QUALITY IN SPORT
eISSN 2450-3118 · Open Access · Peer-reviewed
apcz.umk.pl/QS Nicolaus Copernicus University in Toruń

Cite as: CHWAJTA, Gabriela, CHMIELNICKI, Filip, PIRGA, Gabriela, KACZOR, Gabriela, CEPIELIK, Barbara, CICHOCKA, Weronika, ANTOS, Martyna, PACZOSA, Kacper, JĘDRUSZKO, Klaudia and OSTOLSKI, Maciej. The Role of Strength Training in Preventing Running-Related Injuries in Long-Distance Runners: A Narrative Review. Quality in Sport. 2026;61:72956. https://doi.org/10.12775/QS.2026.61.72956

ARTICLE TIMELINE
Received: 02.06.2026. Revised: 03.07.2026. Accepted: 04.07.2026. Published: 06.07.2026.

The journal has been awarded 20 points in the parametric evaluation by the Polish Ministry of Higher Education and Science (Annex to the announcement of 05.01.2024, No. 32553). Unique Journal Identifier: 201398. Scientific disciplines assigned: Economics and finance (Field of social sciences); Management and Quality Sciences (Field of social sciences).
Punkty Ministerialne z 2019 – aktualny rok 20 punktów. Załącznik do komunikatu Ministra Szkolnictwa Wyższego i Nauki z dnia 05.01.2024 Lp. 32553. Posiada Unikatowy Identyfikator Czasopisma: 201398. Przypisane dyscypliny naukowe: Ekonomia i finanse (Dziedzina nauk społecznych); Nauki o zarządzaniu i jakości (Dziedzina nauk społecznych).

The Role of Strength Training in Preventing Running-Related Injuries in Long-Distance Runners: A Narrative Review

Gabriela Chwajta, ORCID https://orcid.org/0009-0004-0658-2096

E-mail gabriela.chwajta@gmail.com

Medical University of Lublin, Aleje Racławickie 1, 20-059 Lublin, Poland

Filip Chmielnicki, ORCID https://orcid.org/0009-0000-2314-1699

E-mail chmielnicki.filip6@wp.pl

Medical University of Lublin, Aleje Racławickie 1, 20-059 Lublin, Poland

Gabriela Pirga, ORCID https://orcid.org/0009-0004-6558-3590

E-mail gabigabi20014@gmail.com

Medical University of Lublin, Aleje Racławickie 1, 20-059 Lublin, Poland

Gabriela Kaczor, ORCID https://orcid.org/0009-0002-4908-3591

E-mail gabi456654@gmail.com

Medical University of Lublin, Aleje Racławickie 1, 20-059 Lublin, Poland

Barbara Cepielik, ORCID https://orcid.org/0009-0001-4068-2750
E-mail barbaracepielik12@gmail.com
Medical University of Lublin, Aleje Racławickie 1, 20-059 Lublin, Poland

Weronika Cichocka, ORCID https://orcid.org/0009-0009-7581-1733
E-mail wera011012@gmail.com
Medical University of Lublin, Aleje Racławickie 1, 20-059 Lublin, Poland

Martyna Antos, ORCID https://orcid.org/0009-0009-9663-1811
E-mail a.martyna28@wp.pl
Medical University of Lublin, Aleje Racławickie 1, 20-059 Lublin, Poland

Kacper Paczosa, ORCID https://orcid.org/0009-0005-2778-7493
E-mail paczosakacper@gmail.com
Medical University of Lublin, Aleje Racławickie 1, 20-059 Lublin, Poland

Klaudia Jędruszko, ORCID https://orcid.org/0009-0002-3072-0626
E-mail klaudiajedruszko01@gmail.com
Medical University of Lublin, Aleje Racławickie 1, 20-059 Lublin, Poland

Maciej Ostolski, ORCID https://orcid.org/0009-0005-0723-4103
E-mail maciekostolski@gmail.com
Medical University of Lublin, Aleje Racławickie 1, 20-059 Lublin, Poland

Corresponding Author: Gabriela Chwajta, E-mail gabriela.chwajta@gmail.com

Abstract

Background: Running-related injuries (RRIs) are among the most common musculoskeletal problems affecting long-distance runners and frequently result in training interruption and reduced athletic performance. Strength training has been increasingly proposed as a potential strategy for injury prevention; however, its effectiveness remains debated.

Aim: The aim of this narrative review was to evaluate the current evidence regarding the role of strength training in preventing running-related injuries among long-distance runners.

Materials and Methods: A narrative review of the literature was conducted using the PubMed database. Studies published in English between January 2012 and May 2026 were considered. Systematic reviews, meta-analyses, randomized controlled trials, prospective studies, and narrative reviews investigating injury risk factors, biomechanics, neuromuscular function, and strength-training interventions in runners were included.

Results: The reviewed literature indicates that running-related injuries are multifactorial conditions influenced by training-related, biomechanical, neuromuscular, and individual factors. Strength training appears to improve muscular strength, hip stability, lumbopelvic control, running economy, and selected biomechanical variables associated with injury risk. However, current evidence does not consistently demonstrate a significant reduction in injury incidence following strength-training interventions. Supervised and individualized programs may provide greater benefits than unsupervised approaches.

Conclusions: Strength training represents a valuable component of comprehensive injury-prevention strategies in long-distance runners. Although current evidence does not consistently demonstrate an independent reduction in injury incidence, resistance training improves several factors associated with injury resilience and athletic performance.

Keywords: strength training; resistance training; running-related injuries; injury prevention; long-distance runners; endurance running; biomechanics.

1. Introduction

Long-distance running is widely practiced worldwide because of its accessibility, minimal equipment requirements, and well-documented health benefits. Regular participation in running is associated with improved cardiovascular fitness, enhanced metabolic health, reduced risk of chronic diseases, and positive effects on psychological well-being [2]. Consequently, the number of recreational and competitive runners has increased substantially over recent decades, resulting in growing scientific interest in factors affecting both performance and injury risk.

Despite its well-established health benefits, long-distance running is associated with a relatively high incidence of musculoskeletal injuries. Running-related injuries (RRIs) are among the most common reasons for training interruption and reduced participation in running activities [7,14,15]. Epidemiological studies have demonstrated that injury rates remain high across various populations of runners, regardless of age, sex, or performance level. Videbæk et al. reported that novice runners sustain approximately 17.8 injuries per 1000 hours of running exposure, whereas recreational runners experience approximately 7.7 injuries per 1000 hours of running exposure [15]. These findings indicate that RRIs represent a substantial burden for both recreational and competitive athletes.

The lower extremities are the anatomical region most frequently affected by running-related injuries. According to Lopes et al., the most commonly reported conditions include patellofemoral pain syndrome, medial tibial stress syndrome, Achilles tendinopathy, plantar fasciitis, and iliotibial band syndrome [14]. Similarly, recent reviews have identified the knee, lower leg, ankle, and foot as the primary locations of injury occurrence among runners [3,7]. These injuries are predominantly classified as overuse injuries resulting from repetitive mechanical loading during training and competition.

The development of RRIs is influenced by a complex interaction of intrinsic and extrinsic factors. Previous injury history, training errors, excessive training load, biomechanical characteristics, neuromuscular deficits, and musculoskeletal factors have all been identified as potential contributors to injury development [3,11–13]. Among these factors, a history of previous injury has consistently been reported as one of the strongest predictors of future injury occurrence [11,12]. However, no single factor has been shown to independently explain the development of RRIs, highlighting the complexity of injury prevention in endurance runners.

Recent research has increasingly focused on modifiable risk factors that may be targeted through preventive interventions. In particular, deficits in muscular strength, neuromuscular control, lumbopelvic stability, and lower-limb biomechanics have been associated with movement patterns that may increase tissue loading and injury susceptibility [5,6,9,10]. Weakness of the hip abductors and impaired gluteus medius function have been linked to excessive hip adduction, pelvic drop, altered lower-extremity alignment, and increased stress on musculoskeletal structures during running [9,10,20]. These observations support the rationale for interventions aimed at improving muscular function and movement control in runners.

Strength training has therefore emerged as a promising strategy for injury prevention in runners. In addition to its established benefits for running economy and athletic performance, resistance training may improve muscle strength, enhance neuromuscular coordination, increase tissue capacity to tolerate repetitive loading, and positively influence running biomechanics [4,8,16]. Several authors have proposed that targeted strengthening of the hip musculature, core stabilizers, and lower-extremity muscles may contribute to reducing the incidence of running-related injuries through improved movement control and load distribution [4,9,10].

However, despite increasing interest in strength training as a preventive intervention, the current body of evidence remains inconclusive. While some studies have reported favorable adaptations following strength-training interventions, others have failed to demonstrate significant reductions in injury incidence [1,2]. A recent systematic review and meta-analysis by Wu et al. concluded that exercise-based prevention programs do not consistently reduce injury risk among endurance runners, although supervised interventions appear to be more effective than unsupervised programs [2]. Similarly, Toresdahl et al. found that a 12-week strengthening program did not significantly reduce injury rates among first-time marathon runners [1]. These findings indicate that the relationship between strength training and injury prevention remains incompletely understood.

Given the growing popularity of long-distance running and the substantial burden associated with running-related injuries, a comprehensive synthesis of current evidence is warranted. Therefore, the aim of this narrative review is to evaluate the role of strength training in preventing running-related injuries in long-distance runners, with particular emphasis on injury epidemiology, risk factors, potential mechanisms of action, and the effectiveness of strength-training interventions reported in the scientific literature.

2. Research Materials and Methods

2.1. Study Design

This narrative review was undertaken to evaluate the current evidence regarding the role of strength training in the prevention of running-related injuries among long-distance runners. Particular attention was given to injury epidemiology, injury risk factors, biomechanical and neuromuscular determinants of injury, and the effectiveness of strength-training interventions.

A narrative review approach was considered appropriate because the available literature comprises a diverse range of study designs, including systematic reviews, meta-analyses, randomized controlled trials, prospective cohort studies, and observational investigations addressing different aspects of injury prevention in runners.

2.2. Literature Search Strategy

A comprehensive literature search was performed using the PubMed database because of its broad coverage of biomedical, sports medicine, and exercise science literature.

The literature search was conducted in May 2026. Publications published in English between January 2012 and May 2026 were considered eligible for inclusion.

Search terms consisted of combinations of keywords related to endurance running, injury prevention, resistance training, biomechanics, and neuromuscular function. Examples of keywords included “strength training”, “resistance training”, “running-related injuries”, “injury prevention”, “running biomechanics”, “running economy”, “hip strength”, “gluteus medius”, “lumbopelvic stability”, and “neuromuscular control”.

To maximize the completeness of the review, additional relevant publications were identified through manual screening of reference lists from selected articles.

2.3. Eligibility Criteria

Inclusion Criteria

Studies were eligible for inclusion if they:

- involved recreational, competitive, or endurance runners;
- investigated the epidemiology, risk factors, biomechanics, or neuromuscular determinants of running-related injuries;
- evaluated the effects of strength-training or exercise-based interventions on injury prevention or injury-related outcomes;
- were published in peer-reviewed scientific journals;
- were available in full text and written in English.

Greater emphasis was placed on systematic reviews, meta-analyses, randomized controlled trials, and prospective cohort studies because of their methodological rigor and relevance to the research objective.

Exclusion Criteria

Studies were excluded if they:

- focused exclusively on post-injury rehabilitation;
- investigated sports other than running;
- included only non-running populations;
- were conference abstracts, editorials, expert opinions, or commentaries lacking original scientific data;
- provided insufficient methodological information.

2.4. Data Extraction and Analysis

Data extracted from the selected studies included study design, participant characteristics, investigated variables, intervention protocols, primary outcomes, and key findings relevant to the research objective.

The evidence was synthesized qualitatively using a narrative review approach. Because of substantial heterogeneity in study designs, participant populations, intervention protocols, and outcome measures, quantitative meta-analysis was not considered appropriate.

The findings were organized into four thematic categories:

1. Epidemiology of running-related injuries.
2. Risk factors associated with injury occurrence.
3. Mechanisms through which strength training may influence injury risk.
4. Evidence supporting strength-training interventions as a preventive strategy in long-distance runners.

This framework facilitated a structured synthesis of the literature and helped identify areas requiring further investigation.

3. Research results

3.1. Epidemiology of Running-Related Injuries

Although long-distance running is widely recognized as an effective form of physical activity that promotes cardiovascular, metabolic, and psychological health, participation in this sport is frequently accompanied by musculoskeletal injuries. Running-related injuries (RRIs) remain one of the most common factors limiting training consistency and long-term participation in both recreational and competitive runners [7,14,15].

The reported incidence of RRIs varies substantially across studies due to differences in injury definitions, study design, follow-up duration, and participant characteristics. Nevertheless, epidemiological evidence consistently indicates that running is associated with a considerable injury burden. A systematic review and meta-analysis conducted by Videbæk et al. demonstrated that novice runners experience the highest injury rates, reaching approximately 17.8 injuries per 1000 hours of running exposure, whereas recreational runners sustain approximately 7.7 injuries per 1000 hours of running [15]. These findings suggest that limited running experience and insufficient adaptation to training loads may increase susceptibility to injury.

The majority of running-related injuries affect the lower extremities, reflecting the repetitive mechanical loading associated with endurance running. According to Lopes et al., the most frequently reported conditions include patellofemoral pain syndrome, medial tibial stress syndrome, Achilles tendinopathy, plantar fasciitis, and iliotibial band syndrome [14]. More recent reviews have confirmed that injuries involving the knee, lower leg, ankle, and foot account for the largest proportion of musculoskeletal complaints reported by runners [3,7].

A substantial proportion of RRIs are classified as overuse injuries that develop gradually as a consequence of repetitive loading exceeding the capacity of biological tissues to recover and adapt. Unlike acute traumatic injuries, overuse conditions often result from the cumulative interaction of training-related, biomechanical, and physiological factors over time [3,11]. The complexity of injury mechanisms highlights the need for comprehensive prevention strategies targeting multiple potentially alterable determinants simultaneously.

The consequences of running-related injuries extend beyond temporary reductions in training volume. Injuries may disrupt long-term athletic development, impair performance progression, and reduce adherence to regular physical activity. Furthermore, evidence suggests that runners who have previously sustained an injury are at greater risk of experiencing subsequent injuries, indicating that unsuccessful prevention and management strategies may contribute to recurrent musculoskeletal problems [11,12].

Given the high prevalence of RRIs and their potential impact on both health and athletic performance, identifying effective preventive interventions has become a major objective of contemporary sports medicine research. Recent investigations increasingly focus on modifiable factors such as muscular strength, neuromuscular control, and movement biomechanics, which may represent potential targets for injury prevention programs [4–6,9,10]. Consequently, strength training has emerged as a promising approach that may reduce injury susceptibility by addressing several mechanisms implicated in the development of running-related injuries.

3.2. Risk Factors for Running-Related Injuries

Understanding the factors associated with running-related injuries is essential for developing effective prevention strategies. Current evidence indicates that RRIs arise from the interaction of multiple intrinsic and extrinsic factors rather than from a single identifiable cause [3,11,12].

Among the factors examined, previous injury is the most consistently reported predictor of future injury. Saragiotto et al. found that runners who sustained an injury within the previous 12 months were more likely to experience a subsequent injury than previously uninjured runners [12]. Similar conclusions were reported by Sanfilippo et al. [11]. Persistent functional deficits, incomplete rehabilitation, and residual movement alterations may partly explain this increased susceptibility.

Training-related factors have also been widely investigated. High training volumes, rapid increases in workload, and insufficient recovery are frequently associated with injury occurrence. However, no clear thresholds for training volume or intensity have been established, and individual responses to mechanical loading vary considerably [13].

Demographic and anthropometric characteristics, including age, sex, body mass index, and running experience, have produced inconsistent findings. Although greater body mass and competitive participation have been linked to a higher risk of lower-extremity injuries in some studies, these associations are not consistently observed across different populations [11,12].

Biomechanical factors represent another important area of investigation. Prospective studies have identified associations between selected movement patterns and injury occurrence [19]. Reviews by Peterson et al. and Willwacher et al. reported that altered lower-limb kinematics, loading patterns, and movement asymmetries may contribute to specific running-related injuries [5,6]. Nevertheless, no single biomechanical profile has been shown to predict injury across all runner populations.

Muscular strength and neuromuscular function have received increasing attention because they represent potentially modifiable factors. Weakness of the hip musculature, impaired gluteus medius function, reduced lumbopelvic stability, and deficits in movement control have been associated with excessive hip adduction, pelvic instability, and altered lower-extremity alignment during running [9,10,20]. These alterations may increase tissue loading and contribute to injury development.

Taken together, the available literature supports a multifactorial model of injury development in which previous injury, training load, biomechanical characteristics, and neuromuscular function interact with individual adaptation capacity [3,11,12]. This complexity highlights the need for comprehensive prevention strategies and provides a rationale for including strength training as one component of injury-risk management [4,8].

3.3. Mechanisms Through Which Strength Training May Reduce Injury Risk

Strength training is frequently included in injury-prevention programs because it influences several physiological, neuromuscular, and biomechanical factors associated with running-related injuries. Although its direct effect on injury incidence has not been definitively established, resistance training produces adaptations that are relevant to injury prevention and long-term musculoskeletal health [4,8].

One of the primary adaptations induced by strength training is an increase in muscular strength and force-producing capacity. During long-distance running, the musculoskeletal system is exposed to thousands of repetitive loading cycles. When the active structures responsible for shock absorption become unable to effectively manage these forces, greater mechanical stress is transferred to passive tissues such as tendons, ligaments, cartilage, and bone. By increasing the capacity of muscles to absorb and generate force, resistance training may improve tolerance to repetitive loading and reduce stress placed on vulnerable structures [4].

Particular attention has been directed toward the hip musculature, especially the hip abductors and gluteus medius. These muscles contribute substantially to pelvic stability and lower-limb alignment during the stance phase of running. Several studies have linked deficits in hip strength and impaired gluteal function to altered movement patterns, including excessive hip adduction, contralateral pelvic drop, and dynamic knee valgus [10,20]. Such alterations may increase loading of structures commonly affected by overuse injuries, including the patellofemoral joint and iliotibial band. Consequently, strengthening the hip musculature has been proposed as an effective strategy for improving movement control during running [10,20].

Another important mechanism involves lumbopelvic stability and neuromuscular control. Efficient running requires coordinated interaction between the trunk, pelvis, and lower extremities. Deficits in this coordination can compromise movement efficiency and alter force distribution throughout the kinetic chain. Resistance training, particularly when combined with exercises targeting core stability and functional movement patterns, enhances motor control and improves synchronization of muscle activation across multiple joints [4,16]. These adaptations improve force transmission and reduce compensatory movement patterns that have been associated with overuse injuries.

Strength training may also influence selected biomechanical characteristics of running. Studies have reported improvements in lower-limb stiffness, force production, and movement efficiency following resistance-training interventions in both recreational and competitive runners [4,8]. Biomechanical characteristics are closely related to running economy, making movement efficiency an important target for training interventions [9]. However, improvements in muscular strength do not automatically translate into substantial changes in running mechanics, and the relationship between strength gains and biomechanical adaptations remains complex [9,20].

Beyond neuromuscular and biomechanical adaptations, resistance training promotes structural changes within muscles, tendons, and connective tissues. Repeated exposure to appropriately prescribed loading stimulates tissue remodeling and increases the capacity of biological structures to tolerate repetitive mechanical stress [4]. Increased tendon stiffness and improved musculotendinous function may be particularly relevant in reducing the cumulative loading associated with overuse injuries.

Another consistently reported benefit of strength training is improved running economy, defined as the oxygen cost required to maintain a given running speed [4,8]. Although running economy is primarily considered a performance-related outcome, it may also have implications for injury prevention. Improved efficiency reduces unnecessary energy expenditure and may delay the onset of neuromuscular fatigue. Because fatigue has been associated with deteriorations in movement control and running mechanics, delaying its onset may help maintain more stable movement patterns during prolonged exercise.

While resistance training consistently improves muscular strength, neuromuscular function, running economy, and selected biomechanical variables, the extent to which these adaptations directly reduce injury incidence remains uncertain [2,4]. Nevertheless, the available evidence indicates that strength training positively influences several factors associated with injury resilience and therefore represents a valuable component of comprehensive injury-prevention programs for long-distance runners.

3.4. Evidence for Strength Training in Injury Prevention

Although several physiological and biomechanical mechanisms support the use of strength training in injury-prevention programs, the key question remains whether these adaptations translate into a measurable reduction in running-related injury incidence. The current body of research provides mixed results.

One of the most frequently cited randomized controlled trials on this topic was conducted by Toresdahl et al. [1], who investigated the effects of a 12-week strength-training program in first-time marathon runners. Despite improvements in participation and adherence to training, the intervention did not significantly reduce injury incidence compared with the control group. Marathon performance also remained unchanged. These findings indicate that the inclusion of a strength-training program alone is unlikely to guarantee a reduction in injury rates, particularly when exercise quality and compliance are difficult to monitor.

The findings of Toresdahl et al. should be interpreted within the broader context of injury development. Running-related injuries arise from the interaction of numerous factors, including training load, recovery practices, previous injury history, biomechanical characteristics, and individual adaptation capacity [3,11,12]. Consequently, expecting a single intervention to eliminate injury risk may be unrealistic. In addition, adherence to preventive exercise programs varies considerably among recreational runners and may influence intervention outcomes.

More recent evidence was provided by Wu et al. [2], who conducted a systematic review and meta-analysis of exercise-based injury-prevention programs in endurance runners. The analysis included nine studies involving more than 1,900 participants. When all interventions were considered together, no significant reduction in injury incidence was observed. However, supervised programs produced more favorable outcomes than unsupervised interventions. This finding highlights the importance of exercise execution, adherence, progression, and professional supervision in determining the effectiveness of preventive strategies.

Additional preventive approaches have also shown promising results in selected running populations. Foot-core strengthening programs and multifactorial prevention protocols have been associated with improvements in foot function, movement control, and musculoskeletal capacity [17,18]. Although the evidence remains limited, these findings support the view that effective injury prevention is likely to require a multifaceted rather than single-intervention approach.

An important observation emerging from the review by Wu et al. is that program design may influence outcomes as much as the exercises themselves. Individualized, progressive, and properly supervised interventions appear more likely to produce meaningful adaptations than generic exercise routines performed without feedback or monitoring.

The value of strength training is further supported by studies examining injury-related variables rather than injury incidence alone. Several reviews have reported improvements in muscular strength, neuromuscular function, movement efficiency, and selected biomechanical characteristics following resistance-training interventions [4,8,16]. Although such outcomes do not constitute direct evidence of injury reduction, they affect factors that have repeatedly been associated with injury susceptibility. Improvements in hip strength, lumbopelvic stability, and movement control may therefore contribute to a more favorable movement profile during running [9,10,20].

Particular attention has been given to strengthening interventions targeting the hip musculature. Enhanced hip muscle function has been associated with improved pelvic stability, more efficient lower-limb control, and reduced mechanical loading during running [10,20]. Improvements in gluteus medius function may be especially relevant because of their role in controlling frontal-plane motion of the pelvis and lower extremity. While these adaptations cannot be interpreted as direct proof of injury reduction, they provide biologically plausible explanations for the potential protective effects of strength training.

Another important distinction concerns the difference between performance-related adaptations and injury-prevention outcomes. Strength-training interventions consistently improve running economy and force-production capacity in endurance runners [4,8]. Enhanced running economy reduces the physiological demands of running and may delay fatigue during prolonged exercise. Because fatigue has been linked to alterations in movement control and running mechanics, these adaptations could indirectly contribute to lower injury susceptibility.

Taken together, the available evidence does not support the view that strength training alone can prevent all running-related injuries. However, resistance training consistently improves several factors associated with injury resilience, including muscular strength, neuromuscular control, tissue capacity, and movement efficiency. For this reason, it should be regarded as one component of a broader injury-prevention strategy that also includes appropriate load management, recovery, and individualized training prescription.

3.5. Practical Implications for Coaches and Long-Distance Runners

From a practical perspective, the available evidence supports the inclusion of strength training as a regular component of long-distance running programs [1,2,4]. Although resistance training alone cannot eliminate injury risk, it improves several physical qualities associated with both performance and injury resilience. Consequently, strength training should be viewed as an integral part of endurance training rather than as an intervention reserved for injured athletes.

One important implication is the need for long-term planning. Adaptations in muscular strength, neuromuscular control, and tissue capacity develop gradually and require consistent exposure to appropriately prescribed resistance exercise [4,8]. For this reason, strength training should be incorporated throughout the training year instead of being implemented only during periods of rehabilitation or immediately before competition.

The findings reviewed in this paper also highlight the importance of targeting muscle groups that contribute to running stability and movement control. Particular attention should be directed toward the hip musculature and lumbopelvic region, as deficits in these areas have been associated with altered lower-limb mechanics and inefficient movement patterns during running [10,20]. Exercises focusing on the gluteal muscles, hip abductors, and trunk stabilizers may therefore be especially valuable for runners with a history of lower-extremity injuries or observable deficits in movement control.

Another practical consideration concerns exercise supervision. Evidence from exercise-based prevention programs indicates that supervised interventions generally produce more favorable outcomes than unsupervised training [2]. This finding suggests that exercise quality, progression, and adherence are likely to influence the effectiveness of preventive programs. Coaches, physiotherapists, and strength and conditioning specialists should therefore emphasize proper technique and progressive overload rather than focusing solely on exercise completion.

Exercise selection should be guided by the desired training adaptations. High-load resistance training primarily develops maximal strength and force-production capacity, whereas plyometric exercises enhance reactive strength, neuromuscular efficiency, and stretch-shortening cycle performance [4,8]. Combining these approaches may provide a broader range of adaptations than relying on a single training modality. The specific structure of a strength-training program should be adjusted according to the athlete’s experience, training history, injury profile, and performance goals.

At the same time, strength training should not be considered a substitute for appropriate training-load management. Previous injury, excessive workload, inadequate recovery, biomechanical characteristics, and individual adaptation capacity all contribute to injury development [3,11–13]. Effective prevention therefore requires a comprehensive approach that combines resistance training with gradual progression of running volume, adequate recovery strategies, and ongoing monitoring of training load.

Novice runners may represent a particularly important target group for preventive interventions. Epidemiological studies consistently demonstrate higher injury rates among inexperienced runners compared with more experienced athletes [15]. Early implementation of structured strength training may improve physical preparedness and increase tolerance to repetitive mechanical loading during the initial stages of running participation.

In summary, strength training should be regarded as one element of a comprehensive strategy aimed at reducing injury risk and supporting long-term athletic development. While current evidence does not demonstrate a consistent reduction in injury incidence across all populations of runners, resistance training improves several factors associated with injury resilience and may contribute to maintaining both health and performance throughout a runner's career.

4. Discussion

This narrative review examined the role of strength training in the prevention of running-related injuries among long-distance runners. The reviewed evidence indicates that resistance training positively influences several physiological and biomechanical factors associated with injury resilience; however, its direct effect on injury incidence remains uncertain.

A recurring observation across the literature is the contrast between mechanistic findings and intervention outcomes. Resistance-training programs consistently improve muscular strength, running economy, neuromuscular function, hip stability, and selected biomechanical characteristics [4,8–10,16]. These adaptations are theoretically relevant to injury prevention because they enhance the capacity of the musculoskeletal system to tolerate repetitive loading. Nevertheless, studies specifically evaluating injury incidence have not produced equally consistent results [1,2].

One explanation is the complex nature of running-related injuries. Unlike acute traumatic injuries, most RRIs develop gradually through repeated exposure to mechanical stress. Their occurrence depends on the interaction of multiple factors, including training load, recovery practices, previous injury history, biomechanical characteristics, and individual adaptation capacity [3,11,12]. Consequently, improving a single component of physical function is unlikely to completely offset the influence of other risk factors.

The inconsistency of available findings may also reflect methodological differences between studies. Existing investigations vary considerably with respect to participant characteristics, intervention duration, exercise selection, supervision, and injury definitions [2]. Such variability complicates comparisons across studies and may partly explain why positive physiological adaptations are not always accompanied by measurable reductions in injury incidence.

The findings reported by Toresdahl et al. [1] illustrate this challenge. Although the intervention did not significantly reduce injury rates among novice marathon runners, factors such as adherence, exercise execution, and limited supervision may have influenced the outcome. In contrast, the meta-analysis conducted by Wu et al. [2] identified more favorable results in supervised prevention programs, suggesting that how an intervention is delivered may be as important as the intervention itself.

An important distinction should also be made between injury-related variables and injury outcomes. Several studies reviewed in this paper reported improvements in hip strength, gluteal muscle function, movement efficiency, and running economy following resistance-training interventions [4,8–10]. While these adaptations cannot be interpreted as direct evidence of injury reduction, they affect factors that have repeatedly been associated with injury susceptibility. Therefore, the absence of statistically significant reductions in injury incidence should not automatically be interpreted as evidence against the value of strength training.

Particular attention should be given to the role of the hip and lumbopelvic musculature. Deficits in hip abductor strength, impaired gluteus medius function, and altered lower-extremity mechanics have been linked to several common running-related injuries [9,10,20]. Although causal relationships remain difficult to establish, these findings provide a strong rationale for incorporating targeted strengthening exercises into training programs, especially in runners presenting with movement-control deficits or a history of previous injury.

The literature reviewed in this study further supports the contemporary view that injury prevention should be approached through an integrated and individualized framework. Rather than relying on isolated interventions, effective prevention strategies are likely to combine strength training with appropriate load management, recovery optimization, movement-quality assessment, and ongoing monitoring of athlete-specific risk factors [3,11–13].

Several limitations of the current evidence base should be acknowledged. The number of randomized controlled trials investigating injury prevention in runners remains limited, and substantial heterogeneity exists across intervention protocols and outcome measures [1,2]. Future studies should employ standardized injury definitions, clearly described training protocols, and sufficiently long follow-up periods to better evaluate the relationship between strength training and injury incidence.

Overall, the available evidence supports the inclusion of strength training as part of comprehensive endurance-running preparation. Although resistance training cannot be regarded as a standalone solution for injury prevention, its positive effects on strength, neuromuscular function, movement efficiency, and tissue capacity provide a strong justification for its regular incorporation into long-distance running programs.

5. Conclusions

Running-related injuries remain a common challenge among long-distance runners and arise from the interaction of multiple training-related, biomechanical, neuromuscular, and individual factors.

The evidence reviewed in this study indicates that strength training improves several characteristics associated with injury resilience, including muscular strength, hip stability, lumbopelvic control, neuromuscular function, movement efficiency, and running economy. These adaptations may enhance the capacity of the musculoskeletal system to tolerate repetitive loading during endurance running.

Despite these benefits, current research does not consistently demonstrate that strength training alone reduces injury incidence. The effectiveness of preventive interventions appears to depend on multiple factors, including program design, supervision, adherence, training load, and individual athlete characteristics.

Based on the available evidence, strength training should be incorporated into a broader injury-prevention framework that combines resistance exercise with appropriate load management, recovery strategies, and individualized training prescription.

Further high-quality prospective studies and randomized controlled trials are needed to establish the optimal characteristics of strength-training programs and to clarify their direct effects on running-related injury incidence.

Disclosure

Author Contributions

Conceptualization: Gabriela Chwajta, Filip Chmielnicki, Gabriela Pirga, Gabriela Kaczor, Weronika Cichocka

Methodology: Gabriela Chwajta, Weronika Cichocka, Kacper Paczosa, Maciej Ostolski

Software: Gabriela Chwajta, Gabriela Pirga, Gabriela Kaczor

Check: Filip Chmielnicki, Kacper Paczosa

Formal analysis: Gabriela Kaczor, Martyna Antos, Klaudia Jędruszko,

Investigation: Gabriela Chwajta, Gabriela Pirga, Barbara Cepielik

Resources: Filip Chmielnicki, Martyna Antos, Barbara Cepielik

Data curation: Gabriela Kaczor, Klaudia Jędruszko

Writing-rough preparation: Gabriela Chwajta, Weronika Cichocka, Maciej Ostolski**,**

Writing-review and editing: Filip Chmielnicki, Gabriela Pirga, Barbara Cepielik

Project administration: Gabriela Chwajta

All authors have read and agreed with the published version of the manuscript.

Financing statement

This research received no external funding.

Institutional Review Board Statement

Not applicable.

Informed Consent Statement

Not applicable.

Data Availability Statement

Not applicable.

Conflict of interest

The authors declare no conflict of interest.

Declaration of the use of generative AI and AI-assisted technologies in the writing process.

In preparing this work, the author(s) used ChatGPT for language improvement and grammatical correction. After using this tool/service, the author(s) have reviewed and edited the content as needed and accept full responsibility for the substantive content of the publication.

References

1. Toresdahl BG, McElheny K, Metzl J, Ammerman B, Chang B, Kinderknecht J. A Randomized Study of a Strength Training Program to Prevent Injuries in Runners of the New York City Marathon. Sports Health. 2020;12(1):74-79. https://doi.org/10.1177/1941738119877180
2. Wu H, Brooke-Wavell K, Fong DTP, Paquette MR, Blagrove RC. Do Exercise-Based Prevention Programs Reduce Injury in Endurance Runners? A Systematic Review and Meta-Analysis. Sports Med. 2024;54(5):1249-1267. https://doi.org/10.1007/s40279-024-01993-7
3. Correia CK, Machado JM, Dominski FH, de Castro MP, de Brito Fontana H, Ruschel C. Risk Factors for Running-Related Injuries: An Umbrella Systematic Review. J Sport Health Sci. 2024;13(6):793-804. https://doi.org/10.1016/j.jshs.2024.04.011
4. Šuc A, Šarko P, Pleša J, Kozinc Ž. Resistance Exercise for Improving Running Economy and Running Biomechanics and Decreasing Running-Related Injury Risk: A Narrative Review. Sports. 2022;10(7):98. https://doi.org/10.3390/sports10070098
5. Peterson B, Hawke F, Spink M, Sadler S, Hawes M, Callister R, Chuter V. Biomechanical and Musculoskeletal Measurements as Risk Factors for Running-Related Injury in Non-Elite Runners: A Systematic Review and Meta-analysis of Prospective Studies. Sports Med Open. 2022;8(1):38. https://doi.org/10.1186/s40798-022-00416-z
6. Willwacher S, Kurz M, Robbin J, Thelen M, Hamill J, Kelly L, Mai P. Running-Related Biomechanical Risk Factors for Overuse Injuries in Distance Runners: A Systematic Review Considering Injury Specificity and the Potentials for Future Research. Sports Med. 2022;52(8):1863-1877. https://doi.org/10.1007/s40279-022-01666-3
7. Kakouris N, Yener N, Fong DTP. A Systematic Review of Running-Related Musculoskeletal Injuries in Runners. J Sport Health Sci. 2021;10(5):513-522. https://doi.org/10.1016/j.jshs.2021.04.001
8. Llanos-Lagos C, Ramirez-Campillo R, Moran J, Sáez de Villarreal E. Effect of Strength Training Programs in Middle- and Long-Distance Runners' Economy at

Different Running Speeds: A Systematic Review with Meta-analysis. Sports Med. 2024;54(4):895-932. https://doi.org/10.1007/s40279-023-01978-y

9. Van Hooren B, Jukic I, Cox M, Frenken KG, Bautista I, Moore IS. The Relationship Between Running Biomechanics and Running Economy: A Systematic Review and Meta-Analysis of Observational Studies. Sports Med. 2024;54(5):1269-1316. https://doi.org/10.1007/s40279-024-01997-3
10. Semciw A, Neate R, Pizzari T. Running Related Gluteus Medius Function in Health and Injury: A Systematic Review with Meta-analysis. J Electromyogr Kinesiol. 2016;30:98-110. https://doi.org/10.1016/j.jelekin.2016.06.005
11. Sanfilippo D, Beaudart C, Gaillard A, Bornheim S, Bruyere O, Kaux JF. What Are the Main Risk Factors for Lower Extremity Running-Related Injuries? A Retrospective Survey Based on 3669 Respondents. Orthop J Sports Med. 2021;9(11):23259671211043444. https://doi.org/10.1177/23259671211043444
12. Saragiotto BT, Yamato TP, Hespanhol Junior LC, Rainbow MJ, Davis IS, Lopes AD. What Are the Main Risk Factors for Running-Related Injuries? Sports Med. 2014;44(8):1153-1163. https://doi.org/10.1007/s40279-014-0194-6
13. Nielsen RO, Buist I, Sørensen H, Lind M, Rasmussen S. Training Errors and Running Related Injuries: A Systematic Review. Int J Sports Phys Ther. 2012;7(1):58-75. https://pmc.ncbi.nlm.nih.gov/articles/PMC3290924/
14. Lopes AD, Hespanhol Junior LC, Yeung SS, Costa LOP. What Are the Main Running-Related Musculoskeletal Injuries? A Systematic Review. Sports Med. 2012;42(10):891-905. https://doi.org/10.1007/BF03262301
15. Videbæk S, Bueno AM, Nielsen RO, Rasmussen S. Incidence of Running-Related Injuries Per 1000 h of Running in Different Types of Runners: A Systematic Review and Meta-analysis. Sports Med. 2015;45(7):1017-1026. https://doi.org/10.1007/s40279-015-0333-8
16. de Carvalho e Silva GI, Brandão LHA, Dos Santos Silva D, de Jesus Alves MD, Aidar FJ, de Sousa Fernandes MS, Sampaio RAC, Knechtle B, de Souza RF. Acute Neuromuscular, Physiological and Performance Responses After Strength Training in Runners: A Systematic Review and Meta-Analysis. Sports Med Open. 2022;8(1):105. https://doi.org/10.1186/s40798-022-00497-w
17. Taddei UT, Matias AB, Duarte M, Sacco ICN. Foot Core Training to Prevent Running-Related Injuries: A Survival Analysis of a Single-Blind, Randomized

Controlled Trial. Am J Sports Med. 2020;48(14):3610-3619. https://doi.org/10.1177/0363546520969205

18. Fokkema T, de Vos RJ, Visser E, Krastman P, IJzerman J, Koes BW, Verhaar JAN, Bierma-Zeinstra SMA, van Middelkoop M. Enhanced Injury Prevention Programme for Recreational Runners (the SPRINT Study): Design of a Randomised Controlled Trial. BMJ Open Sport Exerc Med. 2020;6(1):e000780. https://doi.org/10.1136/bmjsem-2020-000780
19. Moreira PF, Veras PM, Oliveira TMD, Souza MA, Catharino LL, Borel WP, Barbosa AC, Fonseca DS, Felício DC. Incidence and Biomechanical Risk Factors for Running-Related Injuries: A Prospective Cohort Study. J Clin Orthop Trauma. 2024;57:102562. https://doi.org/10.1016/j.jcot.2024.102562
20. Landauer S, Konrad A, Paternoster FK. Influence of Hip Abductor Strength on Running Biomechanics in Healthy Populations: A Scoping Review. Sports Med Open. 2026;12(1):36. https://doi.org/10.1186/s40798-026-01009-w