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Original Article

Prevalence of Medial Tibial Stress Syndrome in Grade 9–12 Students Participating in Sports Activities in Punjab, Pakistan

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ABSTRACT

Background: Medial tibial stress syndrome (MTSS) is one of the most common overuse injuries affecting athletes and physically active individuals, particularly those engaged in repetitive lower-limb loading activities such as running and jumping. Despite its recognized clinical importance, epidemiological evidence in adolescent sports populations from Pakistan remains limited. Objective: To determine the prevalence of medial tibial stress syndrome among grade 9–12 students participating in sports activities in Punjab, Pakistan, and to examine its distribution in relation to selected demographic, anthropometric, and sports-related factors. Methods: A cross-sectional observational study was conducted among 800 sports-active students from high schools and colleges in Punjab. Participants completed a structured questionnaire and underwent standardized physical examination including navicular drop test. MTSS diagnosis was based on compatible history and clinical findings. Descriptive statistics were calculated, and associations between MTSS and selected variables were assessed using contingency analyses and trend evaluation. Results: Among 800 participants (68.1% male; mean age 16.46 ± 1.77 years), MTSS was identified in 345 students, yielding a prevalence of 43.1% (95% CI 39.7–46.6). Navicular drop test positivity was observed in 34.4% of participants. Increasing duration of daily sports participation demonstrated a significant trend association with MTSS occurrence (OR 1.15 per exposure category increase, p = 0.002). No statistically significant associations were observed between MTSS and body mass index (p = 0.992) or warm-up practice (p = 0.134). Prevalence varied descriptively across sport categories but did not reach statistical significance. Conclusion: MTSS was highly prevalent among adolescent sports participants in Punjab, with greater sports participation duration associated with increased occurrence. Monitoring training exposure and promoting structured sports conditioning may help reduce the burden of MTSS in school athletes. Keywords: Medial tibial stress syndrome, Shin splints, Navicular drop test, Adolescent athletes, Sports injuries.

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INTRODUCTION

Medial tibial stress syndrome (MTSS) is a common overuse injury of the lower extremity characterized by exercise-induced pain along the posteromedial border of the tibia, usually arising in physically active individuals exposed to repetitive loading, impact, and inadequate recovery. It represents one of the most frequent causes of exertional lower leg pain in athletic populations and is particularly relevant in activities involving repeated running, jumping, abrupt deceleration, and directional change. Although the term has historically been used interchangeably with "shin splints," contemporary understanding recognizes MTSS as a bone–stress-related clinical syndrome with multifactorial mechanical and training-related contributors rather than a simple inflammatory condition alone (1,4). The condition

may impair training continuity, reduce sports participation, and negatively affect performance, especially in adolescents whose exposure to organized and recreational sports is increasing while preventive education and screening remain limited (3,4).

The epidemiological burden of MTSS has been documented across runners, military recruits, and other athletic groups, with reported occurrence varying widely according to population characteristics, training intensity, diagnostic criteria, and surveillance methods. Previous evidence has shown that MTSS may account for a substantial proportion of lower-limb overuse injuries, with notable rates reported in novice runners and military trainees, indicating that repetitive tibial loading in inadequately adapted individuals is a major clinical concern (2,5,6). This variability in reported frequency also suggests that local training culture, conditioning practices, playing surfaces, and biomechanical factors may materially influence disease burden. In school-aged athletes, the transition from casual to competitive participation may expose students to sudden increases in sports volume without structured warm-up, load progression, or footwear guidance, thereby creating a clinically important window for early identification and prevention.

Current evidence indicates that MTSS is not explained by a single cause but rather emerges from the interaction of intrinsic and extrinsic risk factors. Systematic reviews have identified associations with greater body mass index, female sex, previous history of MTSS, biomechanical deviations, and training-related overload, while other studies have emphasized the role of foot pronation and altered lower-limb mechanics in increasing tibial stress during repeated activity (1,2). Navicular drop, used as a clinical proxy for excessive foot pronation, has been reported to differ between injured and uninjured athletic populations and may provide a practical field-based screening measure in settings where imaging and advanced biomechanical assessment are not feasible (7). Additional hypotheses regarding MTSS pathophysiology have included periosteal irritation, traction-related stress on myofascial attachments, enthesopathic mechanisms, and tibial bone stress reactions, collectively supporting the view that MTSS is best understood as a continuum of tissue overload rather than an isolated structural lesion (8).

Clinically, MTSS remains a diagnosis based primarily on history and physical examination. Patients typically report diffuse pain along the distal two-thirds of the posteromedial tibial border that is provoked by activity and may initially ease with rest, although persistent symptoms can interfere with routine function and sports continuation. Imaging is generally reserved for atypical presentations or when alternative diagnoses such as tibial stress fracture, chronic exertional compartment syndrome, vascular disorders, or other serious pathologies are suspected (9,10). This has particular implications in school and community sports environments, where access to diagnostic imaging is limited and frontline screening depends heavily on structured symptom inquiry and focused physical examination.

Despite the growing literature on MTSS in runners and military populations, evidence from adolescent school students in Pakistan remains scarce. Most available studies have been conducted in adults, specialized athletic cohorts, or defense training populations, limiting direct applicability to school-going students who participate in multiple sports under variable supervision and resource constraints. Moreover, modifiable factors such as warm-up behavior, participation duration, and sport category are especially relevant in this age group because they may be targeted through low-cost preventive strategies in school and college settings. Punjab, as the most populous province of Pakistan with a broad spectrum of educational institutions and sports participation patterns, provides an important context in which to estimate the burden of MTSS and explore associated clinical and behavioral characteristics.

Therefore, this study was undertaken to determine the prevalence of medial tibial stress syndrome among grade 9 to 12 students involved in sports activities in Punjab, Pakistan, and to examine its distribution in relation to selected demographic, anthropometric, sports participation, and foot biomechanics-related variables. It was hypothesized that MTSS would be common in this population and would occur more frequently among students with greater training exposure, inadequate warm-up practices, and positive navicular drop findings.

MATERIALS AND METHODS

This observational cross-sectional study was conducted among students enrolled in grades 9 through 12 who were actively participating in sports activities in high schools and colleges across Punjab, Pakistan. Data collection was completed over a four-month period following approval of the study synopsis. The cross-sectional design was selected to estimate the burden of MTSS at the population level within an accessible school-based sports cohort and to examine the concurrent distribution of selected clinical and activity-related factors relevant to adolescent sports participation. Eligible participants included male and female students from grade 9 to 12 who were regularly involved in organized or routine sports activity at the time of assessment. Students were excluded if they had any physical disability limiting participation, any visible anatomical bony deformity of the lower or upper limbs, any known systemic illness likely to affect musculoskeletal performance or healing, including diabetes mellitus or chronic kidney disease, a known stress fracture, visible swelling or erythema over the medial tibial surface, or pain judged clinically to be unrelated to mechanical loading. These criteria were applied to reduce diagnostic contamination from other causes of lower-leg pain and to improve the clinical specificity of field-based MTSS identification.

Participants were recruited through purposive convenience sampling from educational institutions that granted access for data collection. Students meeting eligibility criteria were approached within their institutions and invited to participate after explanation of the study purpose and assessment procedures. Participation was voluntary. Before assessment, consent procedures were completed in accordance with institutional requirements for student-based research, and all assessments were performed in a standardized manner. To improve consistency, the same structured questionnaire and uniform clinical examination sequence were used for all participants. Anthropometric measurements were obtained before the musculoskeletal assessment. Height and body weight were recorded, and body mass index was calculated as weight in kilograms divided by the square of height in meters, after which participants were categorized as underweight, normal weight, or overweight according to the study's predefined cutoffs.

The target sample size was 800 participants, as estimated using Epitools for prevalence studies based on an assumed prevalence of 41%, sensitivity of 77%, specificity of 90%, desired precision of 5%, and 95% confidence level. A total of 800 students fulfilling the selection criteria were enrolled and analyzed. The study outcome was the presence or absence of MTSS. For operational purposes, MTSS was identified on the basis of a structured history and focused physical examination. Participants were assessed for pain over the shin region, site of pain along the tibia, and the painful area in centimeters on palpation. A diagnosis of MTSS was considered in students presenting with activity-related shin pain localized along the medial tibial region and compatible examination findings on clinical assessment, while participants with features suggesting other causes of lower-leg pain were excluded through the screening criteria and examination process. This approach reflected the accepted clinical principle that MTSS is primarily a history- and examination-based diagnosis in non-imaging field settings.

Data were collected using a self-designed questionnaire supported by direct clinical assessment. The questionnaire captured age, sex, sports category, duration of sports participation per day, warm-up practice before activity, and symptom characteristics related to shin pain and activity limitation. Pain laterality, the effect of shin pain on routine activities, and whether symptoms led the participant to continue or stop sports participation were also documented. Because sports loading and biomechanics are clinically relevant to MTSS, a navicular drop test was additionally performed in all participants to assess dynamic lowering of the medial longitudinal arch as an indicator of pronation tendency. For the navicular drop test, the navicular tuberosity was identified and marked, the participant's foot was positioned to obtain a subtalar-neutral reference position, and the vertical height of the navicular from the supporting surface was measured. The participant was then allowed to relax into a weight-bearing posture, and the excursion of the navicular tuberosity was recorded using the difference between the

two positions. For analytic purposes, the navicular drop result was categorized as positive or negative according to the predefined study criteria.

Several steps were incorporated to improve data integrity and reduce avoidable bias. Eligibility screening and clinical examination were conducted using the same procedural sequence for all participants. Variables were defined before analysis, and all data were entered in a uniform coding framework. Because the study used institution-based convenience sampling, prevalence estimates were interpreted as representative of the sampled sports-active student population rather than all adolescents in Punjab. To reduce information bias, questionnaire administration was coupled with direct examiner clarification when needed, and diagnostic classification was not based on questionnaire responses alone. Potential confounding by sex, age, body mass index, sport category, participation duration, warm-up practice, and navicular drop status was addressed analytically through stratified descriptive reporting and inferential comparison of MTSS status across exposure categories.

Data were analyzed using Statistical Package for the Social Sciences version 26.0. Descriptive statistics were used to summarize participant characteristics. Categorical variables were reported as frequencies and percentages, whereas continuous variables were summarized using mean and standard deviation where appropriate. The prevalence of MTSS was calculated as the proportion of clinically positive cases among all assessed participants. Cross-tabulations were generated to examine the distribution of MTSS across body mass index categories, duration of sports participation, sport category, and warm-up practice. Inferential associations between MTSS status and categorical variables were assessed using appropriate bivariate procedures, and corresponding p values were reported. Correlation statistics were interpreted cautiously and only in relation to ordered variables where relevant. All tests were two-tailed, and a p value of less than 0.05 was considered statistically significant. Only complete records were included in the final analysis set, and data were reviewed before analysis to ensure consistency between coded entries and source forms.

The study was conducted in accordance with accepted ethical principles for human participant research. Confidentiality of participant information was maintained throughout data collection and analysis, and results were reported in aggregate form without identifying individuals or institutions. The methodological sequence, variable definitions, and analytic approach were standardized to support reproducibility and permit replication of the study in comparable school-based athletic populations.

RESULTS

A total of 800 sports-active students from grades 9 to 12 were included in the analysis. Of these, 545 were male and 255 were female, giving a male predominance of 68.1%. The mean age was 16.46 years (SD 1.77), with the largest age groups being 18 years (24.9%), 16 years (23.6%), and 15 years (13.3%). Most participants had a height between 161 and 170 cm (46.4%) and a body weight between 51 and 60 kg (45.6%). Based on body mass index, 407 students (50.9%) were in the normal BMI range, 375 (46.9%) were overweight, and 18 (2.3%) were underweight. Regarding sports exposure, 267 students (33.4%) participated for 30 minutes daily, 219 (27.4%) for 1 hour, and 167 (20.9%) for 1 hour 30 minutes, while 147 (18.4%) reported participation for 2 hours or more per day. Warm-up before sports activity was reported by only 251 students (31.4%), whereas 549 (68.6%) did not perform warm-up. Cricket was the most common sport (31.9%), followed by football (14.8%), volleyball (13.9%), and running (13.1%).

Table 1. Baseline Characteristics of the Study Population (N = 800)

Variable	Category	n	%
Sex	Male	545	68.1
	Female	255	31.9
Age (years)	13	68	8.5
	14	49	6.1
	15	106	13.3
	16	189	23.6

Variable	Category	n	%
	17	94	11.8
	18	199	24.9
	19	95	11.9
Height (cm)	120–130	3	0.4
	131–140	18	2.3
	141–150	28	3.5
	151–160	199	24.9
	161–170	371	46.4
	171–180	173	21.6
	181–190	8	1.0
Weight (kg)	30–40	65	8.1
	41–50	185	23.1
	51–60	365	45.6
	61–70	129	16.1
	71–80	45	5.6
	81–90	11	1.4
Body mass index	Underweight (<18 kg/m²)	18	2.3
	Normal (18–24.99 kg/m²)	407	50.9
	Overweight (>25 kg/m²)	375	46.9
Warm-up before sports	Yes	251	31.4
	No	549	68.6
Daily sports duration	30 min	267	33.4
	1 h	219	27.4
	1 h 30 min	167	20.9
	2 h	78	9.8
	2 h 30 min	20	2.5
	3 h	11	1.4
	3 h 30 min	18	2.3
	4 h	20	2.5
Sport category	Running	105	13.1
	Volleyball	111	13.9
	Basketball	81	10.1
	Cricket	255	31.9
	Football	118	14.8
	Hockey	43	5.4
	Cycling	48	6.0
	Badminton	39	4.9

The overall prevalence of MTSS was 43.1% (345/800), with an exact 95% confidence interval of 39.7% to 46.6%. Navicular drop test positivity was observed in 275 students (34.4%). In relation to pain laterality, 220 students (27.5%) reported bilateral shin pain, 237 (29.6%) reported left-sided pain, and 343 (42.9%) reported right-sided pain. Symptoms affected routine activities variably: 445 students (55.6%) had no pain during common daily activities, 181 (22.6%) had some symptoms, 156 (19.5%) had marked symptoms, and 18 (2.3%) were unable to perform activities because of severe shin pain. When asked whether pain altered sports participation, 368 students (46.0%) reported stopping activity because of symptoms, while 432 (54.0%) continued participation. Pain extent on palpation was at least 5 cm in 345 students (43.1%), less than 5 cm in 342 (42.8%), and absent in 112 (14.0%).

Table 2. Primary Outcome and Key Clinical Findings

Variable	Category	n	%	95% CI
MTSS diagnosis	Positive	345	43.1	39.7–46.6
	Negative	455	56.9	—
Navicular drop test	Positive	275	34.4	31.1–37.8
	Negative	525	65.6	—
Shin pain side	Bilateral	220	27.5	—
	Left	237	29.6	—
	Right	343	42.9	—
Pain during daily activity	None	445	55.6	—
	Some	181	22.6	—
	A lot	156	19.5	—

Variable	Category	n	%	95% CI
	Unable to perform activity	18	2.3	—
Response to pain during sports	Continue activity	432	54.0	—
	Stop activity	368	46.0	—
Pain extent on palpation	No pain	112	14.0	—
	<5 cm	342	42.8	—
	≥5 cm	345	43.1	—

When MTSS was cross-tabulated against BMI categories, the proportions were nearly identical across the positive and negative groups. Among MTSS-positive participants, 50.7% had normal BMI and 47.0% were overweight; among MTSS-negative participants, the corresponding values were 51.0% and 46.8%. Using contingency analysis, this association was not statistically significant (chi-square p = 0.992; Cramer's V = 0.005). Compared with the normal BMI category, the odds ratio for overweight participants was 1.01 (95% CI 0.76–1.34), indicating no meaningful difference in odds. Likewise, warm-up status showed a descriptive but not statistically significant difference. MTSS prevalence was 39.0% among students who performed warm-up and 45.0% among those who did not, corresponding to an odds ratio of 1.28 (95% CI 0.94–1.73) for the no-warm-up group, with p = 0.134.

Table 3. Association of MTSS with Body Mass Index and Warm-Up Practice

Variable	Category	MTSS+, n/N	MTSS prevalence, %	Effect estimate	95% CI	p-value
Body mass index	Underweight (<18 kg/m²)	8/18	44.4	OR vs normal: 1.06	0.41–2.74	0.992*
	Normal (18–24.99 kg/m²)	175/407	43.0	Reference	—	
	Overweight (>25 kg/m²)	162/375	43.2	OR vs normal: 1.01	0.76–1.34	
Warm-up before sports	Yes	98/251	39.0	Reference	—	0.134*
	No	247/549	45.0	OR: 1.28	0.94–1.73	

* p value from overall chi-square test for category-level association.

Daily sports exposure showed a graded increase in MTSS prevalence across ordered participation categories. Prevalence was 36.0% among students participating for 30 minutes per day, rose to 45.7% at 1 hour, 46.2% at 2 hours, 50.0% at 2 hours 30 minutes, 63.6% at 3 hours, 55.6% at 3 hours 30 minutes, and 60.0% at 4 hours. Because duration is an ordinal exposure, the association was re-examined as a linear trend across increasing participation categories. This showed a significant positive gradient, with each one-category increase in daily sports duration associated with 1.15-fold higher odds of MTSS (OR 1.15, 95% CI 1.05–1.25; p = 0.002). Thus, although the overall multi-category chi-square test was modest, the ordered trend across increasing duration categories was statistically meaningful and clinically interpretable.

Table 4. MTSS According to Daily Sports Participation Duration

Daily sports duration	MTSS+, n/N	MTSS prevalence, %	95% CI
30 min	96/267	36.0	30.2–42.0
1 h	100/219	45.7	38.9–52.5
1 h 30 min	74/167	44.3	36.6–52.2
2 h	36/78	46.2	34.8–57.8
2 h 30 min	10/20	50.0	27.2–72.8
3 h	7/11	63.6	30.8–89.1
3 h 30 min	10/18	55.6	30.8–78.5
4 h	12/20	60.0	36.1–80.9

Overall duration effect: ordinal logistic trend across increasing categories, OR 1.15 per category increase (95% CI 1.05–1.25), p = 0.002. MTSS prevalence also varied by sport category when calculated within each sport rather than as percentages inside the MTSS-positive group. The lowest prevalence was observed in volleyball at 30.6%, while the highest was seen in cycling at 52.1%, followed by cricket at 49.4%. Running, basketball, hockey, and badminton each clustered around 41% to 44%, while football showed a prevalence of 39.8%. The overall sport-category association did not reach conventional statistical significance (chi-square p = 0.063; Cramer's V = 0.129), but the absolute distribution suggested a clinically relevant gradient in burden across sports.

Table 5. MTSS Prevalence Within Each Sport Category

Sport category	MTSS+, n/N	MTSS prevalence, %	95% CI	Overall p-value
Running	44/105	41.9	32.3–51.9	0.063*
Volleyball	34/111	30.6	22.2–40.1	
Basketball	34/81	42.0	31.1–53.5	
Cricket	126/255	49.4	43.1–55.7	
Football	47/118	39.8	30.9–49.3	
Hockey	18/43	41.9	27.0–57.9	
Cycling	25/48	52.1	37.2–66.7	
Badminton	17/39	43.6	27.8–60.4	

* Overall p value from chi-square test across all sport categories.

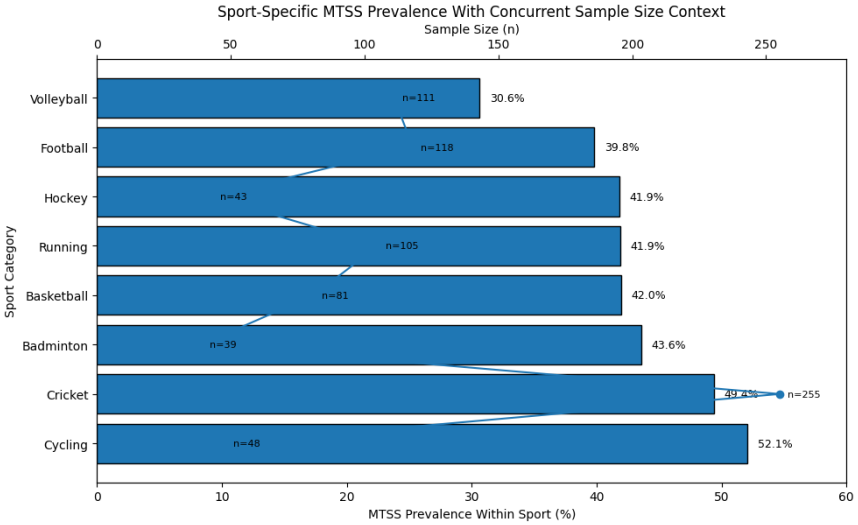

Figure 1 Heterogeneous burden of MTSS across sports

The figure demonstrates a heterogeneous burden of MTSS across sports, with the highest observed prevalence in cycling (52.1%) and cricket (49.4%), followed by badminton (43.6%), basketball (42.0%), running (41.9%), and hockey (41.9%), while volleyball showed the lowest prevalence at 30.6%. The dual presentation of prevalence and sample size also clarifies clinical interpretability: cricket combined both a high prevalence and the largest participant pool (n=255), making it the sport contributing the greatest absolute number of MTSS cases, whereas cycling had the highest proportion but a smaller denominator (n=48). This pattern suggests that the apparent clinical burden is driven not only by sport-specific risk concentration but also by how common each sport is within the sampled student population.

DISCUSSION

The present cross-sectional study investigated the prevalence and distribution of medial tibial stress syndrome among grade 9–12 students participating in sports activities in Punjab, Pakistan. The overall prevalence of MTSS was 43.1%, indicating that nearly two out of five sports-active students experienced symptoms compatible with this condition. This prevalence appears higher than many previously reported estimates in athletic populations, which typically range from 3% to 35% depending on the population, activity intensity, and diagnostic criteria (4,6). Several factors may explain the comparatively higher prevalence observed in the present sample. First, the study population consisted primarily of adolescents engaged in recreational or semi-structured sports activities rather than professional athletes, and such groups may experience abrupt increases in training load without adequate conditioning or recovery. Second, the diagnosis was based on standardized history and physical examination in a field setting, which may capture early symptomatic cases that would not necessarily be diagnosed clinically in hospital-based studies. Third, convenience sampling from institutions willing to participate may have resulted in a slightly higher representation of active sports programs.

Anthropometric characteristics did not demonstrate a statistically significant association with MTSS in this sample. Body mass index categories were almost identically distributed between MTSS-positive and MTSS-negative participants, and contingency analysis confirmed the absence of a meaningful relationship ($p = 0.992$). These findings contrast with several earlier studies suggesting that elevated BMI may contribute to increased tibial loading and prolonged recovery in overuse injuries (1). The lack of association in the current study may reflect the relatively narrow BMI distribution typical of adolescent populations, where extreme obesity is uncommon and the biomechanical impact of weight variation is therefore smaller. It also highlights the importance of interpreting anthropometric indicators within the demographic context of the studied population.

In contrast, sports participation duration showed a statistically significant graded association with MTSS prevalence, with increasing exposure corresponding to progressively higher proportions of affected students. When analyzed as an ordered exposure variable, each step increase in daily sports participation category was associated with approximately 15% higher odds of MTSS. This observation is consistent with the pathophysiological model of MTSS as a bone stress injury resulting from repetitive loading that exceeds the adaptive capacity of tibial bone and surrounding musculature (3,4). Similar relationships between cumulative training load and MTSS have been reported among novice runners and military trainees, where rapid increases in training intensity and inadequate recovery periods contribute to tissue overload (6). The present findings extend this concept to adolescent school athletes, suggesting that sports participation duration may represent a modifiable factor in injury prevention strategies within school environments.

Warm-up practice before sports activity demonstrated a descriptive but not statistically significant relationship with MTSS in this study. Students who did not perform warm-up showed a slightly higher prevalence of MTSS compared with those who reported warming up before activity, but the difference did not reach statistical significance ($p = 0.134$). While warm-up routines are widely recommended to enhance muscle readiness and neuromuscular coordination, the present data do not allow definitive conclusions regarding their protective effect against MTSS. It is possible that the quality, duration, or type of warm-up performed by students varied substantially, and these characteristics were not captured in detail within the questionnaire. Consequently, the observed difference should be interpreted cautiously as a descriptive trend rather than a confirmed association.

Sport-specific prevalence patterns revealed notable variation across activity types. Cycling and cricket demonstrated the highest proportions of MTSS cases within their respective participant groups, whereas volleyball showed the lowest prevalence. Although the overall sport-category association did not reach statistical significance ($p = 0.063$), the distribution suggests that sports involving repetitive running, acceleration, and ground impact may impose greater mechanical stress on the tibia. Running, basketball, football, and cricket are characterized by repetitive loading cycles that may increase the risk of tibial stress reactions if training intensity exceeds the athlete's adaptation capacity (2,6). Conversely, sports involving comparatively lower impact or intermittent loading may exert less cumulative stress on the tibial cortex.

Foot biomechanics have been proposed as a potential contributor to MTSS through mechanisms related to excessive pronation and altered load distribution during gait. The navicular drop test, which assesses dynamic lowering of the medial longitudinal arch, was positive in 34.4% of participants in the present study. Although the current analysis did not formally model its association with MTSS, previous investigations have suggested that greater navicular drop values may correlate with increased tibial loading and risk of MTSS development (7). The relatively high prevalence of navicular drop positivity observed here indicates that biomechanical screening could be a useful component of preventive sports medicine programs in adolescent populations.

The findings of this study should be interpreted in light of several methodological considerations. The cross-sectional design provides a snapshot of disease burden but cannot establish temporal or causal

relationships between exposure variables and MTSS. Furthermore, the use of institution-based convenience sampling limits the generalizability of results to all adolescents in Punjab. Diagnostic classification was based on clinical history and physical examination rather than imaging modalities; however, this approach aligns with accepted practice for field-based identification of MTSS where imaging is reserved for suspected alternative diagnoses (9,10). Despite these limitations, the study contributes valuable epidemiological insight into a population that has been underrepresented in MTSS research and highlights training exposure as a potentially important factor for injury prevention in school athletes.

CONCLUSION

Medial tibial stress syndrome was common among sports-active grade 9–12 students in Punjab, Pakistan, with an overall prevalence of 43.1%. Increasing duration of daily sports participation demonstrated a significant association with MTSS occurrence, whereas body mass index and warm-up practice showed no statistically significant relationship in this sample. Variation in prevalence across sport categories suggests that activities involving repetitive lower-limb loading may contribute to the distribution of MTSS among adolescents. These findings emphasize the importance of monitoring training exposure and implementing structured conditioning and injury-prevention strategies in school-based sports programs.

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