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Risk Factors for Medial Tibial Stress Syndrome in Active Individuals: An Evidence-Based Review

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Clinical Question: What factors put physically active individuals at risk to develop medial tibial stress syndrome (MTSS)?

Data Sources: The authors performed a literature search of CINAHL, the Cochrane Central Register of Controlled Trials, EMBASE, and MEDLINE from each database's inception to July 2013. The following key words were used together or in combination: *armed forces, athlete, conditioning, disorder predictor, exercise, medial tibial stress syndrome, militaries, MTSS, military, military personnel, physically active, predictor, recruit, risk, risk characteristic, risk factor, run, shin pain, shin splints,* and *vulnerability factor*.

Study Selection: Studies were included in this systematic review based on the following criteria: original research that (1) investigated risk factors associated with MTSS, (2) compared physically active individuals with and without MTSS, (3) was printed in English, and (4) was accessible in full text in peer-reviewed journals.

Data Extraction: Two authors independently screened titles or abstracts (or both) of studies to identify inclusion criteria and quality. If the article met the inclusion criteria, the authors extracted demographic information, study design and duration, participant selection, MTSS diagnosis, investigated risk factors, mean difference, clinical importance, effect size, odds ratio, and any other data deemed relevant. After the data extraction was complete, the authors compared findings for accuracy and completeness. When the mean and standard deviation of a particular risk factor were reported 3 or more times, that risk factor was included in the meta-analysis. In addition, the methodologic quality was assessed with an adapted checklist developed by previous researchers. The checklist contained 5 categories: study objective, study population, outcome measurements, assessment of the outcome, and analysis and data presentation. Any disagreement between the authors was discussed and resolved by consensus.

Main Results: A total of 165 papers were initially identified, and 21 original research studies were included in this systematic review. More than 100 risk factors were identified in the 21 studies. Continuous data were reported 3 or more times for risk factors of body mass index (BMI), navicular drop, ankle plantar-flexion range of motion (ROM), ankle-dorsiflexion ROM, ankle-eversion ROM, ankle-inversion ROM, quadriceps angle, hip internal-rotation ROM, and hip external-rotation ROM. As compared with the control group, significant risk factors for developing MTSS identified in the literature were (1) greater BMI (mean difference [MD] = 0.79, 95% confidence interval [CI] = 0.38, 1.20; $P < .001$), (2) greater navicular drop (MD = 1.9 mm, 95% CI = 0.54, 1.84 mm; $P < .001$), (3) greater ankle plantar-flexion ROM (MD = 5.94°, 95% CI = 3.65°, 8.24°; $P < .001$), and (4) greater hip external-rotation ROM (MD = 3.95°, 95% CI = 1.78°, 6.13°; $P < .001$). Ankle-dorsiflexion ROM (MD = –0.01°, 95% CI = –0.96, 0.93; $P = .98$), ankle-eversion ROM (MD = 1.17°, 95% CI = –0.02, 2.36; $P = .06$), ankle-inversion ROM (MD = 0.98°, 95% CI = –3.11°, 5.07°; $P = .64$), quadriceps angle (MD = –0.22°, 95% CI = –0.95°, 0.50°; $P = .54$), and hip internal-rotation ROM (MD = 0.18°, 95% CI = –5.37°, 5.73°; $P = .95$), were not different between individuals with MTSS and controls.

Conclusions: The primary factors that appeared to put a physically active individual at risk for MTSS were increased BMI, increased navicular drop, greater ankle plantar-flexion ROM, and greater hip external-rotation ROM. These primary risk factors can guide health care professionals in the prevention and treatment of MTSS.

Key Words: shin pain, associated risk factors, leg pain

COMMENTARY

Medial tibial stress syndrome (MTSS) is one of the most common causes of exercise-induced lower leg pain.[1] It results in localized pain along the distal two-thirds of the posterior-medial tibia, a condition that clinicians cluster with other overuse lower leg injuries under the category of *exercise-induced leg pain* or *shin splints*.[1–3] Running or impact loading of the lower limb creates stress within the tibia, producing pain that typically limits activity. Authors of a systematic review[4] of 3 prospective studies reported an incidence rate ranging from 13.6% to 20% in runners. Active individuals who reported an injury related to running were twice as likely to incur MTSS.[3] In military personnel, the incidence of MTSS was 7.2% to 35%.[5–7] For many military recruits, the nature and volume of the physical load on the lower legs increase as they adjust to basic training.[7] The lower extremity injuries military recruits sustain have negative effects on morbidity, training time, financial resources, and staffing.[2,8,9]

Based on research findings and practitioners' beliefs, experiences, biases, and paradigms, multiple risk factors are theorized for MTSS.[2] In the 21 studies the authors reviewed, more than 100 risk factors were proposed, yet only 9 risk factors were supported by moderate to strong evidence in clinical practice[5]: body mass index (BMI), navicular drop, ankle plantar-flexion range of motion (ROM), ankle-dorsiflexion ROM, ankle-eversion ROM, ankle-inversion ROM, quadriceps angle, hip internal-rotation ROM, and hip external-rotation ROM. However, BMI, navicular drop, ankle plantar-flexion ROM, and hip external-rotation ROM were greater in patients with MTSS compared with uninjured counterparts.[5] This suggests that these 4 factors are the strongest predictors of a diagnosis of MTSS in an active individual. In a systematic review and meta-analysis conducted by Newman et al,[2] navicular drop, orthotic use, BMI, running experience, history of MTSS, female sex, and hip external rotation were associated with a greater incidence of MTSS. Thus, navicular drop, BMI, and hip external rotation were identified as risk factors in 2 meta-analyses.

Clinicians should approach the BMI risk factor with caution because it is a poor indicator of body fat in certain populations, such as athletes and military personnel.[10] The BMI is not a direct measure of body fat but suggests that those with an increased mass relative to their height are at greater risk for MTSS.[5] In the military setting, tactical athletes carry heavy loads during training. This transient increase in BMI increases stress throughout the kinetic chain and, therefore, the risk of lower leg injuries.[2] To detect body fat, we recommend that clinicians measure the thickness of subcutaneous adipose tissue using skinfold calipers.[11] In the authors' discussion of how BMI may predispose an individual to MTSS, they proposed a link with bone adaptation to loading.[5] During exercise, the tibia bends and bows as a response to activity, thereby producing microtrauma, which is necessary to strengthen, build, and adapt the bone.[5] Medial tibial stress syndrome can occur if the load exceeds the microtrauma threshold of the tibia.[5] In individuals with an increased BMI (ie, increased mass relative to height), clinicians should modify training and exercise to allow for a progressive increase in activity, which will decrease the likelihood of MTSS resulting from the increased stress throughout the kinetic chain.[5] A steady increase in intensity during activity allows the tibia to adapt properly.[5]

An increased navicular drop is another risk factor in the development of MTSS.[2,5] A navicular drop that is greater than 10 mm nearly doubles the likelihood of developing MTSS.[2] In theory, when patients present with an increased navicular drop, the inverse relationship with arch height may result in the absence of a rigid lever and absorption of ground forces.[12] Individuals with an increased navicular drop are at higher risk of MTSS because of the decrease in tibial rotation, which may be an important factor in absorbing impact forces.[5] In previous work,[3] larger navicular-drop measurements were significant for both the right foot (MTSS: 6.1 mm, no MTSS: 5.1 mm; $P = .027$) and the left foot (MTSS: 6.5 mm, no MTSS: 5.0 mm; $P = .034$). (It is important to note that these authors tested navicular drop in standing position; earlier researchers[13] who did not identify navicular drop as a risk factor used a different method.) The individual assumes a bilateral stance and is placed in subtalar joint neutral.[3,13] The distance between the floor and the navicular tuberosity at its greatest prominence is measured in millimeters using a goniometer.[3,13] Next, the participant assumes a unilateral stance, and measurements are taken between the floor and the navicular tuberosity.[3,13] The clinician then calculates navicular drop as the difference between the navicular height recorded in the bilateral and unilateral stances.[3,13] Clinicians should understand the proper technique for measuring the risk factor of navicular drop.

Greater plantar flexion was also identified as a risk factor for MTSS.[5] This increased ankle ROM may alter landing mechanics during running from rearfoot to forefoot landing but needs to be investigated further. In addition, an increased navicular drop, or lower arch height, may lead the active individual to have greater push-off while running.[14] This increased push-off is directly related to the greater plantar flexion.[12] In their systematic review, Yates and White[7] hypothesized that extensibility of the tibialis anterior muscle and greater plantar flexion could affect navicular drop. Thus, the risk factor of greater plantar flexion may be the cause of the navicular-drop risk factor.

Although Hamstra-Wright et al[5] identified greater hip external-rotation ROM as a risk factor for MTSS, little is known about the proposed relationship of this risk factor to the injury. When data from the 3 studies that measured hip external-rotation ROM were combined, values in the MTSS group were greater than those in the control group. However, the individual studies did not identify any significant differences between the MTSS and control groups.[5] The method used to assess hip external-rotation ROM varied in the studies, yet we agree that ROM changes, both deficits and laxity, could increase tibial loading during activity or alter the angle of the femoral neck at the hip joint, thereby increasing torque on the lower leg.[7] This would predispose the active individual to injuries such as exertional medial tibial pain, tibial stress fractures, and MTSS.[6] Even though we do not fully understand the role of hip external-rotation ROM in MTSS, clinicians should continue to assess this factor to develop appropriate prevention and treatment programs.[14] We suggest that clinicians measure their patients passively to identify this risk factor and create prevention and treatment programs that focus on balancing flexibility and strength of the hip internal and external rotators, manual therapy for functional hip alignment, and pelvic tilts for stability. Because this risk factor is poorly understood, we advise clinicians to use patient-reported outcome measures such as the Copenhagen Hip and Groin Outcome Score[15] and the MTSS Score[16] to identify limitations and restrictions in active individuals, as well as the severity of the shin pain. Amassing patient-reported outcomes will improve our understanding of the role of greater hip external rotation in MTSS.

The findings of Hamstra-Wright et al[5] give clinicians insight into risk factors for MTSS. When providing health care to physically active populations such as distance runners and the military, practitioners should implement preparticipation risk factor screenings. We recommend that clinicians screen for risk factors before training rather than after athletes become symptomatic. Body mass index should be assessed using a standard calculation of body mass to squared height. It is important to note that BMI is not being calculated as an indicator of obesity in this context, yet individuals with increased mass relative to their squared height are at greater risk of developing MTSS. As for the risk factor of navicular drop, we suggest that practitioners follow the methods and protocol described by Picciano et al.[13] No consensus currently exists on measuring ankle and hip ROM. We propose passively measuring the ankle and hip for plantar flexion and external rotation, respectively.

However, the literature is inconclusive regarding the interpretation of each measurement. Means for BMI in the MTSS group ranged from 19.3 ± 1.5 to 23.9 ± 2.5 kg/m^2, whereas the means for the control group ranged from 18.4 ± 1.3 to 23.9 ± 2.5 kg/m^2.[5] Although an increased BMI was noted in each study, these values are difficult to apply in clinical practice as they overlap among injured and uninjured individuals. We see similar results of overlapping means in navicular drop, ankle plantar flexion, and hip external rotation.[5] These results are difficult to interpret, but clinicians can immediately implement these assessments. This will be the first step in injury prevention: identifying a value that correlates with MTSS in an active population. Based on these results, clinicians can then design injury-prevention programs to reduce injury rates throughout basic training in military recruits or the competitive season in distance runners.

When designing preventive programs for individuals with increased plantar flexion, practitioners should include eccentric exercises for the tibialis anterior,[5] orthotics and insoles for increased navicular drop,[17,18] and progressive activity programs for increased BMI.[5] Even though researchers do not fully understand the role of greater hip external-rotation ROM, we suggest manual therapy and a balance between flexibility and strength of the hip and pelvis musculature to minimize the risk of developing MTSS. Several commonly used injury-prevention methods have been studied,[17,18] and the 4 risk factors of increased BMI, navicular drop, ankle plantar flexion, and hip external-rotation ROM should be investigated.

Finally, clinicians should continue to include MTSS as a differential diagnosis for active individuals who report lower leg pain. Although the authors of this systematic review and meta-analysis identified 4 significant risk factors for MTSS, the literature they examined identified more than 100 risk factors. To guide patient care, practitioners should continue to apply their clinical expertise in conjunction with the 4 risk factors supported in this meta-analysis. Overall, little is known about whether multiple risk factors multiply the risk of MTSS. This is of interest to clinicians because screening for multiple risk factors may identify various areas to improve through injury-prevention programs. We suggest that clinicians continue to design individual preventive programs to address each risk factor while modifying training if individuals have more than 1 risk factor, which theoretically would increase their chance of injury.

REFERENCES

1. Moen MH, Tol JL, Weir A, Steunebrink M, De Winter TC. Medial tibial stress syndrome: a critical review. *Sports Med*. 2009;39(7):523–546.
2. Newman P, Witchalls J, Waddington G, Adams R. Risk factors associated with medial tibial stress syndrome in runners: a systematic review and meta-analysis. *Open Access J Sports Med*. 2013;4:229–241.
3. Raissi GR, Cherati AD, Mansoori KD, Razi MD. The relationship between lower extremity alignment and medial tibial stress syndrome among non-professional athletes. *Sports Med Arthrosc Rehabil Ther Technol*. 2009;1(1):11.
4. Lopes AD, Hespanhol Junior LC, Yeung SS, Costa LO. What are the main running-related musculoskeletal injuries? A systematic review. *Sports Med*. 2012;42(10):891–905.
5. Hamstra-Wright KL, Bliven KC, Bay C. Risk factors for medial tibial stress syndrome in physically active individuals such as runners and military personnel: a systematic review and meta-analysis. *Br J Sports Med*. 2015;49(6):362–369.
6. Yates B, White S. The incidence and risk factors in the development of medial tibial stress syndrome among naval recruits. *Am J Sports Med*. 2004;32(3):772–780.
7. Sobhani V, Shakibaee A, Khatibi Aghda A, Emami Meybodi MK, Delavari A, Jahandideh D. Studying the relation between medial tibial stress syndrome and anatomic and anthropometric characteristics of military male personnel. *Asian J Sports Med*. 2015;6(2):e23811.
8. Moen MH, Bongers T, Bakker EW, et al. Risk factors and prognostic indicators for medial tibial stress syndrome. *Scand J Med Sci Sports*. 2012;22(1):34–39.
9. Sharma J, Greeves JP, Byers M, Bennett AN, Spears IR. Musculoskeletal injuries in British Army recruits: a prospective study of diagnosis-specific incidence and rehabilitation times. *BMC Musculoskelet Disord*. 2015;16:106.
10. Wallner-Liebmann SJ, Kruschitz R, Hubler K, et al. A measure of obesity: BMI versus subcutaneous fat patterns in young athletes and nonathletes. *Coll Antropol*. 2013;37(2):351–357.
11. Kruschitz R, Wallner-Liebmann SJ, Hamlin MJ, et al. Detecting body fat: a weighty problem. BMI versus subcutaneous fat patterns in athletes and non-athletes. *PLoS One*. 2013;8(8):e72002.
12. Paton JS. The relationship between navicular drop and first metatarsophalangeal joint motion. *J Am Podiatr Med Assoc*. 2006;96(4):313–317.

13. Picciano AM, Rowlands MS, Worrell T. Reliability of open and closed kinetic chain subtalar joint neutral positions and navicular drop test. *J Orthop Sports Phys Ther*. 1993;18(4):553–558.
14. van der Worp H, van Ark M, Roerink S, Pepping GJ, van den Akker-Scheek I, Zwerver J. Risk factors for patellar tendinopathy: a systematic review of the literature. *Br J Sports Med*. 2011;45(5): 446–452.
15. Thorborg K, Holmich P, Christensen R, Petersen J, Roos EM. The Copenhagen Hip and Groin Outcome Score (HAGOS): development and validation according to the COSMIN checklist. *Br J Sports Med*. 2011;45(6):478–491.
16. Winters M, Moen MH, Zimmermann WO, et al. The medial tibial stress syndrome score: a new patient-reported outcome measure. *Br J Sports Med*. 2016;50(19):1192–1199.
17. Thacker SB, Gilchrist J, Stroup DF, Kimsey CD. The prevention of shin splints in sports: a systematic review of literature. *Med Sci Sports Exerc*. 2002;34(1):32–40.
18. Craig DI. Medial tibial stress syndrome: evidence-based prevention. *J Athl Train*. 2008;43(3):316–318.

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