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NARRATIVE REVIEW

Running into Trouble: An Updated Review of Shin Splints, a Common Running Injury a narrative review

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HIGHLIGHTS

- ▶ Medial tibial stress syndrome (MTSS) accounts for 10–20% of running-related overuse injuries and up to 35% in high-risk groups such as military recruits.
- ▶ MTSS pathophysiology involves cumulative bone overload, altered lower-limb kinematics, and impaired neuromuscular control rather than isolated periostitis.
- ▶ Key intrinsic risk factors include female sex, elevated BMI, excessive foot pronation, and rapid increases in training load.
- ▶ Diagnosis is primarily clinical, supported by the Foot Posture Index and Navicular Drop test, with MRI reserved for differential diagnosis of stress fractures.
- ▶ Conservative management centered on load modification and neuromuscular training yields the best outcomes, while evidence for adjunctive therapies remains inconclusive.

ABSTRACT

BACKGROUND: MTSS is an overuse injury of the lower leg, most common in athletes exposed to repetitive loading. It is associated with factors such as excessive pronation and higher BMI. Diagnosis is mainly clinical, and the condition is thought to result from overload and inflammation of the medial tibial periosteum. First-line treatment includes rest and reduction of aggravating activities.

AIM: To review and synthesize current knowledge on MTSS, with emphasis on its etiology, pathophysiology, and key risk factors, as well as to evaluate diagnostic methods and outline current treatment and prevention strategies.

MATERIALS AND METHODS: A search of PubMed, Embase, Cochrane Library, and Web of Science was conducted to identify recent studies on MTSS, which were then analyzed for etiology, pathophysiology, risk factors, diagnosis, treatment, and prevention.

RESULTS: MTSS is a multifactorial overuse condition linked to mechanical overload and biomechanical factors, most common in runners and military populations. Key risk factors include female sex, higher BMI, excessive pronation, and rapid increases in training load. Imaging shows involvement of bone and periosteal tissues, while biomechanical patterns increase tibial loading. Conservative management with load modification is the primary treatment, with limited evidence for adjunctive therapies.

CONCLUSIONS: MTSS remains an important problem in physically active populations, especially runners and military recruits, and its development appears to result from the interaction of mechanical overload, anatomy, and muscle function. Interventions targeting neuromuscular control and training-load optimization seem most promising for prevention and treatment, and a better understanding of MTSS mechanisms may improve future management.

KEYWORDS shin splints; medial tibial stress syndrome; tibial stress injury; etiology; diagnosis; treatment; prevention; risk factors

PLAIN LANGUAGE SUMMARY

Shin splints, medically known as medial tibial stress syndrome (MTSS), is a common overuse injury causing pain along the inner edge of the shinbone. It frequently affects runners, dancers, and military personnel, especially when training intensity increases too quickly. The pain usually starts during exercise, may fade as you warm up, and returns with rest. Modern research shows it is not simply "bone inflammation," but rather a response to repeated stress on the tibia combined with poor foot mechanics, weak hip muscles, and rapid changes in training volume. Doctors diagnose it mainly by feeling the shinbone and checking foot posture. X-rays are usually normal, so MRI is only used to rule out stress fractures. The best treatment is simple: reduce painful activity, switch to low-impact cross-training, use shock-absorbing insoles if needed, and strengthen the hips and feet. Prevention focuses on gradual training progression, proper footwear, and neuromuscular exercises. With patience and the right approach, most athletes recover fully and return to sport.

1. INTRODUCTION

Medial tibial stress syndrome (MTSS) is one of the most common causes of exercise-related shin pain and represents a significant problem among both runners and individuals engaging in intensive physical activity, particularly activities involving repetitive loading of the lower limbs [1,2,4,5]. This condition has long attracted the attention of researchers and clinicians; however, despite numerous publications, it remains a disorder that is still not fully and unequivocally defined in terms of pathophysiology, diagnostic criteria, and optimal management [3,6,7,8]. In clinical practice, MTSS often needs to be differentiated from other causes of exercise-induced lower leg pain, such as tibial stress fracture or chronic exertional compartment syndrome, which further complicates assessment of the condition [9,10].

Over the years, many terms have been used to refer to this syndrome. In the available scientific literature, the condition appears under different names, such as "shin splints," "medial tibial syndrome," "tibial stress syndrome," and "periostitis" [11]. Each of these terms highlighted a slightly different clinical or etiological aspect; however, current scientific knowledge suggests that none fully reflects the nature of the disorder [11,12]. The term "shin splints" is particularly problematic because it is

too nonspecific and has historically been used as an umbrella term for various forms of exercise-related lower limb pain, often including conditions with different pathogenesis [13]. Moen et al., in a critical review, emphasized that MTSS is not merely a simple inflammation of a single structure, but rather reflects a more complex process of bone remodeling secondary to overload [14]. Nevertheless, in light of current knowledge, MTSS appears to be the most appropriate term, as it best reflects both the location of symptoms and the likely overload-related mechanism of the condition.

Despite advances in MTSS research, there are still gaps and ambiguities regarding its etiology, risk factors, pathogenesis, and the effectiveness of available treatment and preventive methods. For this reason, MTSS remains an important research topic, and systematizing current knowledge is necessary both for clinical practice and for further scientific development in the field of lower limb overuse injuries.

2. EPIDEMIOLOGY

Literature data regarding the prevalence of MTSS show significant discrepancies, estimating incidence rates between 4% and 17% [15], and as high as 35% in certain athletic groups [16]. It is generally accepted that MTSS accounts for 10–20% of all overuse injuries in the running population. Military recruits represent a particularly high-risk group, where MTSS is one of the most common reasons for being sidelined from physical activity [16].

Contemporary pathophysiological models suggest that this condition is not merely an isolated inflammation of the periosteum, but rather part of a continuum of bone stress injuries. Failure to appropriately modify training loads during the initial phase may lead to the progression of changes, ranging from a mild bone stress reaction to a full stress fracture [17].

As indicated by a meta-analysis of studies from various countries, MTSS occurs most frequently in India (69.5%) and least frequently in the United States (5.4%). These disparities may stem from geographical and demographic differences, as well as varied research methodologies (e.g., reliance on self-diagnosis versus clinical examination). Factors such as access to specialized footwear and the quality of training surfaces also play a role [12]. Reports from India and the United States show that individuals with more sports experience have a lower risk of MTSS [12]. In contrast, other studies indicate an increased risk among marathon runners [12].

3. PATHOPHYSIOLOGY

The pathophysiology of MTSS is most likely multifactorial and involves the interaction of bone overload, biomechanical abnormalities, and soft-tissue changes.

MRI (Magnetic Resonance Imaging) findings suggest that the disease process is not confined to the periosteum alone, but may also involve the bone marrow and

surrounding tissues along the posteromedial border of the tibia, including adipose tissue and peritendinous structures [18].

Biomechanical studies indicate that, during running, tibial strain increases as speed increases. In this mechanism, contraction of the soleus muscle and the use of previously stored elastic energy appear to play an important role, whereas the contribution of the tibialis posterior and flexor digitorum longus seems smaller than assumed in the classic traction theory, which proposes that repetitive tensile forces acting on the tibial fascia may lead to inflammation [1,19]. At the same time, ultrasound studies have shown that the insertions of the flexor digitorum longus are often located within the typical pain region, which also supports the hypothesis of repetitive traction forces acting on the periosteum [20].

Biomechanical factors of the lower limb are also important. In runners with MTSS, altered foot and shank kinematics have been observed, including increased eversion and abduction of the forefoot and hindfoot, as well as greater internal rotation of the shank and a higher free moment, which may increase torsional and shear stresses within the tibia [21].

Evidence from a systematic review and meta-analysis suggests that factors such as barefoot running, the use of unfamiliar minimalist footwear, increased stride length, and higher running speed substantially increase tibial loading, thereby supporting a biomechanical model of shin splints development [22]. Morphological features of the bone may also predispose to MTSS, such as a smaller tibial shaft thickness, greater bone length, and a larger medullary canal diameter, suggesting a thinner cortical bone [23]. A systematic review also found an association between MTSS and lower lean mass of the lower limb, as well as increased peak soleus activity during propulsion, which may reduce the muscles' ability to absorb load and increase the forces transmitted to the periosteum [24]. In addition hip abductor weakness and impaired pelvic and knee control, manifested by dynamic knee valgus and contralateral pelvic drop, may be important components of the pathomechanism and potential targets for rehabilitation [25].

At the tissue level, MTSS may represent an overuse-related bone response with microdamage. Histological studies have shown a predominance of linear microcracks, with remodeling associated with microcracks being rarely observed, suggesting that fatigue damage caused by repetitive compressive, torsional, and shear loads predominates [26].

Taken together, the available data support a model in which MTSS develops as a result of cumulative overload acting on a morphologically susceptible tibia, in the setting of impaired neuromuscular control, altered lower-limb kinematics, and a reduced capacity of the tissues to absorb energy.

4. RISK FACTORS

MTSS is characterized by a complex, multifactorial etiology. The development of this condition results from the interaction of biomechanical parameters, systemic factors, and training errors.

Intrinsic factors (individual and structural) primarily include [15,24]:

1. elevated BMI,
2. female gender,
3. limited running experience (short training history),
4. lack of mobility training in the exercise program,
5. foot static disturbances, including excessive pronation, clinically manifested by an increased navicular drop and a persistent pronatory pattern during the stance phase.

Extrinsic and biomechanical factors predisposing to MTSS include [25,27]:

1. inappropriate load programming (rapid increase in training volume or intensity),
2. energy and mineral deficiencies (e.g., low calcium and vitamin D intake),
3. lower limb malalignment and technical errors generating excessive mechanical stress,
4. running on hard surfaces and the use of inappropriate footwear.

Clinical analysis of patients with MTSS often reveals significant neuromuscular deficits [28]:

First, increased tension of the iliotibial band (ITB). The ITB (tractus iliotibialis) is a thickened band of fascia lata located on the lateral aspect of the thigh. It originates at the external lip of the iliac crest and inserts at Gerdy's tubercle (the anterolateral aspect of the lateral condyle of the tibia). This structure acts as a key lateral stabilizer of the pelvis and the knee joint and serves as a common insertion point for the gluteus maximus and tensor fasciae latae muscles [29]. In running biomechanics, increased ITB tension forces the runner to adopt an adaptive, wider step width. Although theoretically, this is a mechanism intended to limit foot eversion, clinical observations indicate the opposite: runners with excessive ITB tension more frequently exhibit an increased tendency for foot eversion [28]. This suggests that ITB tension is an element of a complex and not always effective compensatory process within the entire kinetic chain of the lower limb.

Second, insufficiency of the hip abductor muscles (primarily the gluteus medius). This results in increased pelvic drop on the contralateral side (positive Trendelenburg sign) and a lack of dynamic limb stability [28]. Insufficient strength of the hip abductors is a significant causal factor in poor dynamic limb control during weight-bearing activities. This manifests as a lack of stability throughout the entire kinetic chain—from the trunk to the foot—in both the transverse and frontal planes [25].

Dysfunctions such as pes planus and dynamic knee valgus should not be considered as isolated conditions. Rather, they are cascading consequences of proximal (hip) insufficiency that accumulate mechanical stress on the medial border of the tibia, directly leading to the development of MTSS.

5. CLINICAL PRESENTATION

The key symptom of MTSS is pain localized along the posteromedial border of the distal two-thirds of the tibial shaft [12,27]. Although discomfort may occasionally involve the anterior or lateral aspects of the lower leg, the medial location remains pathognomonic [12]. Patients typically describe the pain as dull and nagging [16].

A characteristic feature of the pain is its load-dependency: it intensifies during physical activity and regresses with rest [12,27]. A clinically significant phenomenon is the "warm-up effect", which involves the onset of pain at the beginning of a workout, followed by progressive alleviation as the exercise continues [16]. In severe and chronic cases of MTSS, the pain may radiate toward the foot, accompanied by paresthesia and discomfort at rest [16].

In the physical examination, the extent of palpation tenderness is a crucial differential criterion. In cases of MTSS, the pain is diffuse and covers an area of 5 cm or more. Whereas focal (point) tenderness on the tibial shaft suggests the presence of a tibial stress fracture [12,24].

6. DIAGNOSTICS

The diagnostic process is primarily clinical, relying on a thorough medical history and physical examination, including inspection, palpation, assessment of range of motion, and neurological status. The diagnosis is generally confirmed by the presence of diffuse tenderness along the posteromedial tibial border, in the absence of pitting edema or sensory deficits [30].

To objectify the biomechanical assessment, validated clinical tools are employed:

1. Foot Posture Index (FPI-6): A multi-planar tool used to determine whether the foot is in a neutral, pronated, or supinated position [11].
2. Navicular Drop Test: Used to evaluate the collapse of the medial longitudinal arch by measuring the displacement of the navicular tuberosity between non-weight-bearing and full weight-bearing positions [11]. Evidence confirms that individuals with MTSS exhibit significantly higher navicular drop values compared to asymptomatic controls [2].

Regarding imaging, conventional radiography is typically unremarkable. MRI is the gold standard for differential diagnosis, providing high sensitivity in detecting periosteal edema and early cortical bone changes, thereby definitively ruling out stress fractures. A critical aspect of the diagnostic workup is distinguishing MTSS from conditions with similar presentations, most notably: tibial stress fractures

(characterized by focal and nocturnal pain) and the most common Chronic Exertional Compartment Syndrome (CECS), dominated by a sensation of pressure and potential neurological deficits [12].

Finally, structural factors should be considered; for instance, individuals with a smaller tibial cross-sectional area may demonstrate increased susceptibility to the accumulation of microtrauma [27].

7. TREATMENT

The primary approach to the treatment of MTSS in the early stage is conservative management. This mainly involves relative rest and modification of physical activity, including reducing activities associated with repetitive impact on hard surfaces and replacing them with low-impact alternatives (cross-training). Training program modification should involve reductions in training load, intensity, frequency and duration, followed by a gradual return to sport. Additional commonly recommended measures include the application of ice and the use of shock-absorbing insoles [31,32]. There are currently no established guidelines regarding the duration of rest required for symptom resolution. The duration of recovery varies among individuals and is influenced by factors such as injury severity and its anatomical location [17].

In cases of increased pain intensity, short-term pharmacological management may be considered, including the use of analgesics such as acetaminophen or nonsteroidal anti-inflammatory drugs (NSAIDs) [16].

7.1. Further treatment approaches include:

1. Extracorporeal shock wave therapy

Early investigations into the effectiveness of shock wave therapy for pain reduction and symptom resolution were largely non-randomized or included small sample sizes, potentially limiting the reliability of the findings. In a single randomized, double-blind controlled trial comparing standard and very low doses of shock waves, both groups experienced similar reductions in pain, suggesting that even low-energy treatments may exert beneficial effects on bone tissue. A 2024 systematic review reported that shock wave therapy did not demonstrate superiority over no intervention, although when combined with a standard care program, it produced superior outcomes. Overall, the efficacy of shock wave therapy remains inconclusive, and the extent to which therapeutic effects depend on the applied energy dose has yet to be fully elucidated [29,31].

2. Stretching exercises

Stretching exercises targeting the soleus and gastrocnemius muscles have not demonstrated effectiveness when used as a standalone intervention [31].

3. Running retraining

In the context of MTSS pathophysiology, it has been suggested that increasing running cadence may reduce the impact forces acting on the tibia; however, the evidence supporting this assumption remains very limited. Zimmermann et al. demonstrated that, in healthy runners exhibiting a rearfoot strike pattern, modifications in running technique such as adopting a midfoot strike, increasing cadence to 180 steps per minute, and maintaining a more upright posture reduced ground reaction forces and heel pressure. However, the effectiveness of these modifications has not been evaluated in patients with MTSS [31,34,35].

4. Foot orthoses and insoles

Medial longitudinal arch-supporting insoles may serve as a supplementary measure in MTSS management. They can improve plantar pressure distribution, correct overpronation, and, when combined with exercises or a structured rehabilitation program, may accelerate symptom reduction, especially in the early stages of treatment. Although normalization of plantar pressure does not always alleviate pain, correction of overpronation and navicular drop appears to be important in therapy [31,33].

In cases of biomechanical foot problems, such as excessive pronation or pes planus, the use of orthotic insoles should be considered. In more severe cases, pneumatic braces or plaster casts may be necessary to provide additional support for treatment [16].

5. Surgical management

Surgical treatment may be considered in cases of MTSS that are refractory to conservative management. The most commonly described procedure is fasciotomy of the deep posterior compartment performed through a medial approach, often combined with the release of the painful portion of the periosteum and, in some cases, cauterization of the posteromedial border of the tibia. However, the available evidence on surgical treatment remains limited and is characterized by low methodological quality. Although some studies report reductions in pain and improvements in function, a return to the previous level of sports activity is not always achieved [31,32].

8. PREVENTION

Patient education represents a fundamental component of prevention, as it enhances awareness of strategies that can help minimize the risk of MTSS [17].

Overstress avoidance is considered one of the proposed strategies for the prevention of MTSS, particularly given that overuse-related bone damage may develop before the onset of clinical symptoms. Gradual progression of training loads, appropriate preparation for exercise (warm-up), properly fitted footwear, and the use of insoles

may support prevention, although the effectiveness of some of these measures is supported by limited scientific evidence. Shock-absorbing insoles and orthoses designed to control pronation may be particularly beneficial in individuals with excessive pronation and a reduced medial longitudinal arch (navicular drop) [16].

A relatively recent systematic review and meta-analysis published in 2025 by Marques T.B.T. et al. assessed the efficacy of various preventive strategies for MTSS.

Neuromuscular training has proven to be the most effective strategy for the prevention of MTSS. It improves coordination, stability, strength, and overall performance. By enhancing somatosensory and proprioceptive input, it facilitates more efficient neuromuscular responses to biomechanical disturbances in the lower limbs, thereby improving the body's capacity to absorb and dissipate forces during running.

Training protocols focus on strengthening the core muscles and lower-limb muscles responsible for movement control and load absorption. In the analyzed studies, such protocols included jumps, squats, variations of the isometric plank, scapular and pelvic stabilization, dynamic balance on one leg, calf activation, hamstring stretching, multidirectional running, and a gait re-education program.

Exercises that strengthen the foot and calf muscles particularly the plantar flexors, ankle invertors, and the intrinsic muscles of the foot can improve foot stability and help support the medial longitudinal arch. This, in turn, may reduce excessive drop of the navicular bone, which is considered one of the key risk factors for MTSS. For this reason, training programs should incorporate exercises performed in unstable conditions, such as single-leg stance or drills that involve changes of direction. In individuals with overpronation, it may also be beneficial to consciously correct movement patterns by activating the core, hip, and foot musculature to enhance overall lower-limb alignment and control.

Studies in military recruits have shown that anti-pronation insoles may have a beneficial effect in preventing MTSS. These insoles stabilize the foot and help correct plantar pressure distribution during the initial phase of gait, thereby reducing excessive pronation and the mechanical load on the tibia. The greatest benefits have been observed in individuals with abnormal plantar pressure patterns; therefore, routine use may not produce equally favorable outcomes in all populations.

However, the use of shock-absorbing insoles has not demonstrated a statistically significant effect in preventing MTSS [35].

Vitamin D may be relevant for MTSS prevention. Pseudofractures, a key feature of MTSS, have been linked to low vitamin D levels. Supplementation with vitamin D and calcium supports pseudofracture healing, enhances bone strength and calcium homeostasis, and may reduce the risk of stress fractures. Accordingly, ensuring

adequate intake of these nutrients should be considered in MTSS preventive strategies, particularly for elite athletes [17,36].

9. CONCLUSION

MTSS is a multifactorial condition arising from the interaction of bone overload, biomechanical abnormalities, and soft-tissue changes, with evidence suggesting involvement not only of the periosteum but also of the bone marrow and surrounding tissues along the posteromedial border of the tibia. Running biomechanics play a central role, as tibial loading increases with speed, while longer stride length, barefoot running, and minimalist footwear may further increase stress. In affected individuals, altered foot and shank mechanics, including increased eversion and internal rotation, together with impaired pelvic and knee control, are frequently observed, whereas structural factors such as a thinner tibial shaft and reduced muscle mass may increase susceptibility to injury. Diagnosis relies primarily on history and physical examination, with MRI reserved for differential diagnosis, particularly to exclude tibial stress fracture. Early management should focus on conservative treatment, load modification, and gradual return to sport, while prevention appears to depend most on individualized training, neuromuscular control, and correction of biomechanical deficits.

DISCLOSURE

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

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8.4. Informed Consent Statement

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8.5. Data Availability Statement

Not applicable.

8.6. Acknowledgements

Not applicable.

8.7. Conflict of Interest

The authors declare that there are no financial or personal relationships with other people or organizations that could inappropriately influence (bias) their work.

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Mapped to the CRediT (Contributor Roles Taxonomy, NISO Z39.104-2022). Author initials: MR=Magdalena Rachtan; AR=Agnieszka Radziejewicz; BR=Bartosz Rudziński; AP=Agnieszka Pyrgies; PS=Paulina Soja; DS=Dariusz Szczuraszek; DSo=Dominika Sołyga; ASł=Aleksandra Słowik; OS=Olga Skoczeń.

- Conceptualization: AR, MR
- Methodology: AP, BR, PS
- Software: DS, BR
- Validation (Check): DSo, OS
- Formal analysis: ASł
- Investigation: OS, DSo
- Resources: ASł, AR
- Writing – original draft: MR, AR, BR
- Writing – review & editing: AP, ASł, PS
- Visualization: DS, DSo
- Supervision: MR
- Project administration: MR
- Funding acquisition: Not applicable

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

In preparing this work, the authors used ChatGPT (OpenAI) for language editing, grammar correction, and improvement of text clarity. After using this tool, the authors reviewed and edited the text as needed and accept full responsibility for the content of the publication.

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