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Medial Tibial Stress Syndrome Development: Common Factors, Sprint-Specific Factors and Intervention Strategies

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Abstract. Medial tibial stress syndrome (MTSS) is a prevalent overuse lower-extremity injury. Current research predominantly focuses on endurance runners, leaving the risk factors and pathophysiological pathways specific to sprinters poorly characterized. This narrative review aims to summarize current evidence on sprint-specific factors of MTSS development and their intervention strategies. Including 20 peer-reviewed studies published from 2020 to 2026, this paper analyzes the pathophysiological mechanisms, intrinsic factors, extrinsic factors, and sprint-specific contributors to MTSS, and evaluates the evidences for preventive and rehabilitative interventions. References show that sprinting amplifies tibial stress reaction pathways by rapid force production, abrupt eccentric-concentric muscle transitions, and high anteroposterior shear stress during acceleration. MTSS development in sprinters is driven by the interaction of intrinsic susceptibility (body composition, foot alignment, muscle function), extrinsic training variables (abrupt load progression, footwear), and sprint-specific exposures (starting block position, high-magnitude impact loading, neuromuscular capacity deficits). Supported prevention strategies include neuromuscular training, foot-core strengthening, and arch-support orthoses. For established MTSS, a staged multimodal strategy combining load modification, cryotherapy, progressive therapeutic exercise, and adjunctive interventions yields the best outcomes.

Keywords: Medial tibial stress syndrome (MTSS), common factors, sprint-specific factors, intervention strategies

1. Introduction

Medial tibial stress syndrome (MTSS) is a pervasive overuse lower-extremity injury that frequently disrupts training and competitive participation across sports that involve running and jumping. According to a 2025 scoping review synthesizing 37 studies, MTSS presents in 5.4% among elite female track athletes, and 69.5% among recreational marathon runners [1].

Sprinting is characterized by uniquely rapid force production, abrupt eccentric-concentric muscle transitions, and high anteroposterior tibial shear. This essay analyzes multiple factors of MTSS development, synthesizes evidence on its mechanistic pathways, and evaluates targeted intervention strategies, aiming to establish a framework for MTSS prevention and management tailored to the unique demands of sprints.

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2. How MTSS is developed

Tibial fascial traction theory, the most extensively studied framework, attributes MTSS to periosteal inflammation driven by repetitive excessive tensile stress at the posteromedial tibial border. As reviewed by previous studies, anatomical investigations identify the soleus muscle, deep crural fascia, and tibialis posterior tendon as the primary structures exerting pathological traction [1]. Runners with MTSS show higher peak soleus EMG activity during the stance phase and greater dynamic foot pronation, with increased navicular drop and increased traction on the medial fascial attachments [1-3].

In comparison, the tibial stress reaction theory frames MTSS as an early bone overload injury on the continuum toward tibial stress fracture. Similarly, the 2025 scoping review cites evidence of reduced tibial bone mineral density at symptomatic sites and cortical microcracks with impaired repair responses, confirming that bony microdamage contributes to MTSS pathology [1].

3. Risk factors

3.1. Intrinsic factors

Intrinsic and body-composition factors relate to MTSS development primarily by increasing the pressure on the tibia. Elevated body mass index (BMI) has been repeatedly associated with MTSS, plausibly because greater mass magnifies the ground reaction forces transmitted through the lower limb during stance [1]. Also, reduced lean leg girth limits the tissue's capacity to attenuate and distribute loading and elevates peak soleus activity during propulsion, which is strongly associated with MTSS development [4].

Foot and lower-limb alignment relate to MTSS development by altering load distribution across the medial tibial border. Increased navicular drop and foot pronation have been identified as characteristic intrinsic risk factors, presumably because excessive pronation shifts stress toward the posteromedial tibia [3]. Similarly, higher frontal-plane pelvic tilt and peak internal hip rotation relate to development of MTSS by modifying proximal control and, consequently, altering the forces reaching the distal tibia [3]. Rather than acting independently, these alignment variables interact with joint mobility and muscular performance, a relationship formalized by previous studies as a continuum model in which lower-extremity alignment, range of motion, strength, and gait kinematics mutually influence one another and, in combination, govern MTSS susceptibility [5].

Foot posture index, intercondylar interval, inversion range of motion, eversion strength, and dynamic arch height change have been linked to MTSS development [5]. Also, high soleus muscle activity during the stance phase of running cycle precedes the onset of MTSS, showing that the excessive calf-muscle activation overloads the tibial periosteum and adjacent structures [2]. These findings place MTSS development at the intersection of structure and function, where the way a muscle is recruited matters as much as the morphology of the limb [2, 4].

The persistence of intrinsic characteristics relates to MTSS development by predisposing individuals to recurrent injury. Case–control analyses of long-distance runners with a history of MTSS reveal biomechanical deviations that remain evident during running well after symptoms resolve, supporting that intrinsic traits associate with long-term vulnerability [6]. Taken together, body composition, foot and limb alignment, joint mobility and tendon strength are linked to MTSS.

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3.2. Extrinsic factors

Extrinsic factors refer to the external and environment-related variables that determine the load to which the tibia is exposed. In the development of MTSS, extrinsic factors do not injure the tibia directly, however, but by increasing the magnitude, rate, and volume of repetitive loading, or by undermining the recovery [1].

The most consistently implicated extrinsic factor is training load and its rate of progression. Rapid increases in running volume, intensity, or frequency can exceed the adaptive capacity of bone and periosteum, producing accumulated microtrauma that underlies MTSS [1]. Direct evidence for this mechanism comes from a study whose authors found that most military runners reported recent changes in running parameters (mileage, pace, or training schedule) in the period immediately preceding their lower-limb injuries [7]. The temporal proximity of these changes to injury development supports that abrupt training progression is indeed a proximal driver of MTSS.

High-volume, regimented training environments such as military basic training concentrate large cumulative loads, often with limited opportunity for gradual adaptation, and are consequently associated with elevated MTSS incidence [8]. In this setting, the extrinsic contributors (training volume, progression schedules, footwear, and running surface) increase tibial load exposure [8]. It is also notable that extrinsic factors combine within a specific training context to create conditions favorable to injury development [1].

Footwear alters how impact forces are transmitted and distributed through the lower limb, suggesting that abrupt changes in footwear geometry can disrupt established loading patterns and shift stress toward the tibia [9]. Worn or inappropriate footwear is similarly implicated within broader risk-factor reviews [1,8]. However, the available footwear-specific evidence remains limited in scale and should be interpreted with caution.

Running surface and lifestyle factors represent further extrinsic domains. Hard or uneven surfaces are commonly cited as contributors to MTSS because they may increase peak impact loading. But dedicated surface-specific studies remain sparse and surface, so it is better to be treated as a contextual factor [1, 8]. In addition, sleep quality and mental aspects are factors associated with lower-limb overuse injuries, suggesting that inadequate recovery may potentially lower the threshold for the occurrence of MTSS [10].

Collectively, the extrinsic factors relate to MTSS development through the interaction of extrinsic load and intrinsic susceptibility, such that the same training stimulus tolerated by one runner may cause injuries to another [1]. This interaction supports managing extrinsic variables (training progression, particularly) as a primary strategy for preventing MTSS [1, 7].

3.3. Sprint-specific factors

Sprinting concentrates mechanical load into relatively few but intense ground contacts, including both the start and acceleration phase and intermediate run. For sprinters, these exposures shape how their tibial load accumulates and therefore how MTSS develops [11].

Altering the distance of the starting block measurably changed the internal load experienced by the tibia as shown on elite sprinters, indicating that block positioning and the associated acceleration posture are determinants of tibial stress. Since the start is repeated many times within a training week and demands rapid force production from a near-stationary position, suboptimal starting block setup can concentrate load on the tibia repeatedly, producing cumulative microtrauma that underlies MTSS [12].

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Furthermore, the phenomenon that foot accelerates faster than tibia during sprinting has also been shown to influence tibial stress [13]. Similarly, sprinting exposes the tibia to a loading profile characterized by extremely high force produced within a short time, and the repeated application of such loads is a plausible mechanical pathway to MTSS development [11, 13].

In a clinical trial and cohort study of youth female track-and-field athletes, the authors showed that neuromuscular training reduced the incidence of MTSS, implying that deficits in neuromuscular control, strength, and landing or loading mechanics are modifiable contributing factors [14]. For sprinters, whose performance depends on precisely controlled force application, inadequate neuromuscular preparation may simultaneously impair performance and increase the tibial loading associated with MTSS development [14].

Beyond mechanics, physiological and metabolic status are further sprint-specific risks. One study reported an association between prolactin and a history of stress fracture in elite sprinters and jumpers, a finding that implicates endocrine and energy-availability status in the development of tibial bone stress [15]. Because prolactin is sensitive to energy availability and recovery, this result suggests that the same athletes exposed to high sprint loading may be rendered more susceptible to MTSS when their physiological recovery is compromised [15]. Notably, the track-and-field cohort studied by the cited study supports this multifactorial view, showing that intrinsic factors (anthropometric, physiological, and biomechanical) interact with extrinsic factors (training and footwear) to determine bone stress injury risk [11].

Taken together, the evidence indicates that MTSS development in sprinting contexts is associated with these exposures: start and acceleration mechanics, high-magnitude impact loading, and the athlete's neuromuscular and physiological capacity [11-15].

4. Intervention strategies

Because MTSS develops when repetitive tibial loading exceeds the tissue's capacity to adapt, its management is organised around two complementary aims: reducing the load imposed on the tibia and restoring the athlete's capacity to tolerate that load [16]. No single intervention reliably resolves the condition, and current evidence therefore supports multimodal, individually tailored programmes that combine symptom relief, therapeutic exercise, orthotic support, and progressive load management.

In a systematic review and meta-analysis of 12 randomised controlled trials involving 8,197 participants, the authors found that neuromuscular training (odds ratio [OR] 0.13–0.64) and overpronation insoles (OR 0.10–1.00) were effective in preventing MTSS, with high and moderate certainty of evidence respectively [16]. Notably, shock-absorbing insoles showed no significant preventive effect despite high-certainty evidence, and no benefit was found for static stretching programmes or compression socks. These findings indicate that prevention should target neuromuscular control and foot posture rather than passive cushioning. This conclusion is reinforced by a further study, whose single-blind randomised controlled trial of 118 recreational runners found that participants in the control group were 2.42 times (95% CI, 1.98–3.62) more likely to sustain a running-related injury over 12 months than those who completed an eight-week foot-core strengthening programme [17]. Time to injury correlated with improvements in Foot Posture Index and foot strength, suggesting that strengthening the foot-ankle complex raises the tissue's tolerance to repetitive load.

Once MTSS is established, therapeutic exercise serves primarily to restore function rather than to produce rapid analgesia. In a randomised controlled trial of 40 recreational runners with MTSS, the authors added a tailored lower-leg programme — comprising stretching, strengthening, sensorimotor

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exercises, and foam-roller myofascial release — to a multimodal intervention of ice massage, foot orthoses, and extracorporeal shockwave therapy [18]. The exercise group did not demonstrate significantly greater reductions in pain intensity or MTSS severity, but it did show significant improvements in quality of life, static Foot Posture Index, and dynamic arch index, with lower dynamic arch index scores than controls at six and twelve weeks. The authors concluded that clinicians should integrate such exercises into rehabilitation to improve foot posture and quality of life, while acknowledging that pain outcomes were unchanged and that larger samples and longer follow-up are needed. Exercise, in other words, is best framed as a capacity-building adjunct within a broader programme rather than a standalone cure [18].

Foot orthoses represent a further component whose value lies in modifying load transmission, particularly in runners with excessive pronation. One trial randomised 50 female recreational runners with MTSS to arch-support foot orthoses or sham flat non-contoured orthoses, with both groups receiving ice massage, ankle muscle exercises, and shockwave therapy [19]. The arch-support group reported lower pain and MTSS severity and better physical function and perceived treatment effect at weeks 6 and 12, although the orthoses conferred no additional benefit by week 18 — implying that orthoses may accelerate early recovery, with their advantage attenuating as other adaptations accumulate. This temporal pattern is consistent with the preventive finding that overpronation insoles reduce MTSS risk, and together the two results suggest orthoses are most useful when overpronation is a contributing factor [16].

Extracorporeal shockwave therapy occupies a narrower, adjunctive role. In a systematic review of 56 studies involving 1,874 athletes and physically active individuals, the authors concluded that ESWT may be effective as a standalone treatment for plantar fasciitis, lateral epicondylitis, and proximal hamstring tendinopathy, but that for MTSS its benefit appears primarily as an adjunct to concurrent exercise therapy [20]. Adverse events were minimal, and athletes were generally able to continue training. This adjunctive framing is mirrored in the protocols of the cited studies, where shockwave was one component of a multimodal package that also included ice massage and orthoses, rather than a monotherapy [18, 19].

The evidence supports a staged and multimodal rehabilitation strategy: the initial priority is symptom control and load modification; shock wave therapy, ice massage and orthotic support where pronation contributes are optional and individualized, while neuromuscular and foot-core strengthening exercises are beneficial for MTSS prevention [16-20].

5. Limitation

Following limitations of this analysis should be acknowledged: research focusing on MTSS development specifically in sprinters remains scarce, and supporting evidence on the long-term impact of applying specific sprinting techniques on injury development is still insufficient to draw definitive conclusions.

Future research should focus on scaling up study samples, conducting more experiments that explore sprint-specific factors of MTSS and exercise programs for MTSS prevention. Addressing these gaps will strengthen the evidence base of MTSS-related research, and enable sprinters to obtain better scientific support for their injury and load management practices.

6. Conclusion

Tibial fascial traction and tibial stress reaction are regarded as the core causes of MTSS. Sprinting amplifies both pathways by rapid muscle transition during stance and intense power production at

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the posteromedial tibial border.

Intrinsic factors include elevated body mass index, reduced lean leg girth, excessive foot pronation, hip kinematic deviations, and altered soleus activation. Extrinsic factors comprise abrupt increases in sprint volume or intensity, inappropriate footwear, and hard training surfaces. Sprint-specific factors such as starting block position, acceleration-phase mechanics, high-magnitude impact loading at maximal velocity, and the neuromuscular capacity to control these loads represent distinct, under-recognized contributors that differentiate sprint-related MTSS from its endurance-running counterpart.

Regarding intervention strategies, neuromuscular training, foot-core strengthening, and arch-support orthoses are the most consistently supported preventive measures, while extracorporeal shockwave therapy is supported as an effective adjunct in treating MTSS.

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