technical errors and compromised decision-making during ascent. Similarly, a decline in attentional capacity may delay reaction times, especially in dynamically changing conditions; therefore, climbers' vulnerability to falls and improper usage of protective equipment is elevated (Kováˇrová, 2024). These effects tend to intensify during prolonged climbing sessions or under physically demanding conditions, highlighting the importance of maintaining elevated awareness and rigorously following established safety protocols. Consequently, effective injury prevention in climbing must incorporate strategies that address human performance limitations, such as structured rest intervals, self-monitoring of psychophysical status, and consistent reinforcement of safety practices.

Prevention

Effective prevention of climbing injuries requires a comprehensive approach that integrates physical preparation, technical knowledge, and appropriate supervision.

Climbing-specific warm-up routines consisting of approximately 100 climbing moves play a crucial role, as it has been shown to reduce the risk of finger injuries by improving tendon movement and distributing load more evenly along the flexor tendon sheath (Schweizer 2001). While in subsequent research, the same author suggested a warm-up of 3–4 routes of approximately 40 moves each, or 8–12 boulder problems with progressively increasing intensity, and minimizing the use of a pronounced crimp grip position is recommended (Schweizer, 2012). Interestingly, engaging in cross-training through participation in non-climbing sports may offer a protective effect against climbing-related injuries (Chen, 2025).

Adequate daily iron intake is an essential protective action, since lack of that element is linked to, e.g, overall fatigue, and the majority of women can suffer from its non-optimal level (Gibson-Smith, 2020). Additionally, caffeine was proven to enhance alertness and accelerate reaction times through stimulation of the nervous system, as it elevates intramuscular calcium and lowers potassium concentrations outside the muscles, resulting in a postponed point of fatigue (Hochholzer T, 2003, One Move Too Many, Lochner).

To prevent injuries while climbing, it is essential to adopt a proper falling technique. Climbers should aim to absorb impact primarily through their feet and use their hands to protect the face and head, especially when not wearing a helmet. Additionally, avoiding grabbing or entangling the rope during a fall reduces the risk of rope-related injuries. Practicing controlled falls in a safe environment can further help climbers develop reflexes that minimize the likelihood of serious harm (Schöffl, 2008). Furthermore, consistent use of protective equipment, such as fall mats, is also a key component of injury prevention (Beurienne, 2025). A system of partner check and proper training of dynamic belay techniques should be implemented into the lead climbing routine to avoid misuse of equipment and falls. Moreover, a standardization of the coach-licensing process is fundamental for ensuring new members' safety (Schöffl, 2013).

Importantly, age-appropriate and sport-specific medical supervision, along with targeted education, are recommended (Barrile, 2022; Lutter, 2019). To avoid epiphyseal stress reactions, it is essential to promote adequate load management and recovery, especially among young athletes who are highly motivated to train and climb continuously. (Lutter, 2020)

Consistently adhering to established safety protocols becomes an essential component of effective injury prevention. Consequently, effective injury prevention in climbing must incorporate strategies that address human performance limitations, such as well-structured rest intervals, self-monitoring of psychophysical state, and continuous reinforcement of safety practices (Kováˇrová, 2024).

Collectively, these strategies constitute an integrated framework for reducing injury risk and promoting long-term athletic sustainability in climbing.

Results

The rapid growth of climbing has been accompanied by a notable rise in climbing-related injuries, with fractures, sprains, and strains representing the most common types (Nelson, 2009). There is a strong consensus that upper-extremity injuries are the most frequent (Schöffl, 2015), with chronic overuse conditions occurring more frequently than acute trauma, which is described to happen only 0.02 per 1,000 hours of climbing, with no significant difference observed between male and female participants (Schöffl,2013).

Injury patterns vary across climbing disciplines and techniques. Overall, the severity of injuries in climbing is generally low. Acute injuries are particularly associated with bouldering, whereas rope-protected climbing generally exhibits lower rates of acute trauma (Lutter, 2020).

Indoor wall climbing commonly results in injuries to the arm, hip, and back, while lead climbing and outdoor climbing more frequently involve the head, neck, chest, shoulder, forearm, thigh, knee, shin, and Achilles tendon. Bouldering, in contrast, is associated with injuries to the hand, thumb, wrist, elbow, and ankle (Kovářová, 2024).

Overuse injuries primarily affect the upper extremities, whereas acute traumatic injuries are more often observed in the lower extremities, largely resulting from falls (Lutter, 2020; Schöffl, 2016). Similarly, injuries that predominantly occur in outdoor environments, particularly on mountain and rock walls, where variable terrain and environmental hazards contribute to increased risk, are predominantly the result of falls (Identeg, 2021). For example, alpine climbing is associated with a higher incidence of traumatic injuries (Schöffl, 2015).

Finger injuries, particularly pulley injuries, remain highly prevalent, with the A4 pulley currently more commonly affected than the A2 pulley (Lutter, 2020; Schöffl, 2015). Carpal tunnel syndrome is the most

frequent nerve compression disorder and the leading reason for surgical nerve decompression in climbers (Schweizer, 2012). Compared to previous studies, there is a higher incidence of shoulder injuries (Grønhaug, 2024), including dislocations, acromioclavicular joint injuries, knee injuries, wrist strains, and epiphyseal fractures of the fingers. At the same time, the number of climbing-specific injuries, such as finger pulley injuries and epicondylitis, lowered (Lutter, 2020). Knee and shoulder injuries during bouldering are predominantly linked to ground falls, with ACL tears increasingly observed, ranking as the third most common acute knee injury in climbers (Vagy, 2025). The majority of pelvic injuries involved either complete or partial avulsion of the tendons. (Schöffl, 2016)

This climbing-specific heel hook technique places significant stress on both muscular and passive structures of the posterior thigh, contributing to acute hamstring injuries, posterior cruciate ligament injuries, posterior meniscal injuries, and partial-thickness hamstring tears (Ehiogu, 2020).

Sex- and age-specific patterns have also been observed. Female climbers most commonly sustain shoulder injuries, whereas male climbers predominantly experience finger injuries (Grønhaug, 2024). Males additionally report more chronic injuries, prolonged durations of pain, and extended time away from climbing. Additionally, they tend to delay seeking medical care for their injuries. (Schöffl, 2025). A study performed by Madsen et al indicated that female climbers and those under 18 years of age are more frequently involved in falls within indoor or artificial climbing environments, typically from low heights, whereas male climbers and individuals aged 18 to 50 are more commonly injured in outdoor settings, often from falls of moderate height (Madsen, 2025). Older, more experienced climbers demonstrated a clear predominance of overuse injuries over acute injuries (Schöffl, 2015). Among adolescents, overuse injuries of the upper extremities are most common, with climbers under 16 years frequently exhibiting primary periphyseal stress injuries of the fingers (Schöffl, 2025).

Discussion

The findings of this study present the multifactorial nature of climbing injuries, emphasizing the influence of demographic, physiological, and sport-specific factors on injury patterns, which differ substantially, reflecting the unique biomechanical and physiological demands of each style.

Comparing the available literature raises several challenges due to substantial variability across research designs and populations. The studies often examine different climbing subdisciplines and environments, such as indoor climbing, sport climbing, alpine climbing, or bouldering, notably limiting direct comparability. Furthermore, populations examined vary considerably, ranging from professional athletes to recreational climbers, creating additional diversity. Methodological differences, including inconsistent injury classifications and variations in medical terminology, further complicate the comparison process. Several studies rely on retrospective self-reported data (Grønhaug, 2018), which raises concerns regarding recall bias and objectivity, whereas others include only hospitalized patients, potentially overrepresenting more severe injuries (Nelson, 2009). In addition, a body of research focuses exclusively on a particular type or localization of injury (Pach, 2024; Vagy, 2025).

Despite these difficulties, several consistent patterns emerge. Upper-extremity injuries remain the most prevalent, with chronic overuse conditions occurring more frequently than acute trauma (Schöffl, 2013, 2015). Bouldering is consistently associated with a higher incidence of acute injuries compared to rope-protected climbing (Lutter, 2020), whereas rope-assisted disciplines generally display lower rates of acute trauma. Finger injuries, particularly pulley injuries, remain highly prevalent, with a shift from A2 to A4 pulley involvement noted in recent years (Lutter, 2020; Schöffl, 2015). Shoulder injuries have increased in frequency, alongside knee injuries, wrist strains, and epiphyseal fractures (Grønhaug, 2024; Lutter, 2020).

Age- and sex-specific differences are notable. Female climbers more commonly sustain shoulder injuries, while male climbers are prone to finger injuries, chronic conditions, and prolonged recovery, often delaying medical consultation (Grønhaug, 2024; Schöffl, 2025). However, with presently available data, the question of whether men or women are more prone to climbing injuries cannot be answered (Lutter, 2020; Schöffl, 2015). Adolescents under 16 frequently present with primary periphyseal stress injuries, reflecting growth plate vulnerability (Schöffl, 2025). Environmental factors also influence injury risk: indoor, low-height falls predominate among females and younger climbers, whereas outdoor moderate-height falls are more common in adult males (Madsen, 2025).

Multiple risk factors contribute to climbing injuries, including inadequate warm-up routines, excessive use of hangboards or campus boards, limited cross-training, and nutritional deficiencies (Schweizer, 2001,

2012; Chen, 2025; Hochholzer, 2003; Gibson-Smith, 2020). Cognitive fatigue further increases susceptibility, highlighting the need to address both physical and mental performance factors.

Preventive measures should integrate structured warm-up routines, cross-training, adequate nutrition, appropriate falling techniques, use of protective equipment, and individual coaching and medical supervision (Schweizer, 2001, 2012; Beurienne, 2025; Lutter, 2019; Kovářová, 2024).

In summary, climbing presents unique challenges in injury prevention due to its diversity of disciplines, techniques, and participant characteristics. The literature demonstrates the necessity of tailored strategies that consider individual, environmental, and behavioral factors. Future research should aim to establish standardized methodologies and prevention programs tailored to specific climbing disciplines and demographic groups.

Conclusions

Despite limitations, the literature reveals a number of consistent patterns across studies.

Upper-extremity injuries consistently represent the most common type of climbing-related trauma, while overall injury severity remains low. Acute trauma is primarily associated with bouldering, whereas rope-assisted disciplines show comparatively fewer acute incidents. Sex-specific differences persist, with shoulder injuries being more prevalent among female climbers and finger injuries occurring more often among males, who also report more chronic conditions. Engaging in a broader variety of sports rather than climbing alone appears advantageous for injury prevention. Collectively, the evidence emphasizes the importance of preventive strategies focused on load regulation, proper technique, and targeted strength development.

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