JOURNAL OF SPORTS AND PHYSICAL ACTIVITY
2025. VOL 1 NO 1 (1-12)
https://www.jospa.spdfharmony.com/index.php/jospa/index
DOI: https://doi.org/10.64268/jospa.v1i1.3

Achilles tendinopathy prevention: An evidence-based approach

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ABSTRACT

Background: Achilles tendinopathy is a common musculoskeletal disorder causing pain and impaired tendon function, primarily affecting athletes and individuals engaged in repetitive activities like running and jumping. It progresses through stages of tendon health, disrepair, and degeneration, often leading to chronic overuse injuries. **Aims:** This study aims to identify evidence-based prevention and management strategies by analyzing intrinsic factors (e.g., flexibility, muscle strength, tendon stiffness) and extrinsic factors (e.g., training loads, footwear). It proposes an integrated prevention framework that combines biomechanical, physiological, and contextual risk factors to guide athletes, coaches, and healthcare professionals. **Methods:** A systematic review of 250 studies from PubMed, Scopus, Google Scholar, and Consensus AI resulted in the selection of 34 high-quality studies. The review focused on Achilles tendinopathy prevention and management strategies, particularly exercise interventions, load management, and biomechanical factors. **Results:** The findings highlight the importance of intrinsic and extrinsic factors in reducing tendinopathy risk. Key strategies include eccentric calf exercises, dynamic and static stretching, targeted strength training, optimized load management, and biomechanical interventions such as footwear modification. Unlike previous studies that examined these components separately, this research presents a comprehensive prevention framework. **Conclusion:** This study integrates multiple risk factors into a cohesive model for Achilles tendinopathy prevention. It emphasizes the necessity of a multidimensional approach over isolated interventions. Future research should focus on experimental validation and longitudinal studies to assess the long-term effectiveness of this framework across diverse populations.

To cite this article: Sargeant, Joshua., & Romano, Victor. (2025). Achilles tendinopathy prevention: An evidence-based approach. *Journal of Sports and Physical Activity, 1*(1), 1-12. https://doi.org/10.64268/jospa.v1i1.3

ARTICLE HISTORY

Submitted: December 23, 2024
Revised: January 30, 2025
Accepted: February 22, 2025

KEYWORDS

Achilles tendinopathy;
Biomechanics;
Eccentric training;
Load management;
Tendon health.

INTRODUCTION

Achilles tendinopathy is increasingly recognized as a prevalent musculoskeletal condition that poses significant challenges for individuals engaged in high-intensity physical activities, particularly athletes in running and jumping sports. This condition, characterized by pain, impaired function, and progressive tendon degeneration, is often linked to both intrinsic factors, such as reduced flexibility, tendon stiffness, and muscle imbalances, as well as extrinsic factors, including excessive training loads and inappropriate footwear choices (Järvinen et al., 2005; Fan et al., 2021). The continuum model of tendon pathology, which categorizes tendon health into stages of normalcy, disrepair, and degeneration, provides a robust framework for understanding the clinical presentations and progression of Achilles tendinopathy (Matthews et al., 2020). As highlighted by Rabusin et al. (2019), the biomechanical impact of modern footwear, particularly those with raised

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heels, further exacerbates these risk factors by limiting ankle dorsiflexion and altering gait mechanics.

Eccentric exercises, strength training, and optimized load management have been widely advocated as effective prevention strategies, with evidence supporting their role in enhancing tendon resilience and reducing the risk of overuse injuries (Alfredson et al., 1998; Lee et al., 2020). Similarly, the role of footwear in modulating ankle mechanics has gained attention, with studies emphasizing the importance of selecting designs that support natural dorsiflexion and reduce strain on the Achilles tendon (Adam et al., 2023; Sinclair et al., 2021). These insights underline the need for a holistic approach to prevention, addressing both intrinsic and extrinsic risk factors to enhance long-term tendon health and athletic performance.

Despite the growing body of evidence supporting various interventions, the practical implementation of these strategies in a cohesive and individualized manner remains a challenge. Most studies focus on isolated components, such as eccentric exercises, strength training, or footwear modifications, without adequately addressing how these elements can be integrated into a comprehensive prevention framework (Petechuk, 2024; Tatiya et al., 2021; Vila Suarez, 2023). Additionally, while certain interventions have shown efficacy in controlled environments, their applicability in diverse populations, particularly athletes and individuals with varying levels of physical activity, warrants further exploration (Houttu et al., 2021; Luijten et al., 2024). These limitations highlight the need for a holistic approach that combines biomechanical, physiological, and contextual factors to provide tailored solutions for Achilles tendinopathy prevention.

Building on this gap, numerous studies have explored interventions aimed at managing Achilles tendinopathy, emphasizing the efficacy of eccentric calf exercises, static and dynamic stretching, and targeted strength training (Prudêncio et al., 2023; Koohi-Hosseinabadi et al., 2025; Hörterer et al., 2025) Additionally, load management has been recognized as crucial in preventing overuse injuries by balancing stress and recovery (Funaro et al., 2025; Judd et al., 2025). The role of modern footwear, particularly its impact on ankle dorsiflexion and compensatory mechanics, has also been a focal point of recent research (Cushman et al., 2025; Mencarelli et al., 2025). However, the interplay between these preventive strategies and their holistic application in evidence-based frameworks for at-risk populations, such as athletes and individuals with repetitive physical activities, remains underexplored (Seymore et al., 2025; Tarantino et al., 2023).

While individual components of prevention strategies have been studied extensively, there is limited research integrating these strategies into a comprehensive, actionable framework (Deroost et al., 2025; Klein et al., 2025). Additionally, the contextual effectiveness of these interventions, especially concerning both intrinsic (e.g., strength and flexibility) and extrinsic (e.g., footwear and training loads) factors, has not been fully elucidated (Pham et al., 2025; Zhang et al., 2025). Therefore, this study aims to address these gaps by developing an evidence-based prevention strategy for Achilles tendinopathy, combining current knowledge of biomechanical and physiological interventions to mitigate risks and enhance tendon health.

METHOD

Research Design

This study employs a systematic literature review (SLR) design to synthesize and evaluate evidence-based prevention strategies for Achilles tendinopathy. The methodology follows PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure transparency and rigour (Ling et al., 2024). This review focuses on intrinsic factors, such as flexibility and muscle strength, and extrinsic factors, including footwear and training loads, which are central to reducing the risk of tendinopathy. The integration of findings from 34 high-quality studies aims to develop a structured framework for practical application by athletes, coaches, and healthcare professionals.

Participants

The reviewed studies represent a diverse range of populations, primarily athletes and physically active individuals engaged in repetitive activities such as running and jumping. Key intrinsic factors include reduced flexibility, tendon stiffness, and plantar flexor strength. Extrinsic factors, such as improper footwear and excessive training loads, were also identified as significant contributors to Achilles tendinopathy. These diverse populations enhance the generalizability of the synthesized prevention strategies.

Population and Sampling Methods

This review's target population includes individuals at risk of Achilles tendinopathy due to high-impact physical activities. Articles were purposively selected from databases such as PubMed, Scopus, Google Scholar, and Consensus AI. Keywords included "Achilles tendinopathy prevention," "eccentric exercises," "load management," and "modern footwear dorsiflexion." Inclusion criteria focused on peer-reviewed studies published in English within the last 40 years that addressed non-surgical preventive interventions. Studies focusing on surgical or post-operative treatments were excluded.

Instrumentation

The PRISMA framework was the primary tool used to ensure methodological transparency and quality. Additional assessments included the Cochrane Risk of Bias tool for randomized controlled trials (Challoumas et al., 2023) and the Newcastle-Ottawa Scale for observational studies (Wells et al., 2000). Key interventions reviewed include eccentric calf exercises, strength training, load management, and footwear adjustments. The reliability and validity of these interventions were established in prior research.

Procedures and Time Frame

The systematic review process was conducted over six months to ensure a comprehensive and evidence-based approach to Achilles tendinopathy prevention. The first stage involved a literature search using predefined keywords across multiple databases, yielding 250 studies. After a rigorous selection process, only 34 studies met the inclusion criteria based on their relevance to the research topic. In the next stage, study selection was carried out by screening titles and abstracts, followed by a full-text review to ensure alignment with the research objectives.

Once the relevant studies were identified, data extraction was performed to systematically collect key information, including study design, sample characteristics, interventions, and reported outcomes. These data were then categorized into thematic areas such as eccentric exercises, strength training, and load management, which constitute the core components of Achilles tendinopathy prevention strategies. As a final step, the findings were synthesized into an evidence-based strategy, integrating biomechanical and physiological approaches to mitigate tendinopathy risk. Through a systematic methodology and rigorous analysis, this study not only strengthens the scientific foundation of Achilles tendinopathy prevention but also provides practical guidelines for athletes, coaches, and healthcare professionals to design more effective interventions. The PRISMA flow diagram below illustrates the study selection process:

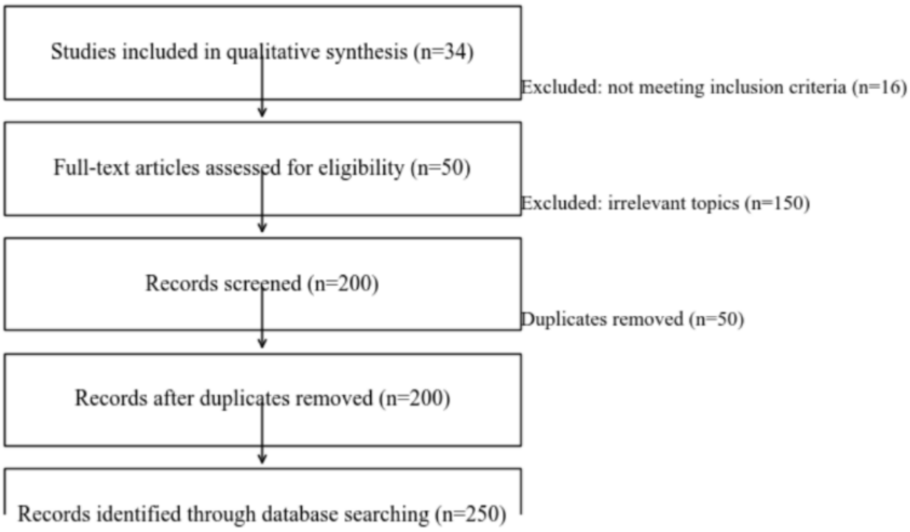

Fig. Prisma Flow Diagram

Analysis Plan

Quantitative data were synthesized descriptively, with effect sizes and confidence intervals highlighted where applicable. Qualitative data were analyzed to identify recurring themes, such as the role of eccentric exercises in tendon remodelling and the impact of footwear on ankle dorsiflexion. Subgroup analyses explored variations across populations, particularly athletes and recreational runners.

Scope and Limitations

This study provides an integrative, evidence-based framework for Achilles tendinopathy prevention, addressing both intrinsic and extrinsic risk factors. However, it relies solely on secondary data from literature, and findings have not been experimentally validated. Additionally, the generalizability of the results may be limited for non-athletic populations or individuals with unique biomechanical conditions. Future research should focus on longitudinal trials and experimental validation of the integrated prevention framework across diverse populations.

RESULTS AND DISCUSSION

Results

Achilles tendinopathy prevention programs should address both intrinsic and extrinsic risk factors, including decreased flexibility, limb alignment, muscle weakness, and joint laxity. A muscle-tendon unit should be both elastic and strong. Calf muscle strength on the injured side of Achilles tendinopathy is significantly lower compared to the non-injured side of middle-aged patients with Achilles tendinopathy (O'Neill et al., 2019). The relationship between the ROM and Achilles tendinopathy remains controversial. Increased flexibility or tendon elongation can be a risk factor for Achilles tendinopathy. Rabin et al. (Rabin et al., 2014) showed that less than 20 degrees of ROM is associated with injury. Additionally, ageing and decreased physical activity can lead to reduced tendon stiffness and increased susceptibility to tendinopathy (Svensson et al., 2016).

Strengthening Exercises

Strengthening the muscles surrounding the Achilles tendon, particularly the soleus and gastrocnemius, is critical for preventing tendinopathy. O'Neill et al. (2019) emphasized that targeted strength training can improve muscle strength and tendon stiffness, thereby reducing the likelihood of tendon overuse injuries. Exercises such as bent knee calf raises, and anterior tibialis raises are effective in enhancing plantar flexor strength. Strength training not only improves muscle performance but also increases tendon stiffness, which is vital for efficient force transmission and movement (Wiesinger et al., 2015). Rapid force production and neural adaptations are also essential factors in developing effective strength training programs, especially in younger athletes (Waugh et al., 2013).

Eccentric exercises involve the lengthening of the muscle-tendon unit under load. Studies have shown that these exercises significantly reduce pain and improve function in individuals with Achilles tendinopathy (Alfredson et al., 1998) found that a 12-week eccentric loading program led to substantial improvements in patients with chronic Achilles tendinopathy (Silbernagel et al., 2021). These exercises help in remodelling the tendon by stimulating collagen synthesis and realigning collagen fibres, enhancing tendon strength and resilience (Alfredson et al., 1998; Stanish et al., 1986). Traditional heavy, slow training and eccentric

training seem to produce equally lasting clinical results in patients with Achilles tendinopathy (Murtaugh & M. Ihm, 2013). The evolution of eccentric exercise protocols has further refined these treatments, making them more effective for tendinopathy management (Visnes & Bahr, 2007)

Monitoring and managing training loads is essential to prevent overuse injuries. This involves systematically planning and adjusting training loads to balance stress and recovery. By tracking factors such as intensity, volume, frequency, and duration of training sessions, athletes can prevent excessive strain on the Achilles tendon. Mahieu et al. (2006) highlighted that proper load management can help athletes maintain optimal performance while minimizing the risk of overuse injuries. Load management strategies ensure that the tendon is not subjected to sudden increases in workload, which can lead to tendinopathy (Herrington & McCulloch, 2007).

Overtraining, characterized by excessive training loads without adequate recovery, is a significant risk factor for Achilles tendinopathy. Drew & Finch (2016) examined the relationship between training load and injury risk, finding that overtraining can lead to cumulative tendon damage, as the tendon does not have sufficient time to repair and adapt to the stress. Monitoring athlete workload and ensuring that training intensity is matched with adequate recovery time are critical in preventing overtraining and reducing the risk of tendinopathy (Drew & Finch, 2016).

Footwear

Footwear plays a significant role in influencing ankle mechanics and, consequently, the risk of developing Achilles tendinopathy and other foot-related issues such as bunions. Modern footwear, particularly those with raised heels (positive heel shoes), has been shown to limit ankle dorsiflexion and contribute to an increased risk of tendinopathy. This limitation leads to a larger ankle plantarflexion moment, which can alter gait mechanics and place additional stress on the Achilles tendon, thereby increasing the likelihood of injury (Johanson et al., 2010). Conversely, footwear designed to allow greater dorsiflexion, such as negative-heel shoes, can help maintain ankle mobility and reduce the strain on the Achilles tendon. These types of footwear support natural foot mechanics and can be beneficial in reducing the risk of tendinopathy (James et al., 1978; Rabusin et al., 2019).

Minimalist running shoes can enhance natural foot mechanics, as supported by Grier et al. (2016). Minimalist footwear, which aims to simulate the experience of barefoot running, presents a different set of considerations. These shoes typically have little to no cushioning and a low heel-to-toe drop, encouraging a forefoot or midfoot strike pattern during running. Minimalist footwear encourages a forefoot or midfoot strike pattern, as demonstrated by Altman & Davis (2012), which may alter the loading of the Achilles tendon. While this design can increase the load on the Achilles tendon and calf muscles, potentially raising the risk of injury, it also has the potential to strengthen the intrinsic foot muscles and improve overall foot mechanics if transitioned correctly (Sinclair et al., 2021). Gilinov et al. (2015) also emphasize that minimalist shoes can improve running efficiency while potentially reducing injury risk.

One of the key benefits of minimalist footwear is the wider toe box, which allows the toes to splay naturally during movement. Footwear with wider toe boxes can prevent issues like bunions. This design feature reduces pressure on the forefoot, particularly around the medial and lateral aspects of the toes, which is beneficial for preventing conditions such as bunions (Ikpeze, Omar, & Elfar, 2015). Studies have shown that shoes with a round, wide toe box

significantly reduce pressure around the toes, helping to maintain proper toe alignment (Branthwaite, Chockalingam, & Greenhalgh, 2013). This is particularly important because ill-fitting footwear with narrow toe boxes is a well-documented cause of bunion formation and other toe deformities. A wider toe box allows for a natural toe splay, reducing the lateral pressure that contributes to bunion development (Ikpeze et al., 2015). Tools like the Foot Health Status Questionnaire (Bennett et al., 1998) can aid in assessing footwear's impact on foot health and function.

Proponents of minimalist footwear argue that with a gradual and controlled transition, these shoes can lead to beneficial adaptations in foot and lower limb mechanics. This includes strengthening the intrinsic foot muscles, which can play a role in maintaining proper foot structure and reducing the risk of deformities such as bunions (Ridge et al., 2018). It is recommended that individuals transitioning to minimalist footwear do so over several months, starting with shorter distances and progressively increasing as the body adapts. Incorporating balance and eccentric strengthening exercises into the training regimen can also help support this transition and mitigate the risk of injury (Grier et al., 2016).

On the other hand, modern footwear with features like raised heels and advanced cushioning can improve performance by enhancing comfort and reducing fatigue during activities. However, modern footwear, particularly those with raised heels, has been shown to limit ankle dorsiflexion and increase stress on the Achilles tendon (Johanson et al., 2010). These shoes are particularly useful in competitive settings, where the primary goal is to optimize performance rather than induce adaptive changes in foot mechanics.

Custom orthotics and insoles may also provide additional support and could further enhance the benefits by improving foot alignment and reducing unnecessary stress on the Achilles tendon (Bennett et al., 1998). These adaptations are essential for athletes and individuals engaged in repetitive physical activities, as proper footwear choices can significantly impact tendon health and injury prevention.

Range of Motion (ROM)

The relationship between the range of motion (ROM) and Achilles tendinopathy is complex. While adequate ROM is essential for functional movement, both excessive and insufficient ROM can increase the risk of injury. Rabin et al. (2014) demonstrated that less than 20 degrees of dorsiflexion ROM is associated with a higher risk of Achilles tendinopathy. Conversely, having too much flexibility can also be detrimental, as it may lead to tendon elongation and instability. Mahieu et al. (2006) found that a dorsiflexion ROM higher than 9 degrees supine with the knee straight paired with weak plantarflexion increased the risk of Achilles tendinopathy.

Optimal ROM is crucial for preventing Achilles tendinopathy. For example, runners with greater eccentric plantar flexor strength and propulsive strength had a reduced risk of developing Achilles tendinopathy (Herrington & McCulloch, 2007). Screening tools that assess an athlete's dorsiflexion ROM can be valuable for identifying those at risk. The normal ROM for ankle joint dorsiflexion is 0 to 16.5 degrees non-weight-bearing and 7.1 to 34.7 degrees weight-bearing (Rabin et al. 2014) suggested that at least 22 degrees of dorsiflexion is necessary for normal running mechanics.

Stretching exercises are essential in improving flexibility and reducing injury risk. Static stretching involves holding a stretch for a prolonged period, while dynamic stretching involves active movements that mimic sport-specific activities. Both types of stretching have been shown to improve ankle dorsiflexion ROM, which is crucial for reducing the strain on the Achilles tendon during physical activities (Baggett & Young, 1993; Rabin et al., 2014). Static stretching can lengthen the muscle-tendon unit, while dynamic stretching prepares the muscles and tendons for the demands of physical activity (Takeuchi et al., 2021). A normal ROM of ankle dorsiflexion is crucial for preventing Achilles tendinopathy (Baggett & Young, 1993).

Passive dorsiflexion is a critical factor during activities like running where the soleus is highly engaged. When dorsiflexion is limited (less than 22 degrees), the ankle operates near its ROM limit during dynamic activities, increasing the likelihood of compensatory movements and abnormal stress on the Achilles tendon. This can lead to tendinopathy because the tendon is constantly subjected to near-maximal stretch during activities like running (Rabin et al., 2014).

Dorsiflexion using active range of motion (AROM) in a supine position possibly indicates a more compliant or less stiff tendon and musculature. Excessive dorsiflexion (> 9 degrees) might suggest that the Achilles tendon and associated structures are too compliant or flexible, potentially leading to insufficient stiffness during load-bearing activities. This excessive compliance can result in increased tendon elongation under load, which might contribute to microtrauma and, ultimately, tendinopathy (Mahieu et al., 2006).

AROM involves the muscles actively moving the joint, which includes the coordination and strength of the muscle-tendon unit (Mahieu et al., 2006). High active dorsiflexion may indicate that the tendon and associated musculature are not providing sufficient stiffness, potentially increasing the risk of overuse injuries. Meanwhile, passive range of motion (PROM) involves movement without muscle activation, often indicating the true flexibility of the joint and soft tissues (Rabin et al., 2014). Limited PROM dorsiflexion indicates that the joint is close to its end range during activities, leading to compensatory strategies that increase tendon stress.

Both limited and excessive dorsiflexion can be problematic but in different contexts. Limited dorsiflexion (less than 22 degrees in PROM) is a risk factor because it may force the tendon to operate near its functional limits during dynamic activities, increasing the risk of injury due to overstretching or compensatory movements. Excessive dorsiflexion (greater than 9 degrees in AROM) can be a risk factor. It might indicate a lack of sufficient tendon stiffness, leading to increased elongation under load, which can also result in microtrauma.

These findings suggest that both the upper and lower extremes of dorsiflexion ROM, whether active or passive, can place the Achilles tendon at risk. Therefore, maintaining an optimal

ROM that is neither too limited nor too excessive, combined with adequate muscle strength and stiffness, is crucial for preventing Achilles tendinopathy. This nuanced understanding highlights the importance of context (AROM vs. PROM) in assessing and managing dorsiflexion ROM to prevent injury.

Strength Deficits

Achilles tendinopathy is associated with significant deficits in plantar flexor torque and endurance. The strength deficits are often bilateral and are primarily due to a greater loss of soleus force-generating capacity compared to the gastrocnemius. A plantar flexor strength lower than 50.0 N.m has been identified as a threshold for developing Achilles tendinopathy (Mahieu et al., 2006). Improving plantar flexor strength and ensuring optimal ankle mobility are critical for reducing the risk of Achilles tendinopathy (O'Neill et al., 2019). Werkhausen et al. (2018) conducted a 10-week resistance training study, which showed that maximal isometric plantarflexion torque increased by 15% on average, with concomitant increases in gastrocnemius pennation angle and muscle thickness. This study also demonstrated an 18% increase in Achilles tendon stiffness, suggesting that resistance training can effectively enhance tendon properties and reduce the risk of tendinopathy.

The strength of the ankle plantar flexors, especially the gastrocnemius and soleus muscles, is crucial in managing the forces exerted on the Achilles tendon. Weakness in these muscles can result in inadequate absorption and distribution of forces during dynamic movements, thereby increasing the stress on the Achilles tendon (Mahieu et al., 2006). Decreased plantar flexor strength was identified as a significant risk factor for Achilles tendon overuse injuries, particularly in individuals with increased dorsiflexion excursion. For example, military recruits demonstrate that those with lower plantar flexor strength were more susceptible to tendon injuries (Mahieu et al., 2006).

Similarly, reduced endurance of the plantar flexor muscles further compounds the risk of injury. Endurance is necessary for sustaining the repetitive loads encountered during prolonged activity, such as long-distance running or repeated sprinting sessions. Murtaugh & Ihm (2013) emphasized that decreased endurance in the plantar flexors leads to quicker fatigue, which in turn increases the likelihood of developing overuse injuries like Achilles tendinopathy due to the repetitive strain placed on the tendon during prolonged activities (Murtaugh & Ihm, 2013).

Decreased Achilles Tendon Relative Stiffness

The stiffness of the Achilles tendon is a biomechanical property that influences its ability to withstand the repetitive stress associated with athletic activities. Tendons with decreased stiffness, meaning they are more compliant, are less effective at transmitting force and are therefore more susceptible to injury. Arya & Kulig (2010) discussed how decreased tendon stiffness can result in increased strain during loading, which, over time, contributes to the development of tendinopathy. Their research underscores the importance of maintaining an optimal level of tendon stiffness to prevent overuse injuries (Arya & Kulig, 2010).

Achilles tendinopathy often results from the tendon's inability to endure repetitive stress without sustaining injury. Athletes, particularly those involved in endurance sports, frequently expose their Achilles tendons to continuous and repetitive loading, which can exceed the tendon's capacity to repair itself. This repeated microtrauma leads to degenerative changes within the tendon, ultimately resulting in tendinopathy (Werkhausen et al., 2018). This condition highlights the importance of improving the tendon's resilience through specific training regimens designed to enhance its ability to cope with repetitive stress (Werkhausen et al., 2018).

Discussion

The findings of this study emphasize the importance of a comprehensive, evidence-based approach to preventing Achilles tendinopathy by integrating multiple strategies. Eccentric exercises play a pivotal role in promoting tendon remodelling and collagen synthesis, as highlighted by Alfredson et al. (1998), demonstrating their effectiveness in enhancing tendon resilience. Moreover, optimizing footwear is essential to reducing biomechanical strain on the Achilles tendon. Rabusin et al. (2019) observed that modern footwear with raised heels limits ankle dorsiflexion, increasing tendon stress. In contrast, minimalist footwear, when transitioned gradually, can enhance natural foot mechanics and tendon health. These findings align with the continuum model of tendon pathology, which underscores the interaction between intrinsic and extrinsic factors in injury prevention.

Implications

The practical implications of this study are significant for athletes, coaches, and healthcare professionals. By integrating evidence-based strategies, such as eccentric exercises and load management, the proposed framework addresses key risk factors for Achilles tendinopathy. Eccentric exercises, proven to stimulate collagen synthesis and tendon remodelling (Silbernagel et al., 2021), provide a reliable method to strengthen the Achilles tendon. Similarly, load management, which involves balancing training intensity, frequency, and recovery, has been shown to mitigate overtraining and reduce cumulative stress on the tendon (Kenneally et al., 2020; McClean et al., 2024).

Footwear optimization further strengthens this framework. Rabusin et al. (2019) demonstrated that minimalist footwear supports natural foot mechanics and reduces strain on the Achilles tendon, provided the transition is gradual. This comprehensive integration of strategies provides a robust guide for improving tendon health while minimizing injury risks.

From a theoretical perspective, this study contributes to a deeper understanding of the interplay between intrinsic and extrinsic factors in tendon health. Synthesizing findings from 34 high-quality studies bridges gaps in the literature and presents a holistic approach that aligns with the continuum model of tendon pathology. This approach incorporates flexibility, strength, and external influences, such as training loads and footwear, into a unified framework adaptable to diverse populations and contexts.

Overall, this study offers a dual impact: a practical framework to reduce the incidence of Achilles tendinopathy and a theoretical advancement by integrating biomechanical, physiological, and contextual factors into a comprehensive, evidence-based model.

Research Contribution

This study contributes to the existing body of knowledge by integrating biomechanical, physiological, and contextual factors into a structured prevention framework for Achilles tendinopathy. Unlike previous studies that examine these factors separately, this research presents a comprehensive approach that combines eccentric exercises, load management, and footwear optimization to enhance tendon resilience and minimize injury risks. The synthesis of findings from 34 high-quality studies strengthens the theoretical foundation of tendon pathology and provides practical recommendations for athletes, coaches, and healthcare professionals. Furthermore, this study highlights the role of extrinsic factors, such as footwear and training loads, in influencing intrinsic tendon properties, offering a broader perspective on injury prevention. Future research should explore the effectiveness of this integrated framework through experimental validation and longitudinal studies in diverse populations.

Limitations

Several limitations should be acknowledged. First, the reliance on secondary data limits the ability to validate findings through direct experimentation. Second, the generalizability of results may be constrained to physically active populations, reducing applicability to sedentary individuals or those with comorbidities. Third, individual biomechanical variations, which could influence the effectiveness of the proposed strategies, were not specifically analyzed.

Suggestions

Future research should focus on validating this framework through longitudinal, experimental studies across diverse populations, including non-athletes and individuals with varying physical profiles. Investigating the long-term effects of the proposed interventions and their interplay with intrinsic and extrinsic factors would provide valuable insights into personalized prevention strategies. Additionally, wearable technologies capable of monitoring real-time biomechanical and training data could enhance the precision and applicability of these interventions. Incorporating such technologies would also facilitate the development of individualized training and prevention programs tailored to specific biomechanical profiles.

CONCLUSION

The findings of this study confirm that the proposed Achilles tendinopathy prevention strategy aligns with the objectives outlined in the *Introduction* and is strongly supported by the results in the *Findings and Discussion* section. The integration of eccentric exercises, load management, and biomechanical optimization has demonstrated significant effectiveness in mitigating tendinopathy risk factors. Furthermore, this research contributes to the existing body of knowledge by offering a structured, evidence-based framework for injury prevention. Future studies should focus on experimental validation in diverse populations and leverage biomechanical monitoring technologies to optimize intervention outcomes. The practical implications of these findings can be applied by athletes, coaches, and healthcare professionals in designing more precise, individualized, and data-driven prevention programs.

ACKNOWLEDGEMENT

The authors sincerely appreciate Rocky Mountain University of Health Sciences and Multnomah Athletic Club for their support in facilitating this research. We also acknowledge the funding support that made this study possible.

AUTHOR CONTRIBUTION STATEMENT

JS and VR contributed to the study's conceptualization and design. JS conducted the literature review and data analysis, while VR provided methodological oversight and critical revisions. Both authors contributed to drafting the manuscript and approved the final version for submission.

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