International Journal of Innovative Technologies in Social Science

e-ISSN: 2544-9435

Operating Publisher
SciFormat Publishing Inc.
ISNI: 0000 0005 1449 8214

2734 17 Avenue SW,
Calgary, Alberta, T3E0A7,
Canada
+15878858911
editorial-office@sciformat.ca

ARTICLE TITLE	FINGER TRAINING ON A HANGBOARD: EFFECTIVENESS, SAFETY, AND PREVENTION OF OVERUSE INJURIES IN ROCK CLIMBERS – A NARRATIVE REVIEW
DOI	https://doi.org/10.31435/ijitss.3(51).2026.6017
RECEIVED	23 May 2026
ACCEPTED	27 August 2026
PUBLISHED	31 August 2026
LICENSE	The article is licensed under a **Creative Commons Attribution 4.0 International License.**

FINGER TRAINING ON A HANGBOARD: EFFECTIVENESS, SAFETY, AND PREVENTION OF OVERUSE INJURIES IN ROCK CLIMBERS – A NARRATIVE REVIEW

Weronika Kuśmierczyk *(Corresponding Author, Email: weronika.kusmierczyk51@gmail.com)*
Samodzielny Publiczny Szpital Kliniczny im. prof. W. Orłowskiego CMKP, Czerniakowska 231, 00-416 Warsaw, Poland
ORCID ID: 0009-0000-5704-1485

Oliwia Grzelak
Mazowiecki Szpital Bródnowski, Ludwika Kondratowicza 8, 03-242 Warsaw, Poland
ORCID ID: 0009-0001-3649-1134

Oliwia Bolek
Central Clinical Hospital, Medical University of Warsaw, Stefana Banacha 1A, 02-097 Warsaw, Poland
ORCID ID: 0009-0006-2399-9808

Maria Fengier
Medical University of Warsaw, Żwirki i Wigury 61, 02-091 Warsaw, Poland
ORCID ID: 0009-0002-9201-5703

Justyna Kącikowska
Dr. Anna Gostyńska Wolski Hospital, Marcina Kasprzaka 17, 01-211 Warsaw, Poland
ORCID ID: 0009-0007-1399-9553

Magdalena Majkowska
Medical University of Warsaw, Żwirki i Wigury 61, 02-091 Warsaw, Poland
ORCID ID: 0009-0001-7472-9537

Krzysztof Rogulski
National Medical Institute of the Ministry of Interior and Administration, Wolska 137, 02-507 Warsaw, Poland
ORCID ID: 0009-0006-7091-0546

Katarzyna Sordyl
Samodzielny Publiczny Zespół Zakładów Opieki Zdrowotnej w Wyszkowie, Komisji Edukacji Narodowej 1, 07-200 Wyszków, Poland
ORCID ID: 0009-0005-1438-154X

Piotr Szczepański
University Clinical Centre of the Medical University of Warsaw, The Infant Jesus Clinical Hospital, Lindleya 4, 02-005 Warsaw, Poland
ORCID ID: 0009-0007-1064-6947

Jakub Trzaskowski
Gajda-Med District Hospital in Pułtusk, Piotra Skargi 23/29, 06-100 Pułtusk, Poland
ORCID ID: 0009-0001-1517-0948

ABSTRACT

The aim of this narrative review was to synthesize current evidence on the effectiveness, safety, and preventive value of hangboard training in adult climbers. The analysis included 45 studies published between 2016 and 2026 examining finger-strength and endurance development, neuromuscular adaptations, injury risk, and rehabilitation protocols.

The findings indicate that hangboard training significantly increases maximal finger strength and, to a lesser extent, finger endurance. The greatest strength improvements occur when loads exceeding 80% of maximal finger force are applied and when progressive overload is implemented. Submaximal protocols are more effective for enhancing endurance and combining different training intensities may produce cumulative benefits. Training safety depends on gradual load progression, appropriate session frequency, and careful control of overall climbing volume. Incorporating exercises for both flexors and extensors, along with varied grip types, may reduce the risk of overload. Evidence highlights the need for individualized programming due to substantial variation in strength profiles and tolerance to loading among climbers.

Hangboard training is an effective way to develop essential physical qualities in climbing. However, optimizing outcomes and minimizing injury risk require personalized training protocols and systematic monitoring for early signs of overload.

KEYWORDS

Hangboard, Finger Training, Overuse Injuries

CITATION

Weronika Kuśmierczyk, Oliwia Grzelak, Oliwia Bolek, Maria Fengier, Justyna Kącikowska, Magdalena Majkowska, Krzysztof Rogulski, Katarzyna Sordyl, Piotr Szczepański, Jakub Trzaskowski. (2026) Finger Training on a Hangboard: Effectiveness, Safety, and Prevention of Overuse Injuries in Rock Climbers – a Narrative Review. *International Journal of Innovative Technologies in Social Science*. 3(51). doi: 10.31435/ijitss.3(51).2026.6017

Introduction

Rock climbing has experienced substantial global growth over the past decade, reflected in its inclusion in major international sporting events and the rapid expansion of indoor climbing facilities.

Among the various physical attributes relevant to climbing, finger strength consistently ranks among the strongest predictors of performance. It reliably distinguishes climbers across ability levels, from recreational participants to elite athletes (Draper et al., 2021; Laffaye et al., 2016; MacKenzie et al., 2020; Michailov et al., 2018). Climbing-specific finger force production is directly linked to the capacity to maintain grip on small holds, execute complex movement sequences, and perform effectively across a range of climbing styles (Buraas et al., 2025; Stefan et al., 2022). Evidence also shows that fingertip force production across different grip positions correlates with performance on climbing routes that utilize those specific grip characteristics (van Bergen et al., 2023). Furthermore, several studies indicate that single-finger strength may serve as a more precise predictor of high-level performance than general handgrip strength, highlighting the unique biomechanical demands of climbing (Stefan et al., 2022; Stien et al., 2019). For example, Stien et al. (2019) demonstrated that bouldering specialists exhibit greater maximal finger strength than lead climbers, whereas finger endurance is comparable across these groups, underscoring discipline-specific differences within the sport.

Hangboard training has become one of the most widely used and influential modalities for developing climbing-specific finger strength. This form of training enables highly targeted loading of the finger flexors and supports the development of maximal strength, explosive force, and muscular endurance in grip positions characteristic of climbing (Devise et al., 2022; Hermans et al., 2022). Although multiple hangboard protocols have demonstrated efficacy, the magnitude and specificity of adaptations depend strongly on training intensity, structure, and duration (López-Rivera & González-Badillo, 2019).

The central role of finger-strength training also raises important safety and long-term impact considerations. Evidence suggests that inadequate load management and poorly structured training programs may increase the risk of finger injuries, particularly pulley strain and overuse-related pathologies (Sjöman et al., 2023). Research in injury management emphasizes the structural vulnerability of finger tissues and highlights the importance of balancing progressive loading with tissue safety (Hartnett et al., 2024). Comparative investigations of various finger-strengthening modalities further underscore the need to assess both physiological adaptations and associated injury risks (Dindorf et al., 2024; Javorský et al., 2023; Limmer et al., 2020). Greater awareness of load monitoring and symptom tracking is reflected in the development of climbing-specific assessment tools such as the VISA-C questionnaire (Gilmore et al., 2025).

As the sport continues to evolve, the need for a deeper scientific understanding of the physical determinants of climbing performance, as well as standardized, validated assessment methods, has become increasingly apparent. Despite the expanding body of literature, few studies integrate training stimuli, performance outcomes, injury risk, and preventive strategies into a unified framework (Bogensperger, 2022; Saeterbakken et al., 2024b). Much of the research examines isolated aspects of training or performance, limiting the ecological validity and practical applicability of findings in real-world settings (Langer et al., 2023; Stien et al., 2023). Consequently, the aim of this review is to synthesize current evidence on finger-training modalities and evaluate how they influence training effectiveness, safety, and long-term athletic development in climbing.

Methods

This narrative review was designed to synthesize contemporary evidence on the effectiveness, safety, and injury-prevention relevance of hangboard-based finger strength training in adult rock climbers. To ensure the inclusion of current, contextually meaningful findings, only studies published within the last 10 years (2016–2026), written in English, and conducted with adult participants were deemed eligible. Research was included if it examined finger strength development, hangboard training interventions, climbing-specific performance outcomes, or injury mechanisms related to finger flexor loading. Studies involving adolescent populations, non-climbing-specific training modalities, or unrelated upper-limb pathologies were excluded.

The primary literature search was conducted in PubMed using three predefined search algorithms targeting complementary conceptual domains: finger strength and climbing-specific training, hangboard-related injuries and overuse conditions, and finger training variables linked to safety, efficacy, and performance outcomes. The first algorithm focused on climbing-specific finger strength and hangboard interventions; the second targeted injuries and overuse syndromes associated with fingerboard loading; and the third combined variables of finger strength training with indicators of safety, effectiveness, and performance enhancement. To broaden the search scope and reduce the likelihood of omitting relevant studies, Google Scholar was additionally queried using an algorithm tailored to capture research addressing hangboard training, finger strength development, and injury-prevention strategies.

All retrieved records were initially screened based on title and abstract, followed by full-text evaluation in accordance with the predefined inclusion and exclusion criteria. Reference lists of key articles were manually examined to identify additional relevant publications. In total, forty-five studies met all eligibility criteria and were included in the final synthesis. Due to substantial heterogeneity across study designs, training protocols, outcome measures, and injury classification systems, the findings were analyzed using a narrative synthesis approach.

Results

Analysis of 45 publications indicates that hangboard training is among the most influential methods for developing finger flexor strength and endurance in climbers, with clear implications for performance enhancement and overload-related injury risk. The findings across studies have been clustered into five major domains: effects on maximal strength, endurance, and fatigue resistance, comparative effectiveness of different protocols, neuromuscular and biomechanical adaptations, and the relationship between hangboard training, injury risk, and rehabilitation.

1. Effects of Hangboard Training on Maximal Finger Strength.

The available evidence consistently demonstrates that hangboard training substantially enhances maximal finger flexor strength across intermediate, advanced, and elite climbers. Randomized controlled trials (Hermans et al., 2022; Mundry et al., 2021) reported significant increases in maximal finger strength compared with climbing-only control groups. Both studies examined intermediate-to-advanced and advanced climbers. Among the evaluated protocols, progressive loading with external weight appears to be the most effective method for eliciting strength adaptations. In contrast, endurance-oriented hangboard training (i.e., prolonged hangs on smaller edges without additional load) did not produce significantly greater strength improvements than regular climbing alone (Mundry et al., 2021). Importantly, a structured hangboard program performed twice per week was sufficient to induce meaningful strength gains over a 10-week period (Hermans et al., 2022). Devise et al. (2022) demonstrated that training at 80% or greater of maximal finger strength (MFS) is necessary to elicit significant strength improvements in a 4-week block. However, the study reported no significant strength gains in groups training at 80% and 60% of MFS.

Comparable results were observed by Gilmore et al. (2024), who demonstrated that different loading paradigms elicit distinct yet consistently positive strength adaptations. This study showed that a 10-minute low-intensity hangboard protocol (“Abrahangs”) produced significant increases in finger strength. Notably, the improvements obtained from low-intensity hangs were roughly equivalent to those resulting from a traditional high-intensity “max hangs” protocol. Moreover, combining low-intensity and maximal-intensity hangs yielded additive strength gains that exceeded those achieved with either method alone, suggesting complementary physiological adaptations across loading strategies.

Ruiz-Lopez et al. (2025) compared a high-intensity, low-volume protocol with a moderate-intensity, higher-volume protocol in experienced climbers. Both approaches effectively improved maximal finger strength, although the high-intensity protocol elicited greater gains. The moderate-intensity protocol, however, was better tolerated by participants, with no injury reports.

Dindorf et al. (2024) investigated neuromuscular electrical stimulation (NMES)-based fingerboard training; however, no changes in maximal strength were observed over the 7-week study period.

2. Effects on Endurance and Fatigue Resistance.

Beyond maximal strength, numerous studies have reported substantial improvements in finger flexor endurance following hangboard interventions. López-Rivera & González-Badillo (2019) compared the effects of three hangboard protocols—maximal strength, endurance, and intermittent training—and demonstrated that each protocol improved grip endurance, with the interval-style training yielding the greatest gains. The authors emphasized that climbing is inherently intermittent, consisting of effort–rest cycles, which likely explains why this protocol aligned most closely with performance improvements. Interestingly, the maximal force protocol also produced significant gains in endurance.

These findings contrast with those of Devise et al. (2022), who reported increased endurance only in groups performing intermittent training at 60% and 80% of maximal finger load. Submaximal intermittent training at moderate relative intensities appears most effective for enhancing stamina during repeated hang cycles, while lower-intensity intermittent loading better promotes fatigue resistance. In the study of Herman et al. (2022), finger endurance increased within the hangboard group but not significantly more than in the control group, indicating that standard hangboard protocols primarily enhance maximal strength rather than endurance.

Dindorf et al. (2024) reported that integrating neuromuscular electrical stimulation (NMES) with hangboard training may yield endurance gains comparable to those of conventional protocols. The NMES-augmented twice-weekly program was non-inferior to the conventional thrice-weekly training in improving climbing-specific finger flexor endurance, suggesting that NMES can maintain training effectiveness even with a reduced total training volume.

Physiological studies (Baláš et al., 2021; Baláš et al., 2024; Ferrer-Uris et al., 2023) have confirmed that hangboard training improves forearm work economy and delays fatigue-induced force decline, indicating task-specific metabolic adaptations. Baláš et al. (2021) emphasized that tests such as dead-hangs, intermittent hangs, and force–time profiles are highly specific for finger flexor capacity but do not capture a climber's holistic endurance. Therefore, finger endurance should be assessed in conjunction with global aerobic capacity to more accurately predict performance outcomes.

The widely used finger hang test, while predictive of performance, predominantly reflects strength rather than endurance (Berta et al., 2025).

3. Comparative Effectiveness of Different Hangboard Training Methods and Protocols.

Based on the comparative analysis of the aforementioned studies, the following general results can be presented. Maximal strength is most effectively improved through high-intensity loads (>80% of maximal finger strength, MFS) and combined training protocols (Devise et al., 2022; Gilmore et al., 2024; Hermans et al., 2022; Mundry et al., 2021). Finger endurance is primarily enhanced by interval and submaximal protocols (López-Rivera & González-Badillo, 2019; Devise et al., 2022). Maximal-intensity training can also support endurance, although the effect is smaller. Dynamic finger training (Saeterbakken et al., 2024c) and the combination of low- and maximal-intensity hangs (Gilmore et al., 2024) increase functional strength and facilitate transfer to actual climbing performance. The application of neuromuscular electrical stimulation (NMES) appears limited to maintaining endurance under reduced training volume. It is important to note the relatively short duration of the training interventions studied, ranging from 4 weeks (Devise et al., 2022) to 16 weeks (Gilmore et al., 2024). While this indicates rapid training effects, it simultaneously limits the ability to draw conclusions regarding long-term adaptations or potential overuse injuries.

Based on the available evidence, no single training protocol can be proven superior, and the observed training effects cannot be directly translated into improvements in overall climbing performance. However, diversifying training protocols and grip types may positively influence adaptation to the wide range of demands encountered in real climbing situations.

A study employing blood-flow restriction (Javorský et al., 2023) showed that BFR can maintain or even improve strength and endurance despite lower external loads, making it potentially useful for climbers progressing through injury rehabilitation. This was not confirmed in the study by Mckellar & Burr (2026), whose results indicate that climbing-specific performance and forearm blood flow adaptations can occur with typical hangboard and climbing training, and that adding post-climbing BFR does not provide a clear additional benefit over traditional training for performance gains. Similarly, ischemic preconditioning did not improve finger-flexor strength or endurance in elite climbers (Platzer et al., 2026).

4. Neuromuscular and Biomechanical Adaptations to Hangboard Training.

Studies have reported that hangboard training elicits climbing-specific neuromuscular adaptations, including improved forearm muscle coordination, enhanced motor-unit recruitment, and increased finger stiffness under load. Most investigations employ sEMG and maximal force assessments as indicators of neuromuscular adaptation (Stien et al., 2022). Grip type substantially alters both the relative involvement of specific muscles and the efficiency with which they generate force (Ferrer-Uris et al., 2023). The sloper grip promotes more balanced activation across the entire forearm and is associated with higher muscular efficiency. In contrast, the crimp grip requires greater activation of the *flexor digitorum superficialis*, imposing higher mechanical and metabolic demands on the finger flexors while being less energy efficient. EMG analyses also indicate greater fatigue of the finger flexor muscles during small-hold tasks (Vigoroux et al., 2019). Small edges simultaneously increase overall muscular engagement and require greater neuromuscular control, whereas larger holds primarily load the finger flexors with reduced stabilisation demands.

Stefan et al. (2022) and Buraas et al. (2025) further emphasise the importance of the distribution of individual finger strength for effective force generation—an ability that appears highly responsive to targeted hangboard training.

Biomechanical validation studies (Stien et al., 2025; van Bergen et al., 2023) confirm that grip type, elbow position, and overall body configuration modulate the mechanical demands placed on the finger flexors, supporting the rationale for individualised hangboard programming based on climbing style and performance objectives.

Mckellar & Burr (2026) analysed the effects of blood-flow-restriction (BFR) hangboard training. The study did not demonstrate any systematic cardiovascular adaptations attributable specifically to BFR. However, participants exhibited improved forearm haemodynamic responses following training, indicating enhanced blood flow and oxygen utilisation dynamics in the finger flexor musculature. These physiological changes may contribute to the observed improvements in climbing performance, although the addition of BFR did not provide clear advantages over conventional (non-BFR) hangboard training.

5. Relationship Between Hangboard Training, Injury Risk, Prevention, and Rehabilitation.

Finger injuries, particularly finger pulley injuries, are among the most common overuse injuries in climbing (Bogensperger, 2022). Climbers who focus on strength- and performance-oriented training—including hangboard, campus board, and weighted pull-ups—exhibit higher rates of both acute and overuse injuries compared to climbers who train primarily for general fitness or endurance (Grønhaug et al., 2024). In contrast, well-structured hangboard programs can enhance muscle balance and improve the load tolerance of finger structures, contributing to injury prevention.

Saeterbakken et al. (2024a) emphasize that gradual load progression increases tissue capacity—particularly in the finger flexors, the pulley system, the forearm flexor–extensor complex, and the shoulder stabilizers—thereby reducing susceptibility to overuse injuries. Conversely, sudden spikes in intensity, often observed in poorly planned hangboard programs, pose a major risk of finger injury. To mitigate this risk, resistance training should be periodized and coordinated with overall climbing volume to avoid excessive clustering of high-intensity sessions. The review also highlights the importance of individualized training based on the specific climbing discipline. Strengthening stabilizers and extensors is critical for preventing imbalances relative to the dominant flexor musculature. Evidence further indicates that dynamic finger loading (e.g., controlled fingertip pull-ups) can increase finger strength while imposing less strain on the A2 pulley compared with maximal static hangs. Long-term, year-round strength training additionally supports the development of robust injury resilience.

These conclusions align with those of Sjöman et al. (2023), who highlight the critical role of progression rate in minimizing injury risk. High-intensity training, such as maximal hangboard protocols, was associated with a higher incidence of finger strain symptoms. Rapid increases in training load—particularly in hangboard intensity—were strongly linked to the development of pulley-related injuries. Not only high intensity, but also training frequency, contributed to the increased incidence of annular ligament injuries. The study also emphasizes the importance of balanced flexor–extensor conditioning. Similarly, Bogensperger (2022) and Devise et al. (2023) stress balanced training, including strengthening flexors, extensors, and stabilizers, to prevent muscular imbalances and reduce injury risk. Hartley et al. (2023) also point out the need to minimize differences in strength between the dominant and non-dominant hand.

Ferrer-Uris et al. (2023) demonstrate that grip type strongly influences muscle activation and coordination during maximal dead-hangs. Aggressive crimp positions engage intrinsic hand muscles to a greater extent, whereas sloper hanging positions produce higher relative activation of wrist- and finger-stabilizing muscles, reflecting a greater demand for joint control. These findings have direct implications for training design, suggesting that varied grip exposure can stimulate targeted musculature, enhance neuromuscular coordination, and improve injury resilience. Such evidence supports a grip-diverse training approach, rather than reliance on a single hang type. Anderson et al. (2016) highlight the importance of hangboard construction ergonomics for reducing pulley overload, providing practical insights for safe hangboard design.

Epidemiological and editorial analyses (Grønhaug et al., 2024; Saeterbakken et al., 2024b; Sjöman et al., 2023) reinforce that injury outcomes depend strongly on experience level, progression rate, and symptom monitoring, emphasizing the need for individualized load management.

During hangboard training, fatigue and intensity should be carefully monitored to prevent injuries (Bogensperger, 2022; Saeterbakken et al., 2024a). Gilmore et al. (2025) introduced the climbing-specific VISA-C questionnaire, a self-administered tool that effectively distinguishes between injured and non-injured climbers, with higher scores indicating better hand and finger function.

Determining the optimal training intensity remains challenging. Several studies provide specific protocol descriptions that define safe and effective load zones, including: Mundry et al. (2021), Hermans et al. (2022), Gilmore et al. (2024), Devise et al. (2022), López-Rivera & González-Badillo (2019), and Ruiz-López et al. (2025). Notably, the longest of these interventions lasted 10 weeks (Mundry et al., 2021; Hermans et al., 2022).

Clinical and rehabilitation-focused studies (Bogensperger, 2022; Bouyer et al., 2016; Hartnett et al., 2024; Schneeberger & Schweizer, 2016) indicate that controlled, progressive isometric training can be beneficial for pulley and tendon injuries, provided that load increments are carefully monitored. Gradual progression during rehabilitation, focusing on incremental load increases, may allow a return to climbing within 3–6 months following confirmed A2 or A3 pulley ruptures (Schneeberger & Schweizer, 2016). While not all studies included hangboard training in their rehab protocols, its potential utility can be inferred based on the selection of appropriate grips and loads for the rehabilitation stage.

Low-intensity active recovery appears more effective than passive rest (Krupková et al., 2024), suggesting that hangboard-based blood-flow-promoting activities may accelerate recovery. Ehrich (2021) tested recovery strategies between hangboard sets—including static stretching, dynamic shakes, and repeated contractions—but found no single method superior for restoring hangboard performance.

Discussion

Currently available scientific research on hangboard training and climbing-specific strength displays several methodological and population-related limitations. Many studies employ small sample sizes, often with very few female participants (Stien et al., 2023), limiting the generalizability of findings and precluding robust conclusions about sex-specific adaptations. Furthermore, the duration of most interventions is relatively short—typically four to ten weeks (Mundry et al., 2021; Hermans et al., 2022; López-Rivera & González-Badillo, 2019)—limiting the ability to draw conclusions about long-term effects, sustainability of performance gains, or cumulative injury risk. With such brief research protocols, it is also impossible to confirm or refute the hypothesis that year-round strength training reduces injury risk (Saeterbakken et al., 2024a).

Methodological approaches differ substantially across studies, including variations in hangboard protocols, load intensities, grip types, and training frequency (Devise et al., 2022; Ferrer-Uris et al., 2023; Gilmore et al., 2024). Outcome measures are likewise inconsistent, ranging from maximal finger strength to endurance or neuromuscular activation (Baláš et al., 2021; Stien et al., 2022). This heterogeneity significantly limits comparability across studies and complicates the synthesis of existing evidence.

Adding to these challenges, proposing uniform, safe, and effective hangboard protocols is difficult because optimal training parameters vary markedly depending on a climber's experience level, training history, and performance capacity. Protocols appropriate for highly trained or elite climbers may be unsafe, excessively fatiguing, or insufficiently effective for intermediate or novice athletes (Saeterbakken et al., 2024b; Sjöman et al., 2023). This reinforces the need for individualized programming tailored to each climber's specific characteristics, needs, and goals.

There is also a notable lack of standardized testing methodologies for evaluating finger strength, endurance, or climbing performance, and only a small number of studies employ large-scale randomized controlled trials to rigorously assess training effects (Gilmore et al., 2024; Hermans et al., 2022). Recent work by Baláš et al. (2024) represents an important methodological advancement by validating the 4-minute all-out finger-flexor test as a reliable estimator of critical force (CF). The study demonstrated strong correlations with traditional endurance assessments, excellent test–retest reliability, and meaningful associations with climbing performance, making it a promising candidate for future standardized testing protocols.

Evidence regarding injuries directly attributable to hangboard training remains scarce. Most information originates from epidemiological or retrospective analyses rather than prospective, protocol-specific monitoring (Bogensperger, 2022; Grønhaug et al., 2024; Sjöman et al., 2023). Moreover, the majority of studies do not distinguish between bouldering and rope-climbing populations, despite substantial differences in movement demands, grip profiles, and typical loading patterns that may influence both training adaptations and injury mechanisms (Stien et al., 2019; Stien et al., 2021).

Collectively, these limitations highlight the need for larger, longer-term, and methodologically consistent investigations to establish evidence-based guidelines for hangboard training, injury prevention, and rehabilitation across diverse climbing populations.

Conclusions

The review indicates that hangboard training is an effective method for improving climbing-specific finger strength and, to a lesser extent, endurance. High-intensity loading (>80% of maximal finger strength, MFS), progressive external weighting, and mixed-intensity protocols consistently elicit meaningful strength gains across intermediate, advanced, and elite climbers. Submaximal intermittent protocols also enhance fatigue resistance, confirming that hangboard training is a reliable tool for improving key performance determinants.

The safety of hangboard training relies on gradual load progression, appropriate training frequency, and consideration of overall climbing workload. Structured protocols performed twice per week minimize injury risk. Balanced development of flexors and extensors, along with diversification of grip positions, further enhances training safety. Regular monitoring of fatigue and pain is recommended to support individualized program adjustments.

Given the substantial variability in climbers' training routines, strength profiles, and load tolerance, no single protocol can be universally recommended for optimal effectiveness and safety. Consequently, individualized programming remains essential for maximizing performance gains while minimizing the risk of overuse injuries.

Acknowledgments

The authors declare the absence of any commercial or financial relationships that could be construed as a potential conflict of interest. No external funding was received for this study.

REFERENCES

1. Anderson, M. L., Anderson, M. L., & Sanders, A. (2016). An innovative hangboard design to improve finger strength in rock climbers. *Procedia Engineering, 147*, 269–274. https://doi.org/10.1016/j.proeng.2016.06.276
2. Baláš, J., Gajdošík, J., Giles, D., Fryer, S., Krupková, D., Brtník, T., & Feldmann, A. (2021). Isolated finger flexor vs. exhaustive whole-body climbing tests? How to assess endurance in sport climbers? *European Journal of Applied Physiology, 121*(5), 1337–1348. https://doi.org/10.1007/s00421-021-04595-7
3. Baláš, J., Gajdošík, J., Javorský, T., Berta, P., & Feldmann, A. (2024). Measuring critical force in sport climbers: A validation study of the 4 min all-out test on finger flexors. *European Journal of Applied Physiology, 124*(9), 2787–2798. https://doi.org/10.1007/s00421-024-05490-7
4. Berta, P., Michailov, M., Kaško, D., Gajdošík, J., Běhounek, M., & Baláš, J. (2025). Validity and normative scores of finger flexor strength and endurance tests estimated from a large sample of female and male climbers. *Journal of Sports Sciences, 43*(3), 245–255. https://doi.org/10.1080/02640414.2024.2449316
5. Bogensperger, J. (2022). *Verletzungen der oberen Extremität im Klettersport: Rehabilitation und Training nach Verletzung* [Master's thesis, University of Graz]. http://unipub.uni-graz.at/obvugrhs/8286105
6. Bouyer, M., Forli, A., Semere, A., Chedal Bornu, B. J., Corcella, D., & Moutet, F. (2016). Recovery of rock climbing performance after surgical reconstruction of finger pulleys. *Journal of Hand Surgery (European Volume), 41*(4), 406–412. https://doi.org/10.1177/1753193415623914
7. Buraas, B. F., Brobakken, M. F., & Wang, E. (2025). Climbing performance in males: The importance of climbing-specific finger strength. *European Journal of Applied Physiology, 125*(10), 2823–2830. https://doi.org/10.1007/s00421-025-05802-5
8. Devise, M., Lechaptois, C., Berton, E., & Vigouroux, L. (2022). Effects of different hangboard training intensities on finger grip strength, stamina, and endurance. *Frontiers in Sports and Active Living, 4*, Article 862782. https://doi.org/10.3389/fspor.2022.862782
9. Devise, M., Pasek, L., Goislard De Monsabert, B., & Vigouroux, L. (2023). Finger flexion to extension ratio in healthy climbers: A proposal for evaluation and rebalance. *Frontiers in Sports and Active Living, 5*, Article 1243354. https://doi.org/10.3389/fspor.2023.1243354
10. Dindorf, C., Dully, J., Berger, J., Becker, S., Wolf, E., Simon, S., Bartaguiz, E., Kemmler, W., & Fröhlich, M. (2024). Assessing the impact of neuromuscular electrical stimulation-based fingerboard training versus conventional fingerboard training on finger flexor endurance in intermediate to advanced sports climbers: A randomized controlled study. *Sensors, 24*(13), Article 4100. https://doi.org/10.3390/s24134100
11. Draper, N., Giles, D., Taylor, N., Vigouroux, L., España-Romero, V., Baláš, J., Altamirano, I. S., Mally, F., Beeretz, I., Canalejo, J. C., Josseron, G., Kodejška, J., Téllez, M. J. A., & Vaca, G. G. C. de. (2021). Performance assessment for rock climbers: The International Rock Climbing Research Association sport-specific test battery. *International Journal of Sports Physiology and Performance, 16*(9), 1242–1252. https://doi.org/10.1123/ijspp.2020-0672
12. Ehrich, D. (2021). *Effects of different recovery methods on hangboard performance in rock climbers: A pilot study* [Master's thesis, Liberty University]. *Masters Theses*. https://digitalcommons.liberty.edu/masters/740
13. Ferrer-Uris, B., Arias, D., Torrado, P., Marina, M., & Busquets, A. (2023). Exploring forearm muscle coordination and training applications of various grip positions during maximal isometric finger dead-hangs in rock climbers. *PeerJ, 11*, Article e15464. https://doi.org/10.7717/peerj.15464
14. Gilmore, N. K., Klimek, P., Abrahamsson, E., & Baar, K. (2024). Effects of different loading programs on finger strength in rock climbers. *Sports Medicine - Open, 10*(1), Article 125. https://doi.org/10.1186/s40798-024-00793-7
15. Gilmore, N. K., Klimek, P., Abrahamsson, E., & Baar, K. (2025). The VISA-C questionnaire: A self-administered assessment to measure finger/hand/wrist pain in climbers. *Sports Medicine - Open, 11*(1), Article 105. https://doi.org/10.1186/s40798-025-00912-y
16. Grønhaug, G., Saeterbakken, A., & Casucci, T. (2024). Painfully ignorant? Impact of gender and aim of training on injuries in climbing. *BMJ Open Sport & Exercise Medicine, 10*(3). https://doi.org/10.1136/bmjsem-2024-001972
17. Hartley, C., Taylor, N., Chidley, J., Baláš, J., & Giles, D. (2023). Handedness, bilateral, and interdigit strength asymmetries in male climbers. *International Journal of Sports Physiology and Performance, 18*(12), 1390–1397. https://doi.org/10.1123/ijspp.2023-0030

18. Hartnett, E., Bondoc, S., & Feretti, A. M. (2024). Climbing while healing: An orthotic intervention for rock climbers with a low-grade A2 pulley injury: A case series. *Journal of Hand Therapy, 37*(3), 419–428. https://doi.org/10.1016/j.jht.2023.08.005
19. Hermans, E., Saeterbakken, A. H., Vereide, V., Nord, I. S. O., Stien, N., & Andersen, V. (2022). The effects of 10 weeks hangboard training on climbing-specific maximal strength, explosive strength, and finger endurance. *Frontiers in Sports and Active Living, 4*, Article 888158. https://doi.org/10.3389/fspor.2022.888158
20. Javorský, T., Saeterbakken, A. H., Andersen, V., & Baláš, J. (2023). Comparing low volume of blood flow restricted to high-intensity resistance training of the finger flexors to maintain climbing-specific strength and endurance: A crossover study. *Frontiers in Sports and Active Living, 5*, Article 1256136. https://doi.org/10.3389/fspor.2023.1256136
21. Krupková, D., Tufano, J. J., & Baláš, J. (2024). Optimizing active recovery strategies for finger flexor fatigue. *Frontiers in Sports and Active Living, 6*, Article 1480205. https://doi.org/10.3389/fspor.2024.1480205
22. Laffaye, G., Levernier, G., & Collin, J.-M. (2016). Determinant factors in climbing ability: Influence of strength, anthropometry, and neuromuscular fatigue. *Scandinavian Journal of Medicine & Science in Sports, 26*(10), 1151–1159. https://doi.org/10.1111/sms.12558
23. Langer, K., Simon, C., & Wiemeyer, J. (2023). Physical performance testing in climbing: A systematic review. *Frontiers in Sports and Active Living, 5*, Article 1130812. https://doi.org/10.3389/fspor.2023.1130812
24. Limmer, M., Buck, S., de Marées, M., & Roth, R. (2020). Acute effects of kinesio taping on muscular strength and endurance parameters of the finger flexors in sport climbing: A randomised, controlled crossover trial. *European Journal of Sport Science, 20*(4), 427–436. https://doi.org/10.1080/17461391.2019.1633415
25. López-Rivera, E., & González-Badillo, J. J. (2019). Comparison of the effects of three hangboard strength and endurance training programs on grip endurance in sport climbers. *Journal of Human Kinetics, 66*, 183–195. https://doi.org/10.2478/hukin-2018-0057
26. MacKenzie, R., Monaghan, L., Masson, R. A., Werner, A. K., Caprez, T. S., Johnston, L., & Kemi, O. J. (2020). Physical and physiological determinants of rock climbing. *International Journal of Sports Physiology and Performance, 15*(2), 168–179. https://doi.org/10.1123/ijspp.2018-0901
27. Mckellar, B. J., & Burr, J. F. (2026). The effect of blood flow restriction training on rock climbing performance, forearm blood oxygenation and cardiovascular responses. *European Journal of Sport Science, 26*(3), Article e70146. https://doi.org/10.1002/ejsc.70146
28. Michailov, M. L., Baláš, J., Tanev, S. K., Andonov, H. S., Kodejška, J., & Brown, L. (2018). Reliability and validity of finger strength and endurance measurements in rock climbing. *Research Quarterly for Exercise and Sport, 89*(2), 246–254. https://doi.org/10.1080/02701367.2018.1441484
29. Mundry, S., Steinmetz, G., Atkinson, E. J., Schilling, A. F., Schöffl, V. R., & Saul, D. (2021). Hangboard training in advanced climbers: A randomized controlled trial. *Scientific Reports, 11*(1), Article 13530. https://doi.org/10.1038/s41598-021-92898-2
30. Platzer, H.-P., Köck, A., Schobersberger, W., & Dünnwald, T. (2026). Ischemic preconditioning does not improve climbing specific performance in elite athletes. *Journal of Strength and Conditioning Research, 40*(1), e69–e75. https://doi.org/10.1519/JSC.0000000000005271
31. Ruiz-López, A., Padilla-Crespo, A., & Bustamante-Sánchez, A. (2025). Comparative analysis of two grip strength training protocols in experienced climbers. *Apunts Educación Física y Deportes, 161*, 32–40. https://doi.org/10.5672/apunts.2014-0983.es.(2025/3).161.04
32. Saeterbakken, A. H., Stien, N., Pedersen, H., Langer, K., Scott, S., Michailov, M. L., Gronhaug, G., Baláš, J., Solstad, T. E. J., & Andersen, V. (2024). The connection between resistance training, climbing performance, and injury prevention. *Sports Medicine - Open, 10*(1), Article 10. https://doi.org/10.1186/s40798-024-00677-w
33. Saeterbakken, A. H., Schöffl, V. R., Schweizer, A., & Grønhaug, G. (2024). Editorial: Injuries, injury prevention and training in climbing. *Frontiers in Sports and Active Living, 6*, Article 1390338. https://doi.org/10.3389/fspor.2024.1390338
34. Saeterbakken, A. H., Bratland, E., Andersen, V., & Stien, N. (2024). Five weeks of dynamic finger flexor strength training on bouldering performance and climbing-specific strength tests: A randomized controlled trial. *Frontiers in Physiology, 15*, Article 1461820. https://doi.org/10.3389/fphys.2024.1461820
35. Schneeberger, M., & Schweizer, A. (2016). Pulley ruptures in rock climbers: Outcome of conservative treatment with the pulley-protection splint—A series of 47 cases. *Wilderness & Environmental Medicine, 27*(2), 211–218. https://doi.org/10.1016/j.wem.2015.12.017
36. Sjöman, A. E., Grønhaug, G., & Julin, M. V. (2023). A finger in the game: Sport-specific finger strength training and onset of injury. *Wilderness & Environmental Medicine, 34*(4), 435–441. https://doi.org/10.1016/j.wem.2023.06.004
37. Stefan, R. R., Camic, C. L., Miles, G. F., Kovacs, A. J., Jagim, A. R., & Hill, C. M. (2022). Relative contributions of handgrip and individual finger strength on climbing performance in a bouldering competition. *International Journal of Sports Physiology and Performance, 17*(5), 768–773. https://doi.org/10.1123/ijspp.2021-0422

38. Stien, N., Saeterbakken, A. H., Hermans, E., Vereide, V. A., Olsen, E., & Andersen, V. (2019). Comparison of climbing-specific strength and endurance between lead and boulder climbers. *PLOS ONE, 14*(9), Article e0222529. https://doi.org/10.1371/journal.pone.0222529
39. Stien, N., Frøysaker, T. F., Hermans, E., Vereide, V. A., Andersen, V., & Saeterbakken, A. H. (2021). The effects of prioritizing lead or boulder climbing among intermediate climbers. *Frontiers in Sports and Active Living, 3*, Article 661167. https://doi.org/10.3389/fspor.2021.661167
40. Stien, N., Pedersen, H., Vereide, V. A., Saeterbakken, A. H., Hermans, E., Kalland, J., Schoenfeld, B. J., & Andersen, V. (2021). Effects of two vs. four weekly campus board training sessions on bouldering performance and climbing-specific tests in advanced and elite climbers. *Journal of Sports Science and Medicine, 20*(3), 438–447.
41. Stien, N., Riiser, A., Shaw, M. P., Saeterbakken, A. H., & Andersen, V. (2022). Effects of climbing- and resistance-training on climbing-specific performance: A systematic review and meta-analysis. *Biology of Sport, 40*(1), 179–191. https://doi.org/10.5114/biolsport.2023.113295
42. Stien, N., Saeterbakken, A. H., & Andersen, V. (2022). Tests and procedures for measuring endurance, strength, and power in climbing: A mini-review. *Frontiers in Sports and Active Living, 4*, Article 847447. https://doi.org/10.3389/fspor.2022.847447
43. Stien, N., Andersen, V., Langer, K., & Saeterbakken, A. H. (2025). Assessing climbing-specific strength: The impact of body position and elbow flexion on reliability and predictive validity. *Journal of Sports Sciences, 43*(9), 852–864. https://doi.org/10.1080/02640414.2025.2477863
44. van Bergen, N. G., Soekarjo, K., van der Kamp, J., & Orth, D. (2023). Reliability and validity of functional grip strength measures across holds and body positions in climbers: Associations with skill and climbing performance. *Research Quarterly for Exercise and Sport, 94*(3), 627–637. https://doi.org/10.1080/02701367.2022.2035662
45. Vigouroux, L., Devise, M., Cartier, T., Aubert, C., & Berton, E. (2019). Performing pull-ups with small climbing holds influences grip and biomechanical arm action. *Journal of Sports Sciences, 37*(8), 886–894. https://doi.org/10.1080/02640414.2018.1532546