PERFORMING ARTS
SPECIAL INTEREST GROUP

ORTHOPAEDIC SECTION
AMERICAN PHYSICAL THERAPY ASSOCIATION

APTA
American Physical Therapy Association
The Science of Healing. The Art of Caring.

PASIG MONTHLY CITATION BLAST: No. 122 **December 2016**

Dear Performing Arts SIG members:

The PASIG has been busy! We have a lot of updates, please see below. Wishing everyone a wonderful holiday season and Happy New Year!

Upcoming Conferences! CSM is right around the corner! CSM 2017 will be February 15-17 in San Antonio, TX. At CSM 2017, the PASIG will provide main session programming "A Guide to Upper Extremity Nerve Entrapment Syndromes in Musicians," by Janice Ying, DPT, OCS, Adriaan Louw, PhD, PT, CSMT, and Erin M. Hayden, PT, DPT, OCS. It is scheduled for Thursday, February 16th from 3:00pm to 5:00pm in room 301B at the Henry B Gonzalez Convention Center. Here is a link for more information: https://apta.expoplanner.com/index.cfm?do=expomap.sess&event_id=23&session_id=12125

The 2017 Orthopaedic Section Annual Conference will be San Diego Hyatt Regency Mission Bay April 20-22.

Fellowship Taskforce Update! The practice analysis re-validation project team is working on final revisions for the upcoming publication of the Description of Fellowship Practice (DFP) for Performing Arts Physical Therapy. The Description of Advanced Specialized Practice (DASP) in Performing Arts Physical Therapy was approved by the ABPTRFE in January 2016. The DFP will go up to review by ABPTRFE in January of 2017. This is the final phase for laying the groundwork for providing current practice guidelines in the sub-specialty area as well as curriculum requirements for Performing Arts PT fellowships.

The Fellowship Taskforce Chair and various project team members will be hosting a Performing Arts Fellowship Development Q&A Session at CSM from 12:00pm – 1:30pm on Saturday February 18th in Convention Center, Room 224. This session is for anyone interested in learning more about starting performing arts fellowships or learning about the practice analysis process. We hope to see you there!

Dancer Screening Update! PASIG is attempting to collect relevant information and resources to share with our membership regarding screening the young dancer (adolescent, pre-pro, collegiate). If you are currently participating in research and/or utilizing young dancer screening tools, please contact our Dancer Screening Chair, Mandy Blackmon, at mandydancePT@gmail.com. We will be meeting at CSM 2017 in San Antonio, TX to discuss and collaborate on current resources. Please let Mandy know if you will be at CSM and are interested in attending that committee meeting, as we need to plan for meeting space. Time: 1:00 PM, Thursday, February 16th.

Interested in a Performing Arts Fellowship? The American Board of Physical Therapy Residency and Fellowship Education (ABPTFRE) has approved the PASIG Description of Specialist Practice (DSP) for the Performing arts as an area of study. We are now working with the ABPTFRE to turn the DSP into a Description of Fellowship Practice (DFP). We anticipate the DFP will be available online by June 2016. This means that sites can begin forming fellowships in dance medicine, music medicine, theater medicine, etc. The PASIG will provide the fellowship criteria for accreditation. We may have a meeting on creating a performing arts fellowship at CSM 2017 on Saturday, February 18th, from 12:00pm to 1:30 PM. Please contact Mariah Nierman Mariah.Nierman@osumc.edu or Laurel Abbruzzese La110@cumc.columbia.edu if interested.

In the news! PASIG Committee Chairs, Janice Ying, PT, DPT and Mandy Blackmon, PT, DPT, are featured in November's PT in Motion article on treating musicians. http://www.apta.org/PTinMotion/2016/11/Feature/KeepingInTune/

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Membership: Current PASIG members, please remember to update your membership: https://www.orthopt.org/login.php?forward_url=/surveys/membership_directory.php

Social Media: For fun PT info and related performing artists info...
1) Facebook page: (closed) so, if you would like to be a part of the group, email me on Facebook: Dawn Doran and let me know you'd like to join.
2) follow PASIG on Twitter: @PT4PERFORMERS

Call for case reports: If you have a brief, clinically-focused case report on a performing arts PT patient, or a clinical commentary, please contact Annette Karim to submit your writing for the next Orthopaedic Physical Therapy Practice Magazine: neoluvsonlyme@aol.com

WE NEED MORE CONTRIBUTORS TO OUR MONTHLY CITATION BLASTS!!!!
Past Monthly citation blasts are available, with citations and EndNote file, listed on the website:
http://www.orthopt.org/content/special_interest_groups/performing_arts/citations_endnotes

TOPICS THAT HAVE BEEN COVERED RECENTLY INCLUDE:
Medial Tibial Stress Syndrome (current)
2nd Tarsometatarsal Joint Injuries in Dancers
Screening Tools for the Young Dancer
Thoracic Outlet Syndrome and Nerve Entrapment in Instrumental Musicians
Plyometric Training in Dancers
HVLAT for Lower Extremity Conditions
Inguinal Disruption
Femoroacetabular Impingement
Hand and Wrist Conditions in Gymnasts
Factors in Optimal Turnout
Achilles Tendinopathy

Biomechanics and Posture in Musicians
Pilates
ACL Injuries in Dancers
Patellofemoral Pain and Dance
Neural Entrapments Found Among Musicians
Stress Fractures of the Foot and Ankle
Dry Needling
Dynamic Warm Up and Stretching
Platelet Rich Plasma Injections
Back Pain in Dancers

If you are interested in contributing by writing a citation blast or joining the research committee, contact me at lbreising@gmail.com.

Sincerely,

Laura

Laura Reising, PT, DPT, MS, OCS
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PERFORMING ARTS CONTINUING EDUCATION, CONFERENCES, AND RESOURCES

Musician Health Series, Janice Ying, PT, DPT, OCS
Glendale Adventist Therapy and Wellness Center, Los Angeles area (Eagle Rock), CA
http://www.musicianshealthcorner.com/
Healthy Musician Series - Overuse

Orthopaedic Section Independent Study Course. *20.3 Physical Therapy for the Performing Artist*.
Monographs are available for:
- Figure Skating (J. Flug, J. Schneider, E. Greenberg),

- Artistic Gymnastics (A. Hunter-Giordano, Pongetti-Angeletti, S. Voelker, TJ Manal), and
- Instrumentalist Musicians (J. Dommerholt, B. Collier).
Contact: Orthopaedic Section at: www.orthopt.org

Orthopaedic Section-American Physical Therapy Association,
Performing Arts SIG
http://www.orthopt.org/content/special_interest_groups/performing_arts
Performing Arts Citations and Endnotes
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ADAM Center
http://www.adamcenter.net/
Publications:
http://www.adamcenter.net/#!vstc0=publications
Conference abstracts:
http://www.adamcenter.net/#!vstc0=conferences

Dance USA
http://www.danceusa.org/
Research resources:
http://www.danceusa.org/researchresources
Professional Dancer Annual Post-Hire Health Screen:
http://www.danceusa.org/dancerhealth

Dancer Wellness Project
http://www.dancerwellnessproject.com/
Becoming an affiliate:
http://www.dancerwellnessproject.com/Information/BecomeAffiliate.aspx

Harkness Center for Dance Injuries, Hospital for Joint Diseases
http://hjd.med.nyu.edu/harkness/
Continuing education:
http://hjd.med.nyu.edu/harkness/education/healthcare-professionals/continuing-education-courses-cme-and-ceu
Resource papers:
http://hjd.med.nyu.edu/harkness/dance-medicine-resources/resource-papers-and-forms
Links:
http://hjd.med.nyu.edu/harkness/dance-medicine-resources/links
Informative list of common dance injuries:
http://hjd.med.nyu.edu/harkness/patients/common-dance-injuries
Research publications:
http://hjd.med.nyu.edu/harkness/research/research-publications

International Association for Dance Medicine and Science (IADMS)
http://www.iadms.org/
Resource papers:
http://www.iadms.org/displaycommon.cfm?an=1&subarticlenbr=186
Links:
http://www.iadms.org/displaycommon.cfm?an=5
Medicine, arts medicine, and arts education organization links:
http://www.iadms.org/displaycommon.cfm?an=1&subarticlenbr=5
Publications:
http://www.iadms.org/displaycommon.cfm?an=3

Performing Arts Medicine Association (PAMA)
http://www.artsmed.org/
http://www.artsmed.org/symposium.html
Interactive bibliography site:
http://www.artsmed.org/bibliography.html
Related links:
http://www.artsmed.org/relatedlinks.html
Member publications:
http://artsmed.org/publications.html

(Educators, researchers, and clinicians, please continue to email your conference and continuing education information to include in future blasts.

Medial Tibial Stress Syndrome

I saw an increase in medial tibial stress syndrome (MTSS) over the past few months due to an increase in activities from summer intensive and now again for dance performances this winter. Dancers, gymnasts, ice skaters, and other performing artists are at risk for MTSS. This month's blast shares some of the most recent research publications focused on examination, diagnostic tools, risk factors, management/rehabilitation, and prevention. Possible risk factors reported in the literature include: increased navicular drop, gender, lower limb rotational alignment, hip and ankle plantarflexion ROM, and calf girth. Physician referral and imaging are essential if there is a concern of a stress fracture or other complication, such as compartment syndrome. Articles presented focus on runners and military personnel, as more research is needed on the management of MTSS in performing artists. But using the wealth of existing information can help serve as a guide to identifying and various treatment options that can be applied to the performing artist with MTSS.

Laura Reising, PT, DPT, MS, OCS
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Bandholm T, Boysen L, Haugaard S, Zebis MK, Bencke J. Foot medial longitudinal-arch deformation during quiet standing and gait in subjects with medial tibial stress syndrome. *J Foot Ankle Surg.* 2008;47(2):89-95.

ABSTRACT: The objective of this study was to investigate (1) if subjects with medial tibial stress syndrome demonstrate increased navicular drop and medial longitudinal-arch deformation during quiet standing and gait compared with healthy subjects, and (2) the relationship between medial longitudinal-arch deformation during quiet standing and gait. Thirty subjects aged 20 to 32 years were included (15 with medial tibial stress syndrome and 15 controls). Navicular drop and medial longitudinal-arch deformation were measured during quiet standing with neutral and loaded foot using a ruler and digital photography. Medial longitudinal-arch deformation was measured during walking gait using 3-dimensional gait analysis. Subjects with medial tibial stress syndrome demonstrated a significantly larger navicular drop (mean +/- 1 SD, 7.7 +/- 3.1 mm) and medial longitudinal-arch deformation (5.9 +/- 3.2 degrees) during quiet standing compared with controls (5.0 +/- 2.2 mm and 3.5 +/- 2.6 degrees, $P < .05$). Subjects with medial tibial stress syndrome also demonstrated significantly larger medial longitudinal-arch deformation (8.8 +/- 1.8 degrees) during gait compared with controls (7.1 +/- 1.7 degrees, $P = .015$). There was no correlation between medial longitudinal-arch deformation during quiet standing and gait in either of the 2 groups ($r < 0.127$, $P > .653$). The subjects with medial tibial stress syndrome in this study demonstrated increased navicular drop and medial longitudinal-arch deformation during quiet standing and increased medial longitudinal-arch deformation during gait compared to healthy subjects. Medial longitudinal-arch deformation during quiet standing did not correlate with medial longitudinal-arch deformation during gait in either of the 2 groups.
ACFAS LEVEL OF CLINICAL EVIDENCE: 5.

Bennett JE, Reinking MF, Pluemer B, Pentel A, Seaton M, Killian C. Factors contributing to the development of medial tibial stress syndrome in high school runners. *J Orthop Sports Phys Ther.* 2001;31(9):504-510.

Study Design: Predictive correlational study.
OBJECTIVES: To identify the incidence of medial tibial stress syndrome (MTSS) in a group of high school cross-country runners and to determine if a relationship exists between lower extremity structural measures and the incidence of MTSS.
BACKGROUND: Medial tibial stress syndrome is an overuse injury that occurs in long-distance runners. Literature exists that implicates structural deformity as a contributor to MTSS, but no studies have developed a predictive model.

METHODS AND MEASURES: We measured 125 high school cross-country runners for tibiofibular varum, resting calcaneal position during stance, and gastrocnemius length. Runners developing MTSS over an 8-week period were placed in the injured group (2 men, 13 women; age 15.3 years 1.0), and 21 randomly selected uninjured runners were placed in the uninjured group (13 men, 8 women; age 15.7 years +/-1.5). Navicular drop was measured for runners in both groups. Reliability of measures was determined using an intraclass correlation coefficient (ICC 3,1). Paired t tests were used to compare the injury and noninjury groups. A logistic regression analysis was used to establish if the descriptive data could accurately predict the development of MTSS.
RESULTS: Paired t tests showed a significant difference in navicular drop test measures between the injured (6.8 mm 3.7) and noninjured (3.6 mm 3.3) groups. Logistic regression analysis revealed navicular drop test measurements and sex correctly identified athletes who developed MTSS with 76% accuracy.
CONCLUSION: Our study supported the hypothesis that a pronatory foot type is related to MTSS. The combination of sex and navicular drop test measures provides an accurate prediction for the development of MTSS. Clinical measures that identify biomechanical risk factors for MTSS may allow prevention or early intervention.

Craig DI. Medial tibial stress syndrome: evidence-based prevention. *J Athl Train.* 2008;43(3):316-318.

REFERENCE: 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.
CLINICAL QUESTION: Among physically active individuals, which medial tibial stress syndrome (MTSS) prevention methods are most effective to decrease injury rates?
DATA SOURCES: Studies were identified by searching MEDLINE (1966-2000), Current Contents (1996-2000), Biomedical Collection (1993-1999), and Dissertation Abstracts. Reference lists of identified studies were searched manually until no further studies were identified. Experts in the field were contacted, including first authors of randomized controlled trials addressing prevention of MTSS. The Cochrane Collaboration (early stage of Cochrane Database of Systematic Reviews) was contacted.
STUDY SELECTION: Inclusion criteria included randomized controlled trials or clinical trials comparing different MTSS prevention methods with control groups. Excluded were studies that did not provide primary research data or that addressed treatment and rehabilitation rather than prevention of incident MTSS.
DATA EXTRACTION: A total of 199 citations were identified. Of these, 4 studies compared prevention methods for MTSS. Three reviewers independently scored the 4 studies. Reviewers were blinded to the authors' names and affiliations but not the results. Each study was evaluated

independently for methodologic quality using a 100-point checklist. Final scores were averages of the 3 reviewers' scores.
MAIN RESULTS: Prevention methods studied were shock-absorbent insoles, foam heel pads, Achilles tendon stretching, footwear, and graduated running programs. No statistically significant results were noted for any of the prevention methods. Median quality scores ranged from 29 to 47, revealing flaws in design, control for bias, and statistical methods.
CONCLUSIONS: No current evidence supports any single prevention method for MTSS. The most promising outcomes support the use of shock-absorbing insoles. Well-designed and controlled trials are critically needed to decrease the incidence of this common injury.

Ewalt KL. Bandaging and taping considerations for the dancer. *J Dance Med Sci.* 2010;14(3):103-113.

ABSTRACT: Although widely disputed, bandaging and taping techniques are common practice in sports medicine. This article reviews literature related to the efficacy of bandaging and taping procedures and their role in sport and dance medicine. It further examines dance-specific application principles, and outlines selected techniques for treatment of common dance-related pathologies.

Fogarty S. Massage treatment and medial tibial stress syndrome: a commentary to provoke thought about the way massage therapy is used in the treatment of MTSS. *J Bodyw Mov Ther.* 2015;19(3):447-452.

ABSTRACT: As students and practitioners we are taught about the treatment and causative factors of medial shin pain, in particular' shin splints' or the more recent term; medial tibial stress syndrome (MTSS). During the years there have been many theories, conjecture and misunderstandings about the mechanisms of 'shin splints/medial tibial stress syndrome' however the ramifications of these mechanisms on how massage treatment is delivered have not being discussed. The evidence for the treatment of MTSS is largely clinical with little evidence of any treatment being proven to be effective in treating MTSS. The aim of this article is to present a summary of the mechanisms of MTSS and a commentary to provoke thought about the way massage therapy is used in the treatment of MTSS based on these mechanisms.

Fredericson M, Bergman AG, Hoffman KL, Dillingham MS. Tibial stress reaction in runners: correlation of clinical symptoms and scintigraphy with a new magnetic resonance imaging grading system. *Am J Sports Med.* 1995;23(4):23(4):472-481.

ABSTRACT: Medial tibial pain in runners has traditionally been diagnosed as either a shin splint syndrome or as a stress fracture. Our work using magnetic resonance imaging suggests that a progression of injury can be identified, starting with periosteal edema, then progressive marrow involvement, and ultimately frank cortical stress fracture. Fourteen runners,

with a total of 18 symptomatic legs, were evaluated and, within 10 days, referred for radiographs, a technetium bone scan, and a magnetic resonance imaging scan. In 14 of the 18 symptomatic legs, magnetic resonance imaging findings correlated with an established technetium bone scan grading system and more precisely defined the anatomic location and extent of injury. We identified clinical symptoms, such as pain with daily ambulation and physical examination findings, including localized tibial tenderness and pain with direct or indirect percussion, that correlated with more severe tibial stress injuries. When clinically warranted, we recommend magnetic resonance imaging over bone scan for grading of tibial stress lesions in runners. Magnetic resonance imaging is more accurate in correlating the degree of bone involvement with clinical symptoms, allowing for more accurate recommendations for rehabilitation and return to impact activity. Additional advantages of magnetic resonance imaging include lack of exposure to ionizing radiation and significantly less imaging time than three-phase bone scintigraphy.

Galbraith RM, Lavallee ME. Medial tibial stress syndrome: conservative treatment options. *Curr Rev Musculoskelet Med*. 2009;2(3):127-133.

ABSTRACT: Medial tibial stress syndrome (MTSS), commonly known as "shin splints," is a frequent injury of the lower extremity and one of the most common causes of exertional leg pain in athletes (Willems T, Med Sci Sports Exerc 39(2):330–339, 2007; Korkola M, Amendola A, Phys Sportsmed 29(6):35–50, 2001; Hreljac A, Med Sci Sports Exerc 36(5):845–849, 2004). Although often not serious, it can be quite disabling and progress to more serious complications if not treated properly. Often, the cause of MTSS is multi-factorial and involves training errors and various biomechanical abnormalities. Few advances have been made in the treatment of MTSS over the last few decades. Current treatment options are mostly based on expert opinion and clinical experience. The purpose of this article is to review published literature regarding conservative treatment options for MTSS and provide recommendations for sports medicine clinicians for improved treatment and patient outcomes.

Holder LE, Michael RH. The specific scintigraphic pattern of "shin splints in the lower leg": concise communication. *J Nucl Med.* 1984;25(8):865-869.

ABSTRACT: The clinical entity, "shin splints," is now being recognized, and more specifically characterized by the findings of exercise-induced pain and tenderness to palpation along the posterior medial border of the tibia. In this prospective study, ten patients with this syndrome were evaluated using three-phase bone scintigrams, and a specific scintigraphic pattern was determined. Radionuclide angiograms and blood-pool images were all normal. On delayed images, tibial lesions involved the posterior cortex, were longitudinally oriented, were long, involving one third of the length of the bone, and often showed varying tracer uptake along that length. Obtaining both lateral and medial views was crucial. The location of activity suggested

that this entity is related to the soleus muscle. These scintigraphic findings can be used to differentiate shin splints from stress fractures or other conditions causing pain in the lower leg in athletes.

Kenawey M, Liodakis E, Krettek C, Ostermeier S, Horn T, Hankemeier S. Effect of the lower limb rotational alignment on tibiofemoral contact pressure. *Knee Surg Sports Traumatol Arthrosc.* 2011;19(11):1851-1859.

PURPOSE: he effect of the rotational alignment of lower extremities on the tibiofemoral contact mechanics is not known. This study was designed to measure the contact area and pressure within medial and lateral tibiofemoral compartments following controlled serial rotational deformities through femoral and tibial shafts.

METHODS: Eight lower extremities of fresh frozen cadavers were used. Computed tomography was conducted to measure the rotational profile of the lower extremities. Through a medial parapatellar arthrotomy, pressure sensors were implanted into both tibiofemoral compartments. Femoral and tibial mid-shaft osteotomies were performed and stabilized by non-locked intramedullary nails and external fixators in neutral rotation. The contact area and pressure were measured under axial loading in neutral rotation and following serial malrotations from 40° external to 40° internal malrotation in 10° increments.

RESULTS: Contact area was not affected by malrotations. Medial compartment contact pressure rose with external and decreased with internal malrotations whether femoral or tibial ($P < 0.0001$) while lateral pressure was not affected. When correlated with the cadavers' original rotational profile, decreased femoral neck anteversion was associated with increased medial pressure up to 28.5% at 20° of retroversion while it decreased with increased anteversion. On the other hand, decreased tibial torsion angle was associated with decreased medial pressure up to -32% at 10° of internal torsion and it increased with excessive external torsion. Furthermore, there was a strong positive correlation with the total rotational alignment as measured by the neck malleolar angle.

CONCLUSION: A significant interaction could be detected between the rotational alignment of the lower extremity and medial tibiofemoral compartment contact pressures.

Kijowski R, Choi J, Mukharjee R, de Smet A. Significance of radiographic abnormalities in patients with tibial stress injuries: correlation with magnetic resonance imaging. *Skeletal Radiol.* 2007;36(7):633-640.

OBJECTIVES: The objective was to correlate radiographic findings with magnetic resonance imaging (MRI) findings in patients with suspected tibial stress injuries in order to determine the significance of radiographic signs of stress injury in these individuals.

PATIENTS AND METHODS: The study group consisted of 80 patients with suspected tibial stress injuries who underwent a radiographic and MR examination of the tibia. Nineteen patients had bilateral involvement. Thus, a

total of 99 tibias were evaluated. All radiographs and MR examinations were retrospectively reviewed, 1 month apart, in consensus by two musculoskeletal radiologists. The radiographs were reviewed without knowledge of the site of the clinical symptoms. Fisher's exact tests were used to determine the association between a positive radiograph and the presence of various MRI signs of a high-grade stress injury.
RESULTS: There was a strong association between the presence of periosteal reaction on radiographs at the site of the clinical symptoms and a Fredericson grade 4 stress injury on MRI.
CONCLUSIONS: The presence of periosteal reaction on radiographs at the site of clinical symptoms is predictive of a high-grade stress injury by MRI criteria.

Kudo S, Hatanaka Y. Forefoot flexibility and medial tibial stress syndrome. *J Orthop Surg (Hong Kong).* 2015;23(3):357-360.

PURPOSE: To investigate the association between medial tibial stress syndrome (MTSS) and morphology and flexibility of the foot arches.
METHODS: 131 feet from 74 healthy subjects and 31 feet from 27 patients with MTSS were classified as normal feet (n=78 in 40 subjects), flat feet (n=53 in 34 subjects), or MTSS feet (n=31 in 27 patients). The medial longitudinal arch (MLA) ratio and the transverse arch length (TAL) were measured in both rearfoot and forefoot loading positions. The difference between the 2 positions indicated the flexibility of the MLA (diff-MLA ratio) and the transverse arch (diff- TAL).
RESULTS: The MLA ratio was higher in normal feet than MTSS feet or flat feet (15.1% vs. 12.8% vs. 12.3%, $p<0.001$). The diff-TAL was lower in MTSS feet than normal feet or flat feet (0.4% vs. 0.8% vs. 0.9%, $p<0.001$]). The 3 groups were comparable in terms of the diff-MLA ratio and the TAL. Respectively for the MLA ratio and the diff-TAL, the cut-off value was 11.9% and 0.61% based on the Youden index. The sensitivity, specificity, and odds ratio of the cut-off value were 0.4, 0.9, and 4.8 for the MLA ratio, and 0.6, 0.7, and 9.8 for the diff-TAL, respectively.
CONCLUSION: Decreased flexibility of the transverse arch and decreased MLA ratio are risk factors for MTSS. In contrast, the flexibility of the MLA and the height of the transverse arch were not risk factors for MTSS.

Loudon JK, Dolphino MR. Use of foot orthoses and calf stretching for individuals with medial tibial stress syndrome. *Foot Ankle Spec.* 2010;3(1):15-20.

ABSTRACT: Use of orthotics and calf stretching may alleviate symptoms in runners with medial tibial stress syndrome (MTSS). The objective of this study was to determine which patients with MTSS have a positive response to off-the-shelf foot orthoses and calf stretching based on selected clinical tests to establish a clinical prediction rule. This prospective cohort/predictive validity study enrolled 23 women and men aged 22 to 44 years with symptoms of MTSS. Interventions included off-the-shelf basic foot

orthotics and calf stretching. Fifteen of the 23 runners had a 50% reduction of pain in 3 weeks of intervention. Duration was a significant factor that differentiated groups. Although an initial treatment for runners with MTSS may include off-the-shelf orthotics and calf stretching, this regimen should be only one component of an individualized rehabilitation program.

Magnusson HI, Ahlborg HG, Karlsson C, Nyguist F, Karlsson MK. Low regional tibial bone density in athletes with medial tibial stress syndrome normalizes after recovery from symptoms. *Am J Sports Med.* 2003;31(4):596-600.

BACKGROUND: Although the exact cause of medial tibial stress syndrome is unclear, changes in bone metabolism are likely to be involved.
HYPOTHESIS: Localized low bone mineral density at the junction of the middle and distal thirds of the tibia in patients with medial tibial stress syndrome develops in conjunction with the symptoms; these changes are reversible and are not inherited.
STUDY DESIGN: Prospective cohort study.
METHODS: Bone mineral density in 14 adult male athletes with long-standing medial tibial stress syndrome was measured when they were symptomatic and after recovery (mean follow-up, 5.7 years). Repeat measurements were also made prospectively in 13 nonathlete control subjects and single measurements were made in 18 healthy athletes.
RESULTS: Bone mineral density was 9% +/- 11% higher in the proximal tibia but 11% +/- 12% lower in the tibial region corresponding to pain in patients when compared with nonathlete control subjects. It increased by 19% +/- 11% in the region of pain after recovery from symptoms and, at follow-up, was no lower than in nonathlete control subjects.
CONCLUSION: Athletes with medial tibial stress syndrome and increased scintigraphic uptake regain normal tibial bone mineral density after recovery from symptoms. Initially localized low bone mineral density is not an inherited condition, but instead may develop in conjunction with the symptoms.

Moen MH, Bongers T, Bakker EW, Zimmermann WO, Weir A, Tol J, Backx FJG. Risk factors and prognostic indicators for medial tibial stress syndrome. *Scand J Med Sci Sports.* 2012; 22(1):34-39.

ABSTRACT: The objective of the study was to examine the risk factors and prognostic indicators for medial tibial stress syndrome (MTSS). In total, 35 subjects were included in the study. For the risk factor analysis, the following parameters were investigated: hip internal and external ranges of motion, knee flexion and extension, dorsal and plantar ankle flexion, hallux flexion and extension, subtalar eversion and inversion, maximal calf girth, lean calf girth, standing foot angle and navicular drop test. After multivariate regression decreased hip internal range of motion, increased ankle plantar flexion and positive navicular drop were associated with MTSS. A higher body mass index was associated with a longer duration to full recovery. For other prognostic indicators, no relationship was found.

Moen MH, Rayer S, Schipper M, Schmikili S, Weir A, Tol JL, Backx FJ. Shockwave treatment for medial tibial stress syndrome in athletes; a prospective controlled study. *Br J Sports Med.* 2012;46(4):253-257.

OBJECTIVE :The purpose of this study was to describe the results of two treatment regimens for medial tibial stress syndrome (MTSS); a graded running programme and the same running programme with additional shockwave therapy (extracorporeal shockwave therapy; ESWT).
DESIGN: A prospective observational controlled trial. Setting Two different sports medicine departments. Participants 42 athletes with MTSS were included.
INTERVENTION: Patients from one hospital were treated with a graded running programme, while patients from the other hospital were treated with the same graded running programme and focused ESWT (five sessions in 9 weeks).
MAIN OUTCOME MEASURES: Time to full recovery (the endpoint was being able to run 18 min consecutively without pain at a fixed intensity).
RESULTS: The time to full recovery was significantly faster in the ESWT group compared with the patients who only performed a graded running programme, respectively 59.7±25.8 and 91.6±43.0 days (p=0.008).
CONCLUSIONS: This prospective observational study showed that MTSS patients may benefit from ESWT in addition to a graded running programme. ESWT as an additional treatment warrants further investigation in a prospective controlled trial with the addition of randomisation and double blinding.

Moen MH, Schmikli SL, Weir A, Steeneken V, Stapper G, de Slegte R, Tol JL, Backx FJ. A prospective study on MRI findings and prognostic factors in athletes with MTSS. *Scand J Med Sci Sports.* 2014;24(1):204-210.

ABSTRACT: In medial tibial stress syndrome (MTSS) bone marrow and periosteal edema of the tibia on the magnetic resonance imaging (MRI) is frequently reported. The relationship between these MRI findings and recovery has not been previously studied. This prospective study describes MRI findings of 52 athletes with MTSS. Baseline characteristics were recorded and recovery was related to these parameters and MRI findings to examine for prognostic factors. Results showed that 43.5% of the symptomatic legs showed bone marrow or periosteal edema. Absence of periosteal and bone marrow edema on MRI was associated with longer recovery (P = 0.033 and P = 0.013). A clinical scoring system for sports activity (SARS score) was significantly higher in the presence of bone marrow edema (P = 0.027). When clinical scoring systems (SARS score and the Lower Extremity Functional Scale) were combined in a model, time to recovery could be predicted substantially (explaining 54% of variance, P = 0.006). In conclusion, in athletes with MTSS, bone marrow or periosteal edema is seen on MRI in 43,5% of the symptomatic legs. Furthermore, periosteal and bone marrow edema on MRI and clinical scoring systems are

prognostic factors. Future studies should focus on MRI findings in symptomatic MTSS and compare these with a matched control group.

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.

ABSTRACT: Medial tibial stress syndrome (MTSS) is one of the most common leg injuries in athletes and soldiers. The incidence of MTSS is reported as being between 4% and 35% in military personnel and athletes. The name given to this condition refers to pain on the posteromedial tibial border during exercise, with pain on palpation of the tibia over a length of at least 5 cm. Histological studies fail to provide evidence that MTSS is caused by periostitis as a result of traction. It is caused by bony resorption that outpaces bone formation of the tibial cortex. Evidence for this overloaded adaptation of the cortex is found in several studies describing MTSS findings on bone scan, magnetic resonance imaging (MRI), high-resolution computed tomography (CT) scan and dual energy x-ray absorptiometry. The diagnosis is made based on physical examination, although only one study has been conducted on this subject. Additional imaging such as bone, CT and MRI scans has been well studied but is of limited value. The prevalence of abnormal findings in asymptomatic subjects means that results should be interpreted with caution. Excessive pronation of the foot while standing and female sex were found to be intrinsic risk factors in multiple prospective studies. Other intrinsic risk factors found in single prospective studies are higher body mass index, greater internal and external ranges of hip motion, and calf girth. Previous history of MTSS was shown to be an extrinsic risk factor. The treatment of MTSS has been examined in three randomized controlled studies. In these studies rest is equal to any intervention. The use of neoprene or semi-rigid orthotics may help prevent MTSS, as evidenced by two large prospective studies.

Patel DS, Roth M, Kapil N. Stress fractures: diagnosis, treatment, and prevention. *Am Fam Physician.* 2011;83(1):39-46.

ABSTRACT: Stress fractures are common injuries in athletes and military recruits. These injuries occur more commonly in lower extremities than in upper extremities. Stress fractures should be considered in patients who present with tenderness or edema after a recent increase in activity or repeated activity with limited rest. The differential diagnosis varies based on location, but commonly includes tendinopathy, compartment syndrome, and nerve or artery entrapment syndrome. Medial tibial stress syndrome (shin splints) can be distinguished from tibial stress fractures by diffuse tenderness along the length of the posteromedial tibial shaft and a lack of edema. When stress fracture is suspected, plain radiography should be obtained initially and, if negative, may be repeated after two to three weeks for greater accuracy. If an urgent diagnosis is needed, triple-phase bone scintigraphy or magnetic resonance imaging should be considered. Both modalities have a similar sensitivity, but magnetic resonance imaging has

greater specificity. Treatment of stress fractures consists of activity modification, including the use of nonweight-bearing crutches if needed for pain relief. Analgesics are appropriate to relieve pain, and pneumatic bracing can be used to facilitate healing. After the pain is resolved and the examination shows improvement, patients may gradually increase their level of activity. Surgical consultation may be appropriate for patients with stress fractures in high-risk locations, nonunion, or recurrent stress fractures. Prevention of stress fractures has been studied in military personnel, but more research is needed in other populations.

Pell RF, Harpal SK, Cooley R. Leg pain in the running athlete. ***J Am Acad Orthop Surg.*** **2004;12:396-404.**

ABSTRACT: Leg pain is a common complaint among recreational and professional athletes who compete in running sports. Evaluation of the individual with intermittent or constant leg pain should be well organized and inclusive. Duration of the pain, its relation to injury, intensity of the pain, and its pattern are important factors. Additionally, changes in the training regimen, its level, intensity, or duration, or in the nature of the routine are critical components of the assessment. Physical examination can help differentiate bony from soft-tissue etiologies. Studies are dictated by the differential diagnosis but include radiographs in almost all patients and selected use of other modalities. These include bone scans and magnetic resonance imaging for medial tibial stress syndrome and stress fractures and intracompartmental pressure measurements for chronic compartment syndrome. Treatment often requires either rest or a change in training regimen. Surgery for conditions such as chronic compartment syndrome frequently allows a return to preinjury activities.

Plisky MS, Rauh MJ, Heiderscheit B, Underwood FB, Tank RT. Medial tibial stress syndrome in high school cross-country runners: incidence and risk factors. ***J Orthop Sports Phys Ther.*** **2007;37(2):40-47.**

STUDY DESIGN: Prospective cohort.

OBJECTIVE: To determine (1) the cumulative seasonal incidence and overall injury rate of medial tibial stress syndrome (MTSS) and (2) risk factors for MTSS with a primary focus on the relationship between navicular drop values and MTSS in high school cross-country runners.

BACKGROUND: MTSS is a common injury among runners. However, few studies have reported the injury rate and risk factors for MTSS among adolescent runners.

METHODS AND MEASURES: Data collected included measurement of bilateral navicular drop and foot length, and a baseline questionnaire regarding the runner's height, body mass, previous running injury, running experience, and orthotic or tape use. Runners were followed during the season to determine athletic exposures (AEs) and occurrence of MTSS.

RESULTS: The overall injury rate for MTSS was 2.8/1000 AEs. Although not statistically different, girls had a higher rate (4.3/1000 AEs) than boys

(1.7/1000 AEs) (P = .11). Logistic regression modeling indicated that only gender and body mass index (BMI) were significantly associated with the occurrence of MTSS. However, when controlled for orthotic use, only BMI was associated with risk of MTSS. No significant associations were found between MTSS and navicular drop or foot length.
CONCLUSIONS: Our findings suggest that navicular drop may not be an appropriate measure to identify runners who may develop MTSS during a cross-country season; thus, additional studies are needed to identify appropriate preseason screening tools.

Reinking MF. Exercise related leg pain (ERLP): a review of the literature. *N Am J Sports Phys Ther.* 2007;2(3):170-180.

ABSTRACT: Exercise related leg pain (ERLP) is a regional pain syndrome described as pain between the knee and ankle which occurs with exercise. Indiscriminant use of terminology such as "shin splints" has resulted in ongoing confusion regarding the pathoanatomic entities associated with this pain syndrome. Each of the pathoanatomic entities – medial tibial stress syndrome, chronic exertional compartment syndrome, tibial and fibular stress fractures, tendinopathy, nerve entrapment, and vascular pathology – which manifest as ERLP are each described in terms of relevant anatomy, epidemiology, clinical presentation, associated pathomechanics, and intervention strategies. Evidence regarding risk factors for ERLP general and specific pathoanatomic entities are presented in the context of models of sports injury prevention.

Reinking MF, Austin TM, Richter RR, Kreiger MM. Medial tibial stress syndrome in active individuals: a systematic review and meta-analysis of risk factors. *Sports Health.* 2016. pii: 1941738116673299. [Epub ahead of print]

CONTEXT: Medial tibial stress syndrome (MTSS) is a common condition in active individuals and presents as diffuse pain along the posteromedial border of the tibia.
OBJECTIVE: To use cross-sectional, case-control, and cohort studies to identify significant MTSS risk factors.
DATA SOURCES: Bibliographic databases (PubMed, Scopus, CINAHL, SPORTDiscus, EMBASE, EBM Reviews, PEDRo), grey literature, electronic search of full text of journals, manual review of reference lists, and automatically executed PubMed MTSS searches were utilized. All searches were conducted between 2011 and 2015.
STUDY SELECTION: Inclusion criteria were determined a priori and included original research with participants' pain diffuse, located in the posterior medial tibial region, and activity related.
STUDY DESIGN: Systematic review with meta-analysis.
LEVEL OF EVIDENCE: Level 4.
DATA EXTRACTION: Titles and abstracts were reviewed to eliminate citations that did not meet the criteria for inclusion. Study characteristics identified a priori were extracted for data analysis. Statistical heterogeneity

was examined using the I2 index and Cochran Q test, and a random-effects model was used to calculate the meta-analysis when 2 or more studies examined a risk factor. Two authors independently assessed study quality. RESULTS: Eighty-three articles met the inclusion criteria, and 22 articles included risk factor data. Of the 27 risk factors that were in 2 or more studies, 5 risk factors showed a significant pooled effect and low statistical heterogeneity, including female sex (odds ratio [OR], 2.35; CI, 1.58-3.50), increased weight (standardized mean difference [SMD], 0.24; CI, 0.03-0.45), higher navicular drop (SMD, 0.44; CI, 0.21-0.67), previous running injury (OR, 2.18; CI, 1.00-4.72), and greater hip external rotation with the hip in flexion (SMD, 0.44; CI, 0.23-0.65). The remaining risk factors had a nonsignificant pooled effect or significant pooled effect with high statistical heterogeneity. CONCLUSION: Female sex, increased weight, higher navicular drop, previous running injury, and greater hip external rotation with the hip in flexion are risk factors for the development of MTSS.

Reschef N, Guelich DR. Medial tibial stress syndrome. *Clin Sports Med.* 2012;31(2):273-290.

ABSTRACT: MTSS is a benign, though painful, condition, and a common problem in the running athlete. It is prevalent among military personnel, runners, and dancers, showing an incidence of 4% to 35%. Common names for this problem include shin splints, soleus syndrome, tibial stress syndrome, and periostitis. The exact cause of this condition is unknown. Previous theories included an inflammatory response of the periosteum or periosteal traction reaction. More recent evidence suggests a painful stress reaction of bone. The most proven risk factors are hyperpronation of the foot, female sex, and history of previous MTSS. Patient evaluation is based on meticulous history taking and physical examination. Even though the diagnosis remains clinical, imaging studies, such as plain radiographs and bone scans are usually sufficient, although MRI is useful in borderline cases to rule out more significant pathology. Conservative treatment is almost always successful and includes several options; though none has proven more superior to rest. Prevention programs do not seem to influence the rate of MTSS, though shock-absorbing insoles have reduced MTSS rates in military personnel, and ESWT has shortened the duration of symptoms. Surgery is rarely indicated but has shown some promising results in patients who have not responded to all conservative options.

Schulze C, Finze S, Bader R, Lison A. Treatment of medial tibial stress syndrome according to the fascial distortion model: a prospective case control study. *ScientificWorldJournal.* 2014;2014:790626. doi: 10.1155/2014/790626. Epub 2014 Oct 14.

ABSTRACT: Medial tibial stress syndrome (MTSS) is a common problem among athletes and soldiers. There is no proven theory that could explain the pathophysiology of shin splints. The therapies described so far are time-consuming and involve a high risk of relapse. The method according to the

fascial distortion model (FDM) addresses local changes in the area of the lower leg fascia. It is suited to reduce pain and functional impairments associated with this symptom complex by applying targeted manual techniques. 32 patients (male: 30; female: 2) participated in this study. Visual analogue scale (VAS) was used for the quantification of pain. Scores were also given to rate the maximum painless exercise tolerance of the patients. Subsequently treatment of the crural fascia was performed. Patients retested ability of running and jumping. Therapy was continued until full exercise tolerance or painlessness was reached. A significant reduction of the VAS pain score from 5.2 to 1.1 could be achieved ($P < 0.001$). The impairment of exercise tolerance could be reduced from 7 to 2 points ($P < 0.001$). The duration of treatment was 6.3 (SD: 4.3) days on average. The FDM therapy is a potential effective method for acute treatment of MTSS.

Snyder KR, Earl JE, O'Conner KM, Ebersole KT. Resistance training is accompanied by increases in hip strength and changes in lower extremity biomechanics during running. *Clin Biomech (Bristol, Avon).* 2009;24(1):26-34.

BACKGROUND: Movement and muscle activity of the hip have been shown to affect movement of the lower extremity, and been related to injury. The purpose of this study was to determine if increased hip strength affects lower extremity mechanics during running.

METHODS: Within subject, repeated measures design. Fifteen healthy women volunteered. Hip abduction and external rotation strength were measured using a hand-held dynamometer. Three-dimensional biomechanical data of the lower extremity were collected during running using a high-speed motion capture system. Measurements were made before, at the mid-point, and after a 6-week strengthening program using closed-chain hip rotation exercises. Joint range of motion (rearfoot eversion, knee abduction, hip adduction, and internal rotation), eversion velocity, eversion angle at heel strike, and peak joint moments (rearfoot inversion, knee abduction, hip abduction, and external rotation) were analyzed using repeated measures analysis of variance ($P <or= 0.05$). The independent variable was time (pre-, week 3, and week 6). A separate analysis of variance was conducted with the dependent variables of peak hip abduction and external rotation strength.

FINDINGS: Hip abduction ($P=0.009$) and external rotation strength ($P<0.0005$) increased by 13% and 23%, respectively. Eversion range of motion decreased ($P=0.05$), hip adduction range of motion increased ($P=0.05$), and a trend of decreased hip internal rotation range of motion ($P=0.08$) were found. Rearfoot inversion moment ($P=0.02$) and knee abduction moment ($P=0.05$) decreased by 57% and 10%, respectively.

INTERPRETATION: The hip abductors and external rotators were strengthened, leading to an alteration of lower extremity joint loading which may reduce injury risk. These exercises could be used in the rehabilitation, or prevention, of lower extremity injuries.

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.

PURPOSE: To review the published and unpublished evidence regarding risk factors associated with shin splints, assess the effectiveness of prevention strategies, and offer evidence-based recommendations to coaches, athletes, and researchers.
METHODS: We searched electronic data bases without language restriction, identified citations from reference sections of research papers retrieved, contacted experts in the field, and searched the Cochrane Collaboration. Of the 199 citations identified, we emphasized results of the four reports that compared methods to prevent shin splints. We assessed the methodologic quality of these reports by using a standardized instrument.
RESULTS: The use of shock-absorbent insoles, foam heel pads, heel cord stretching, alternative footwear, as well as graduated running programs among military recruits have undergone assessment in controlled trials. There is no strong support for any of these interventions, and each of the four controlled trials is limited methodologically. Median quality scores in these four studies ranged from 29 to 47, and serious flaws in study design, control of bias, and statistical methods were identified.
CONCLUSION: Our review yielded little objective evidence to support widespread use of any existing interventions to prevent shin splints. The most encouraging evidence for effective prevention of shin splints involves the use of shock-absorbing insoles. However, serious flaws in study design and implementation constrain the work in this field thus far. A rigorously implemented research program is critically needed to address this common sports medicine problem.

Winkelmann ZK, Anderson D, Games KE, Eberman LE. 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.

REFERENCE/CITATION: 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.
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.1 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, quadriceps angle, hip internal-rotation ROM, hip external-rotation ROM, ankle-eversion ROM, and ankle-inversion 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; 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). Dorsiflexion ROM (MD = -0.01°, 95% CI = -0.96, 0.93; P = .98), quadriceps angle (MD = -0.22°, 95% CI = -0.95°, 0.50°; P = .54), hip internal-rotation ROM (MD = 0.18°, 95% CI = -5.37°, 5.73°; P = .95), ankle-eversion ROM (MD = 1.17°, 95% CI = -0.02, 2.36; P = .06), and ankle-inversion ROM (MD = 0.98°, 95% CI = -3.11°, 5.07°; P = .64) 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.

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.

PURPOSE: To identify the incidence of medial tibial stress syndrome (MTSS) in a group of naval recruits undergoing a 10-week basic training period and to determine potential risk factors.

METHOD: One hundred and twenty-four recruits (84 men and 40 women) were followed prospectively during basic training. Anthropometric and lower limb biomechanical data were recorded at the start of the program along with injury history and previous sporting activity for the 3 months prior to enlisting. Recruits were monitored during training for development of medial tibial stress syndrome and were asked to complete an exit interview at the end of the program.

RESULTS: Forty recruits (22 men and 18 women) developed medial tibial stress syndrome, giving an incidence of 35%. A significant relationship existed between gender and medial tibial stress syndrome (P =.012), with female recruits more likely to develop medial tibial stress syndrome than male recruits (53% vs 28%). A risk estimate revealed a relative risk of 2.03. The biomechanical results indicated a more pronated foot type (P =.002) in the medial tibial stress syndrome group when compared to the control group. A risk estimate established that recruits with a more pronated foot type had a relative risk of 1.70.

CONCLUSION: Identifying a pronated foot type prior to training may help reduce the incidence of medial tibial stress syndrome by early intervention to control abnormal pronation. Findings of a higher incidence of medial tibial stress syndrome among female recruits require further investigation.