A Review of the Treatment and Prevention Options for Medial Tibial Stress Syndrome

Samantha Yamasaki

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____
David Titcomb, DPT
Thesis Chair

____
David Dinsmore, Ph.D.
Committee Member

____
Justin Kilian, M.Ed.
Committee Member

____
Mark Ray Schmidt, Ph.D.
Assistant Honors Director

____
Date

Abstract

Medial Tibial Stress Syndrome (MTSS) is a chronic lower-limb injury that effects a large population of athletes and exercisers. There is no definitive knowledge on what causes this injury, making prevention and treatment difficult. The purpose of this thesis is to identify the prevention and treatment methods for MTSS that seem the most promising. The risk factors of MTSS and possible preventative methods are first presented. Following this is an overview of both traditional and cutting-edge treatment options. One of the major conclusions reached in this thesis is that prevention of MTSS is often easier than treating it after onset. This thesis therefore highlights the need for a shift in emphasis from treatment to prevention of MTSS and presents practical ways to do so. This thesis also points to the need for continuing research, especially into less conventional treatment methods.

A Review of the Treatment and Prevention Options for Medial Tibial Stress Syndrome

Overview of Medial Tibial Stress Syndrome

A common exercise-related injury seen in the world of athletics is known as Medial Tibial Stress Syndrome (MTSS) (or "shin splints," the layman's term for this condition). MTSS is an overuse injury that occurs through exercise or physical activity and is characterized by its symptoms of palpable pain and tenderness (Becker, Richardson & Brown, 2016). This pain is commonly widespread and is located along the posteromedial tibial border or in layman's terms, the inside of the lower leg above the ankle. Though it can occur in any place along this border, it typically affects the distal two-thirds of the bone. The pain is often described as a dull ache following exercise which can last several hours or days. The symptoms are typically only present when exercising but may progress to remaining in activities of daily life in severe cases of MTSS (Yates & White, 2004). Furthermore, many health professionals believe that if left untreated MTSS may progress to the development of a tibial stress fracture (Beck, 2016). MTSS is most commonly seen in runners but also found in other high activity sports such as soccer, football, basketball and dancing (Galbraith & Lavallee, 2009).

The etiology or cause of this condition is still unclear as many health professionals and studies have produced conflicting results on what provokes this condition. One prevailing hypothesis states that the injury may be the result of a traction induced inflammation of the periosteum caused by muscle forces or forces sent through the deep crural fascia (Becker, Nakajima, & Wu, 2018). The American College of Sports Medicine (ACSM) explains this as a repetitive incidence of the muscle or fascia pulling on the periosteum, or the connective tissue that covers the long bones in the body (Beck, 2016). A second hypothesis states that MTSS could be a sign of bone remodeling failure, similar to what is seen in stress reactions or stress fractures (Becker, Nakajima, & Wu, 2018). Physiologically, bone remodeling occurs by long term bending of a long bone that stimulates it to widen its cross section by signaling the bone cells in the periosteum to lay down more bone. When increases in training continually occur during this adaptive process, the bone cells are unable to keep up and micro-damage occurs, inflaming the area and causing pain (Beck, 2016).

The Relevance of This Topic

In the last decade, the health and fitness industry of America has experienced remarkable growth. The IHRSA (International Health, Racquet and Sportsclub Association) reports a 33.6% increase in gym membership from 2008 to 2017 (Rodriguez, 2018). In addition, in 2017 the IHRSA stated that health clubs had served a milestone 70 million Americans in that year, a number that had been a goal since 1987 when the IHRSA first began recording these statistics. The total number of health club visits had also increased, from 4.3 billion in 2008 to 5.9 billion in 2017. (Rodriguez, 2018). One must remember that these numbers do not even include those who exercise at home or outdoors. Forbes published an article in the last year explaining the growing health club industry, citing factors such as wearable fitness devices and the realization that exercise can help lower healthcare costs as driving forces behind this growth (Midgley, 2018) Indeed, decreased healthcare costs are a huge motivation for many individuals, families and even corporations in increasing physical activity levels. In the past two decades, the prevalence of obesity has risen in the United States, bringing with it a concomitant increase of diseases such as type II diabetes, heart disease and stroke (Reinking, Austin, Richter & Krieger, 2016). Prestigious organizations such as the American College of Sports Medicine have recognized the benefits of treating these diseases with exercise, launching initiatives such as the "Exercise is Medicine" movement. One of the primary goals of this initiative is to encourage doctors to include physical activity in their prescriptions for patients dealing with various diseases and ailments (Exercise is Medicine, 2019). Wherever one looks, from the news to social media to advertising, fitness and exercise is everywhere.

While the increasing interest in exercise has exciting ramifications for the future of America, there are still negative potentials that accompany this growing trend. One of the biggest negatives that accompanies this increase in physical activity is the potential for injury. Statistics support this problem noting that there are approximately 29 million Americans that run 50 or more days a year, with anywhere between 19% and 79% experiencing an overuse injury in this time (Becker, Nakajima, & Wu, 2018). One of the most common chronic sports conditions involving the lower limb is "exercise-induced pain." There are several injuries that can cause this condition with the most common being MTSS (Yates, Allen, & Barnes, 2003). Research has found MTSS to account for up to 30% of all running related injuries (Becker, Nakajima, & Wu, 2018). Combatting common chronic injuries such as MTSS is extremely important as it can inhibit an individual from participating in the exercise that is so important for maintaining their physical health.

Thesis Purpose

The disagreement and confusion in the medical community behind what causes MTSS makes treatment and prevention difficult (Craig, 2008). With the diversity of theories, research, and potential strategies regarding this condition in the health and wellness community today, there is no consensus on which methods have the greatest likelihood of helping those who suffer from MTSS. The purpose of this thesis is to explore and review the different preventative measures and treatments for MTSS. Using current research for support, this paper will examine which options are the most effective and how exercisers can better prevent MTSS.

Prevention of MTSS

Identifying Potential Risk Factors

Without doubt, the best way to prevent something from occurring is to determine the factors that may cause it and stop them at the source. It follows that being able to identify risk factors in developing MTSS is an important step in being able to prevent it. In addition, with the lack of understanding of etiological factors, identifying preventative measures is especially important (Hamstra-Wright, Huxel Bliven & Bay, 2015). There are two types of risk factors that must be considered when attempting to prevent a condition: intrinsic and extrinsic. Intrinsic risk factors are concerned with variables such as anatomical structure or a trait that is inherent to the individual, such as gender. Extrinsic risk factors are more concerned with environmental variables that are external to the individual themselves.

In a recent systematic review involving 21 different studies, over 100 potential intrinsic risk factors of MTSS were identified. Of those risk factors, nine were identified as having a moderate to strong occurrence in clinical practice. These nine included body mass index (BMI), ankle plantar-flexion range of motion (ROM), ankle dorsiflexion ROM, navicular drop, ankle eversion ROM, ankle inversion ROM, quadriceps angle, hip internal rotation ROM, and hip external rotation ROM. Out of these nine, the systematic review found BMI, navicular drop, ankle plantar-flexion ROM and hip external ROM to be the strongest risk factors (Winkelmann, Anderson, Games, & Eberman, 2016).

The body mass index (BMI) risk factor should be considered with caution as it is often an inaccurate indicator of body fat in populations such as military personnel and athletes. Rather, this risk factor may suggest that those with a higher mass relative to their stature are at a greater risk for MTSS. Despite the fact that a high BMI does not always equate to obesity, individuals who are overweight or obese may be at risk for developing MTSS because of this risk factor. Physiologically, the tibia bows and bends in response to physical activity, producing microtrauma which functions to strengthen and build the bone. However, MTSS can ensue if the load exceeds the tibia's microtrauma threshold (Hamstra-Wright et al., 2015). A situation where this may occur is in a military setting where the soldiers carry heavy loads throughout their training. In overweight or obese individuals, the increased stress throughout the kinetic chain that occurs as a result of exercising while carrying extra weight could make them susceptible to MTSS (Winkelmann et al., 2016). In addition, studies have found that males with MTSS often have a smaller tibial cortical bone shape and area and females with MTSS often have a smaller tibial cortical bone shape when compared with controls, but researchers were unsure of whether this was a cause or effect of the injury. Regardless, because the bone is an adaptable organism, slow and steady progressions in exercise would likely allow for the bone to properly adapt. Individuals with higher BMIs may just need a longer adaption period (Hamstra-Wright et al., 2015).

An increased navicular drop is another risk factor that was found to be strong by the Winkelmann et al. (2016) systematic review. Navicular drop is measured by first having the subject stand on both feet with the subtalar joint in a neutral position. Using a goniometer, the distance between the navicular tuberosity at its greatest prominence and the floor is measured in millimeters. The subject then assumes a one-legged stance and the same distance is measured. The navicular drop is calculated as the difference between the navicular height measured in the one and two-legged stances. The review reported that a navicular drop that is greater than 10 mm has been found to nearly double the likelihood of developing MTSS (Winkelmann et al., 2016). Navicular drop is commonly used as a measure of arch height and there is an inverse relationship between the two where the greater the navicular drop, the lower the arch height (Hamstra-Wright et al., 2015). In fact, several studies have found an association between low arches, or pes planus in developing MTSS (Bennet, Reinking, Pluemer, Pentel, Seaton, Killian, 2001). Navicular drop is also commonly used as a measure of pronation (Hamstra-Wright et al., 2015). Pronation is defined as an inward turning of the foot or when the heel bone is angled inward and the arch collapses (Striano, 2013). Authors have suggested that a navicular drop greater than 10-15 millimeters may imply an abnormal degree of pronation in an individual and many past studies have cited overpronation as a likely contributor to the development of MTSS (Bennett et al., 2001).

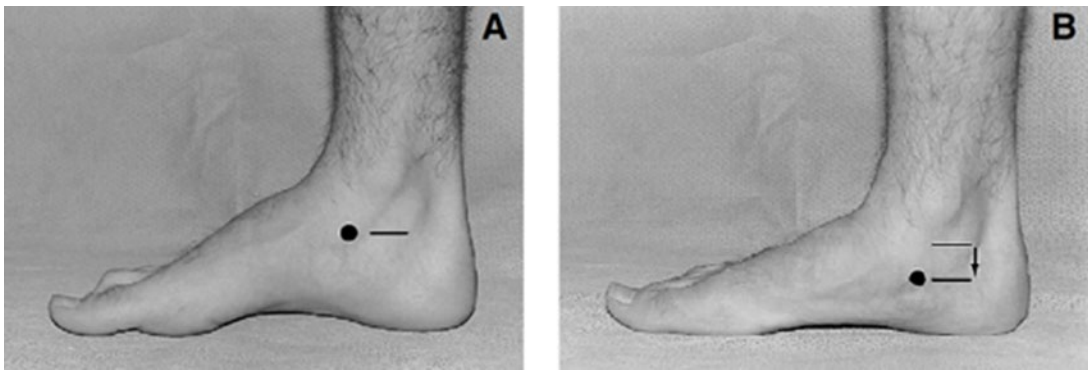

Figure 1- Navicular Drop (Menz, 1998)

Closely related to navicular drop is the risk factor of greater plantar flexion range of motion (ROM). Plantar flexion is defined as a “forward-downward movement of the foot in the sagittal plane, so that the dorsal surface of the foot moves away from the anterior surface of the leg” (Hamilton, Weimar, & Luttgens, 2012, p. 196). This potential risk factor still needs further investigation, but researchers believe that this increased ROM in the ankle may alter landing mechanics when running. It has been hypothesized that the increased plantarflexion results in a greater likelihood of the individual landing on their forefoot rather than their rearfoot while running, possibly increasing the strain on the posteromedial tibia. It is further speculated that greater plantar flexion ROM could be related to an increased navicular drop. Pronation occurs in the first half of the stance phase of running. If an individual has a greater navicular drop (lower arch) and consequently greater pronation, they may push through their medial midfoot bones more heavily as their arch approaches the ground. This occurs when they are pronating the most to absorb the force of impact. In theory, a greater push-off could lead to a greater plantarflexion ROM and potentially, higher extensibility of muscles responsible for dorsiflexion such as the anterior tibialis. Hypothetically, a higher extensibility of the anterior tibialis that is associated with greater plantarflexion ROM, could have an influence on navicular drop because of its pull on the bones adjacent to the navicular. Researchers suggested that performing eccentric exercises for the tibialis anterior may be helpful in improving end-range plantarflexion and therefore correcting this problem (Hamstra-Wright et al., 2015).

The last strong intrinsic risk factor that was identified in the Winkelmann et al. (2016) review was greater hip external rotation range of motion (ROM). However, not much is known at this time about the proposed relationship between MTSS and this risk factor. When data was pooled from three different studies measuring hip external rotation ROM in MTSS patients and a control group, the MTSS group values were higher than the control group. However, none of the individual studies actually found *statistically* significant differences between the groups. Because of this, more research is needed to confirm this risk factor. Winkelmann et al. (2016) agreed that ROM deficits and laxity could increase torque on the lower leg by altering the angle of the femoral neck or increase the tibial loading during physical activity. These changes would make one more susceptible to injuries such as MTSS. The systematic review concluded that even though researchers do not fully understand the role of this risk factor in MTSS, it is still something that clinicians should continue to assess in developing prevention and treatment plans for patients. This can be done by passively measuring the patients hip external rotation to identify the risk factor. Once the risk factor is identified, programs can be created that focus on balancing the strength and flexibility of the external and internal rotators of the hips, manual hip alignment, and pelvic tilts to improve stability (Winkelmann et al., 2016).

In addition to the four key intrinsic risk factors highlighted by the Winkelmann et al. (2016) systematic review, other studies have proposed theories of contributing intrinsic risk factors. A study conducted by Yüksel, Özgürbüz, Ergün, İşlegen, Taşkıran, Denerel, & Ertat (2011) investigated the inversion and eversion strength balance of the ankle in patients with MTSS and compared them to a healthy control group. The study found that the eversion strength was greater in the group with MTSS, while inversion strength was similar between the two groups. The researchers concluded that this could cause MTSS because of the greater eversion strength moment when the foot is in contact with the ground. They believed that this biomechanical factor could over-pronate the foot and consequently, overload the soleus muscle. Also, stronger evertor muscles could lead to the foot maintaining a pronated position for a longer time, placing traction stress, or excessive pulling on the soleus fascia which can also contribute to the development of MTSS. The researchers concluded that this potential risk factor could be eliminated by creating a strengthening program that would resolve the imbalance in inversion/eversion strength (2011). This is yet another example of a study that highlights overpronation as a possible factor in developing MTSS.

Some researchers have cited tightness or weakness in the triceps surae as a potential risk factor for MTSS. The triceps surae is composed of the gastrocnemius, soleus, and plantaris muscles. Athletes who are weak in this area are thought to be more prone to muscle fatigue which can lead to altered running mechanics and tibial strain (Galbraith & Lavallee, 2009).

Another study researching risk factors for MTSS in naval recruits highlighted gender as a possible risk factor. This particular study's results showed that female recruits had double the risk of developing MTSS when compared with male recruits. The researchers concluded that this was likely because in a military training setting, women are forced to march at a pace that is unnatural to the average woman's gait length when they are marching with men. In addition, the physical activity level that is required is likely more strenuous for females than males. Both of these factors could increase the stress on the female recruits' lower limbs, heightening the risk of developing MTSS. The authors of this article suggested a solution of separate training sessions for male and female recruits to address this issue, though this is not necessarily an ideal solution in a military setting (Yates & White, 2004). It is worth noting that several researchers have found that women seem to have a 1.5 to 3.5 times increased risk for the progression of MTSS to a stress fracture. Also, women have a higher incidence of decreased bone density and osteoporosis so it is especially important for clinicians to monitor women whose MTSS is not quickly healing and be aware of amenorrhea or disordered eating as these together can be detrimental to bone health (Galbraith & Lavallee, 2009).

A study conducted by Griebert, Needle, McConnell, & Kaminski (2016) with the underlying purpose of observing the effect of Kinesio tape in individuals with MTSS identified a more recent potential intrinsic risk factor for MTSS. A plantar pressure mat was used to collect the data throughout the study and subjects walked across the mat during the testing. The mat was used because of its believed ability to quantify altered kinematics seen during gait. The results from this study reported a higher rate of loading in the medial midfoot in the MTSS patients when compared with the healthy individuals. In addition, a slower rate of loading was noted in healthy patients compared with MTSS patients. However, because of their study design they were unable to conclude whether the findings represented a risk factor for MTSS or just an adaptation of the body in response to the injury. A limitation identified by the study was that normal gait rather than running was investigated, so the exact effects of the rate of loading while running or jumping were unknown. More research is needed to determine if this risk factor is legitimate (2016).

A final potential intrinsic risk factor that has been identified in several research studies is the duration of rearfoot eversion during the stance phase of the gait cycle. The mechanical theory behind this hypothesis is that during the push off period of stance, the foot functions as a rigid lever. However, if the foot remains in an everted position during the push-off, the bones of the lower leg are in a more flexible position. This requires the intrinsic and extrinsic foot musculature to produce higher forces to stabilize the foot and produce an adequate push-off. These higher forces with each step may contribute to the development of MTSS. However, more research investigating this potential cause is still needed (Becker et al., 2018).

In addition to the potential intrinsic risk factors, there are several extrinsic risk factors that have been identified. One extrinsic risk factor is improper footwear, such as jogging in a shoe that was not designed for running. Another area where footwear could cause shin splints is running in worn out shoes as the shock-absorbing properties of the shoe are compromised after extensive miles have been run in them (Mahoney, 2017). A poor training surface is also an extrinsic risk factor, since certain materials such as concrete impact the body with more force than a surface like grass. Other extrinsic risk factors include low levels of conditioning or deconditioning before beginning a program and a rapid increase in volume or intensity of training (Gardner, 2003). The ACSM recommends training increases of no greater than ten percent a week (Beck, 2016). It is likely that deviating from these could cause an individual to develop a chronic injury such as MTSS.

Research-Supported Practical Prevention Options

Prevention of MTSS seems to be possible if the correct risk factors are identified in the individual before the injury occurs. One systematic review reported that the best way to prevent MTSS is preparticipation screenings that identify risk factors before training starts, rather than after an individual becomes symptomatic (Winkelmann et al., 2016). Many physical therapy centers and sports performance centers offer one-on-one running biomechanical evaluations. These evaluation sessions can identify deficiencies and issues that may cause injuries in the future for the individual (Mercy Therapy Services, 2017; Rose Physical Therapy Group, 2018). Given the prevalence of MTSS in active individuals, clinics and sports performance centers could greatly benefit their clients by creating evaluations that specifically screen for MTSS, or by incorporating a thorough screening for it in their current biomechanical evaluations. Programs like these could be very beneficial since with a difficult to treat injury such as MTSS, erring on the side of caution from the beginning may be the best strategy for prevention. In addition, as more is learned about the potential intrinsic and extrinsic risk factors of MTSS, the more valuable and beneficial these screenings would likely be.

Researchers have identified some key preventative measures that have produced positive results in studies when implemented. Once potential risk factors or weaknesses have been identified in an individual, one or more of these preventative strategies can be applied. One of the most basic preventative measures that can be taken is starting light and slowing increasing the intensity and/or duration of exercise routines. Allowing one's muscles and joints to slowly acclimatize to the added work by gradually progressing workout regimens should help reduce the harmful stress on the lower legs (Mahoney, 2017). The American College of Sports Medicine (ACSM) recommends training increases of less than ten percent a week as a safe way to progress exercise while minimizing the chance of an overuse injury (Beck, 2016). So, rather than run a vigorous several mile workout on the first day of training, a better approach could be jogging for fifteen minutes several times a week and adding an extra minute and a half a week. It is noteworthy that while many studies have recommended gradual increases in training to combat overuse injuries, there remains minimal available information on what this practically looks like for an individual exerciser. There is also the possibility that what is safe progression for one person, could result in injury for a different person. Considering this and the research still needed in this area, the ACSM recommendations for progression of exercise are likely the best current option. This heightens the importance of making coaches, health professionals, and individuals who engage in physical activity aware of these recommendations. Progressing at a safe rate combats not only the extrinsic risk factors of increasing training intensity too quickly and being deconditioned at the start of exercise, but also the intrinsic risk factor of a high BMI.

Another preventative measure that can be taken is obtaining a pair of custom-made foot orthoses. Foot orthoses are defined as "shoe inserts that closely contour to the foot's plantar surface and function to "'assist, resist, facilitate, stabilize or improve range of motion and functional capacity'" (Bonanno, Landorf, Munteanu, Murley & Menz, 2017, p. 2). Custom foot orthoses are specifically derived from a three-dimensional model or scan of an individual's foot. The distinction must be made between "foot orthoses" and "shock-absorbing insoles" as the latter are shoe inserts that are minimally contoured to the foot and manufactured from "soft" materials such as neoprene, polyurethane and viscoelastic polymers. Their primary function is to lessen shock. A systematic review that analyzed eighteen research studies reported that evidence exists that foot orthoses reduce the risk of developing shin pain by 73%. The same review reported that shock-absorbing insoles were found to be ineffective in preventing overall injury, soft-tissue injuries or stress fractures (Bonanno et al., 2017). The reason why these foot orthoses have been found to be an effective solution could be because they address and correct some of the potential intrinsic risk factors involving anatomical abnormalities in the foot such as an increased navicular drop, overpronation and lower arch height. If an athlete undergoes a preparticipation screening and is found to have any of these intrinsic risk factors, obtaining a pair of custom foot orthoses could be helpful in preventing MTSS.

If an individual is found to have increased plantar flexor ROM, incorporating eccentric strengthening exercises for the tibialis anterior could address this issue (Hamstra-Wright et al., 2015). Eccentric strengthening is essentially a type of exercise where the muscle elongates under tension as opposed to contracting which is seen in concentric strengthening (Bubbico & Kravitz, n.d.). Eccentric strengthening of the tibialis anterior may be effective since it is the muscle responsible for dorsiflexion of the ankle and by eccentrically strengthening it, one might have better control of end-range plantarflexion (Hamstra-Wright et al., 2015). One example of this type of exercise is toe raises where one's heels are elevated on a board with their toes on the ground. The toes are lifted off the ground as the heels remain on the board and then slowly lowered for the required number of repetitions. The slow lowering accounts for the eccentric strengthening of the tibialis anterior (Gardner, 2003).

If an imbalance in inversion and eversion ankle strength is found in an individual, strengthening exercises to resolve this imbalance may prevent an MTSS diagnosis later (Yüksel et al., 2011). Examples of exercises that help with ankle eversion and inversion strength are simply moving the ankle through the inversion or eversion movement while creating resistance with an elastic band. Exercises such as heel raises can be done to strengthen the triceps surae if weakness is identified here (Gardner, 2003). Each of the aforementioned preventative strengthening exercises is promising, yet more research investigating their effectiveness in specifically preventing MTSS is still needed. This is manifested by the preliminary studies that have produced mixed results (Brushøj, Larsen, Albrecht-Beste, Nielsen, Løye, & Hölmich, 2008). In addition, if factors such as a greater external hip ROM are present, prevention programs that look to balance hip rotator flexibility and strength could be effective in preventing MTSS (Winkelmann et al., 2016). However, more research needs to be completed in this area as it is not currently a widely recognized risk factor.

A preventative measure that does not specifically address any identified risk factors, yet has still been recommended by many health professionals, is the stretching of the muscles around the shin, such as the anterior tibialis. The ACSM also recommends specifically acquiring good dorsiflexion flexibility prior to the start of the season or exercise (Beck, 2016). This practice would address the risk factor of tightness in the triceps surae. One of the major causes of poor dorsi-flexion range of motion is this lack of flexibility in the gastrocnemius and soleus. Furthermore, research has found poor ankle dorsiflexion (caused by the tightness in the triceps surae) to predispose an individual to conditions such as MTSS (Stanek, Sullivan & Davis, 2018).

Because extrinsic risk factors involve issues that are external to the individual, they are more easily fixed than intrinsic risk factors when identified. The extrinsic risk factor of a poor type of footwear can be solved by purchasing running shoes from a reputable running company. Many people are also unaware of how often shoes need to be replaced to prevent injury. Individuals can ensure that footwear is still usable by tracking how many miles they have run in a pair of shoes and switching them out for a new pair when they have logged 300-400 miles on them. The extrinsic risk factor of poor training surfaces can simply be fixed by ensuring that the individual is making the proper choice when it comes to the surface on which they are training. One important consideration is to ensure that there is not an abrupt transition between training surfaces. For instance, if a runner has been training on a grass field for several weeks, suddenly switching to pavement could result in developing MTSS. Health professionals also recommend rotating running routes since many roads are arched on one side for drainage purposes. Consistently running the same route everyday could lead to the body slanting downward on one side which may throw off proper running mechanics (Mahoney, 2017). In addition, many health professionals suggest that running on softer surfaces such as a rubber track versus concrete could help reduce stress on the lower limbs, potentially preventing MTSS.

Treatment of MTSS

Correctly Diagnosing MTSS

As simplistic as it may sound, the first step in correctly treating MTSS is ensuring that the diagnosis of MTSS in the patient is correct. No matter how effective treatment options are, they will be unhelpful if used to treat the wrong condition. There has always been a cloud of uncertainty around clinically diagnosing MTSS. Adding to this, there are other lower limb injuries such as chronic exertional compartment syndrome and lower extremity stress fractures that can also cause exertional leg pain (Becker, Richardson & Brown, 2016).

Contrary to many other sports injuries, imaging techniques (x-ray, MRI, CT scan) are not always accurate tools in the diagnosis of MTSS. In fact, a recent study published by a team of Dutch researchers concluded that MTSS can be reliably diagnosed using patient history and physical examination (Winters, Bakker, Moen, Barten, Teeuwen &

Weir, 2018). This study examined athletes sixteen years and older who presented with at least one week of gradual onset lower leg pain. Two experienced clinicians were randomly selected from a pool of clinicians to analyze each subject on the same day. Each clinician used the same series of steps to analyze the athlete's condition. Three steps were related to the history and asked the patient (1) about the location of the pain, (2) whether the pain is provoked by physical activity and reduced with rest, and (3) a question regarding the presence of the symptoms of compartment syndrome, which might rule out MTSS. If the patient reported that the pain was exercise-induced and along the distal two-thirds of the medial tibial border, that it was provoked by physical activity, and that the symptoms of compartment syndrome were not present, the clinician moved on to the last couple steps related to a physical examination. The physical examination consisted of a palpation of the posteromedial tibial border. If an area was painful and spread greater than five centimeters, the clinician would lastly investigate to see if there were any symptoms that were not typical of MTSS such as visible swelling along the medial border of the tibia. If no unusual symptoms were found, a diagnosis of MTSS was made. The study assessed the inter-rater reliability of diagnosing MTSS in this way. There was a high percentage of agreement between the clinicians with only two out of forty-six subjects diagnosed differently by the clinicians that assessed them. These results showed that MTSS can be diagnosed clinically with near perfect reliability using this method (Winters, Bakker, Moen, Barten, Teeuwen & Weir, 2018.) The implications of this study are a clearer understanding of diagnosing MTSS, and less time and resources wasted on imaging techniques that could be less helpful than a simple clinical diagnosis.

Conservative Treatment Options

Once a diagnosis of MTSS is made, the next step is to look for a treatment plan. Many clinicians identify two stages of treatment in dealing with MTSS: the acute stage and the sub-acute stage (Galbraith & Lavallee, 2009). The acute stage is associated with clinical findings of pain, redness, heat, swelling and loss of function. Typically, the patient experiences pain at rest or when active in the acute stage, or when stress is applied to a specific area. Some of the goals of the acute treatment phase are to control the inflammation, minimize pain and swelling, limit pain causing positions or activities, maintain aerobic fitness, and maintain the integrity of the soft tissue (Dutton, 2017). For years, many health professionals have favored a simple and traditional treatment approach in dealing with MTSS in the acute phase. The most common acute phase treatment option is simply to rest and use ice on the affected area (Carr, Sevetson, & Aukerman, 2008). The American College of Sports Medicine (ACSM) recommends a minimum of 7-10 days of rest from pain-inducing activities. In the meantime, athletes can maintain their aerobic fitness levels by participating in cross-training activities such as pool-running or cycling. (Beck, 2016). However, some athletes may need as long as a two to six week long rest which can be determined on a case by case basis.

In terms of cryotherapy, or the use of ice, many health professionals recommend applying ice after exercise to the affected area for about 15-20 minutes (Galbraith & Lavallee, 2009). Another common acute phase treatment option is Non-Steroidal Anti-Inflammatory Drugs (or NSAIDs). These drugs help reduce inflammation in the body by reducing prostaglandins. Some common NSAIDs that have been approved in the United

States include ibuprofen, aspirin, and naproxen (Ogbru & Marks, n.d.). Since MTSS is hypothesized to involve inflammation these drugs may help during the acute phase. Additional physical therapy modalities such as ultrasound, electrical stimulation, and unweighted ambulation may be used during the acute phase, however they have not been shown to be any more effective than traditional treatment options (Galbraith & Lavallee, 2009).

The sub-acute stage is characterized by a return to pain-free active and passive range of motion and an overall reduction in pain. However, despite the pain being lessened, the individual is still not completely healed in this stage as stress to the injured area will still cause pain (Dutton, 2017). The sub-acute stage of treatment overlaps with and addresses many of the risk factors dealing with prevention of MTSS. Once the individual has passed the acute stage of treatment, the sub-acute stage focuses on return to activity by modifying training regimens and addressing any biomechanical issues that the individual may have. Cross-training can greatly benefit athletes in the sub-acute stage because of its low-impact nature. Excellent cross-training options include elliptical machines, pool-running, swimming or riding a stationary bike. Athletes should be encouraged not to run on hills, or on uneven or extremely hard surfaces during the sub-acute treatment phase. In addition, running that is performed should be reduced in intensity and duration by 50% (Galbraith & Lavallee, 2009). However, future research is needed investigating whether excessive increases in intensity or duration play a greater role in the development of overuse injuries.

Over several weeks, athletes may slowly begin to increase their training duration and intensity while incorporating sport specific movements provided that they remain pain-free. If any exercises cause pain or provoke their symptoms, athletes should scale back on them. In addition, if an individual never had a preparticipation screening to identify potential risk factors for MTSS, a clinician can analyze the individual for these problem areas. Once the deficiencies are identified they can be properly addressed in rehabilitation, whether that be gait retraining or an emphasis on proper technique (Galbraith & Lavallee, 2009). As with preventative procedures, if a greater navicular drop, lower arch or overpronation is discovered, obtaining custom made foot orthoses may be an effective solution.

Less Conventional Forms of Treatment

In addition to the more traditional treatment options for MTSS, there are several more unconventional treatment options. Some of these have been researched with mixed results while others are newer and have limited research behind them. One method that is still a relatively new treatment idea is the use of Kinesio tape. Kinesio taping (KT) has emerged in the last several years as a popular treatment for many different musculoskeletal conditions. Kinesio tape is different from the traditional non-elastic athletic tape because of its wave-like grain that imitates the thickness of human skin. The claim is made that when Kinesio tape is applied with the right tension, it lifts the fascia and soft tissue, producing extra space below the area of application. This is said to improve circulation as well as realign the fascial tissue, normalizing muscle function, while also providing increased proprioceptive input (Sinha & Sharma, 2017). As previously mentioned, a study conducted in 2016 examined the effect of Kinesio tape on the rate of loading in individuals. The higher rate of loading in the medial midfoot that was identified in the group with MTSS appeared to be corrected with the application of Kinesio tape. However, this was the first study that specifically investigated the use of Kinesio tape in treating MTSS (Griebert et al., 2016). In 2017, a different group of researchers conducted a study with the research question being whether the addition of Kinesio tape to conventional therapy modalities for athletes with acute shin splints reduced discomfort and pain. A secondary research question was whether this same effect can be obtained with the application of traditional rigid athletic tape (Sinha & Sharma, 2017). Thirty college level athletes were recruited for this three-day study. The athletes were divided into a Kinesio tape group, a rigid tape group and a control group (who received cryotherapy and electrical stimulation). The tests that the researchers used to evaluate the effectiveness of the modalities included a fifty-meter sprint, a measurement of the volume of the leg (to identify swelling or edema), and a pain response that was measured using the Numeric Pain Rating Scale (NPRS). Each participant completed a baseline measurement of each of these tests upon arrival and then completed another trial of the tests twenty-four hours later after receiving their group's respective treatment modality. The results of this study reported that there were no benefits of Kinesio tape over rigid tape or the control group modalities for the patients with MTSS. However, a limitation of the study was the small sample size that was used. More research is needed before this option is either affirmed or discredited but this particular group of researchers did not believe that it would prove to be a viable treatment option (Sinha & Sharma, 2017).

Another newer treatment method that is still being researched is “extra corporeal shockwave therapy” (ESWT). This therapeutic method is currently being tested because of its potential to reduce recovery and pain from MTSS. (Garcia, Rona, Tinoco, Rodriguez, Ruiz, Letrado, . .Garcia, 2017). “Extra corporeal shockwave therapy” utilizes electrohydraulic shockwave generation and has been shown to induce tissue repair and regeneration (Wang, 2012). A study done in 2012 claimed to be the first study that investigated ESWT used in the treatment of MTSS. Patients from two different sports medicine clinics were used in the study. In one clinic, patients were advised to simply participate in a graded running program. In the second clinic, the graded running program was combined with the ESWT. This research study found that the group that underwent the ESWT had a significantly quicker recovery than the group that solely participated in the graded running program. However, they identified several limitations in their study such as their smaller sample size and the possibility of a placebo effect. Regardless, this study effectively laid the groundwork for future studies investigating this treatment method (Moen, Rayer, Schipper, Schmikli, Weir, Tol, & Backx, 2012). A study was done in 2017 where 42 military cadets were recruited and split into an intervention group and a control group. The intervention group participated in an exercise program and the ESWT while the control group participated in simply the exercise program. This study found that pain free running time was significantly increased in the ESWT group. The researchers concluded that ESWT seems safe, effective and efficient. However, they noted that the long-term effects of this treatment are still unknown (Garcia et al., 2017).

Prolotherapy is a treatment method that has been used for many other musculoskeletal disorders and involves a non-surgical injection into painful areas that promotes growth of normal cells and tissues. This method has been used with some success in a variety of different musculoskeletal disorders, however there is limited research on its effectiveness for MTSS. Despite this, it still stands as a strong potential treatment in need of more investigation going forward (Hauser, Lackner, Steilen-Matias, & Harris, 2016).

Another less conventional treatment option is the Graston technique or instrument assisted soft tissue mobilization (IASTM). IASTM is a technique which uses special tools with sloping edges to assist the clinician in evaluating and mobilizing soft tissue. The technique is done by stroking the instruments across the skin in a multidirectional manner at 30-60 degree angles (Gulick, 2018). The use of Graston tools is a common IASTM technique that utilizes stainless steel instruments to localize and release the soft tissue constrictions (Stanek, Sullivan, & Davis, 2018). IASTM or Graston has been reported to provide many positive therapeutic and healing benefits in pathologies such as plantar fasciitis, carpel tunnel syndrome, and lateral epicondylitis (Gulick, 2018). A study done comparing compressive myofascial release and IASTM in improving ankle dorsiflexion range of motion exemplified the use of IASTM on the triceps surae to help improve ankle dorsiflexion. This was theorized to have the potential of helping many lower leg conditions such as plantar fasciitis, achilles tendinopathy and MTSS. The study did not find a great improvement in ankle dorsiflexion following the IASTM treatment, yet the study only tested the ankle dorsiflexion immediately after a single IASTM treatment. The researchers stated that contrary to their results, many clinicians have experienced success with IASTM and their results could have been due to the fact that they did not examine the long term effects of IASTM (Stanek, Sullivan, & Davis, 2018). This treatment could be beneficial for an individual who is beginning to show symptoms of MTSS resulting from tightness in the triceps surae or for an individual returning to running after a bout with MTSS to reduce the likelihood of sustaining the injury again. Though there has not yet been extensive scientific research done on IASTM in relation to MTSS, its success in helping similar conditions involving soft tissue injuries shows its potential for rising to the status of a conventional treatment option.

Surgical Intervention

If all other treatments of MTSS fail, some health professionals recommend resorting to a surgical treatment option. However, this method should be approached with caution as there is not much available scientific research on this treatment method. Statistics reporting success of this method have ranged from anywhere between 29% to 86% (Yates et al., 2003). Another limitation in determining the effectiveness of this method is the small sample of case study data, as there is a small percentage of individuals who undergo such procedures. Also, many authors have not specifically stated whether or not athletes were able to fully return to their sports activity following surgery.

A research study published by Yates, Allen, and Barnes (2003) analyzed the outcomes of surgical intervention for MTSS. They determined the success of the surgeries by comparing the pre-operative exercise levels with the post-operative levels. The surgical procedure involved making a longitudinal linear incision along the distal two thirds of the inner tibial border. The deep posterior compartment fascia that inserts along the posteromedial tibial border was exposed. The surgeon then performed a deep posterior compartment fasciotomy by dividing the fascia at the fascia-bone interface. This is also known as the release of the soleus bridge. A strip of periosteum that is about two centimeters wide was then removed from the inner border of the tibia. Following these procedures, the wound was closed, dressing was applied and the individual was permitted to walk with the aid of crutches and go home. After two weeks, the patient could stop using crutches and after three months they were permitted to resume running. It was predicted to take between six to twelve months for a full return to activity. This study found a significant decrease in symptoms following the surgery. However, the authors advised that the results be interpreted cautiously as only 59% of the original subjects were responsive in reporting post-operative outcomes. Also, the study found that though the symptoms were found to have decreased, many athletes were not able to return to their full pre-operative level of activity. This study concluded that surgery could be a beneficial option for those who have been plagued by MTSS symptoms for over twelve months, however athletes must be appropriately counseled going into this method as a full recovery to athletics may not be possible. Furthermore, the authors strongly emphasized that the individuals who underwent this treatment had been presenting with MTSS symptoms and had tried several types of conservative treatment for a minimum of twelve months with no success. They greatly represent the minority in individuals with MTSS and the results of the Yates et al. study highlight the fact that this should not be a treatment option for anyone struggling with MTSS (Yates et al., 2003).

Conclusions

The vast array of potential treatment options for MTSS and the amount of ongoing research demonstrate just how little is still known about how to effectively heal those who have this condition. The one common thread in each of the research studies and health professional's advice is that resting is the one tried and true method of combatting this injury (Becker, Richardson, & Brown, 2016). Even though new treatments and technologies have shown promise, research on their effectiveness is inconclusive due to small sample sizes and limited data on long term effects. Many of the studies also do not account for the placebo effect, which must be accounted for in future studies. The newest treatment option that currently seems the most promising is the extra-corporeal shockwave therapy. Despite the cutting-edge technology that is currently being studied, most research studies and health professionals still recommend a conservative and traditional treatment of MTSS. Other options likely need to be weighed on a case by case basis. This can be done by seeing a Physical Therapist or Sports Medicine Doctor.

Though incredible progress has been made in the research of MTSS, far more research is still needed. This is clearly seen in the fact that even with the progress that has been made in scientific technology, MTSS still remains a gray area in the health community. There appears to be far more conclusive evidence and agreement on risk factors than there is regarding treatment. This is a major hurdle in addressing the problem of helping individuals who have already developed the condition.

Since MTSS is a condition that seems to be easier to prevent than it is to treat, the emphasis should be shifted towards increased awareness of the potential causes and identifying risk factors before activity begins. Coaches, personal trainers and other health professionals must ensure that they are training their athletes in a way that allows their bodies to gradually make adaptations to the stresses of training rather than having a “no pain, no gain” mentality that pushes the individual in an unhealthy way. In addition, recreational exercisers must be aware of how to safely progress their own fitness regimen. This can be accomplished by ensuring that there is proper awareness of exercise progression guidelines such as the American College of Sports Medicine recommendation of increases of 10% or less a week. In addition, exercise and health leaders must be aware of the importance of preparticipation screenings and encourage those that they influence to identify and correct risk factors before beginning activity. As long as there is still great uncertainty regarding etiology and treatment, the best thing that can be done is to attempt to prevent MTSS before it happens.

Once etiology on MTSS has been solidly confirmed in research, finding effective prevention and treatment options should be easier. However, because current research shows a vast array of viable causes, it could even be possible that the etiology for this condition varies from individual to individual. The importance of prevention is heightened since the research on treatment is inconclusive.

It is possible that MTSS is a condition where modern medical intervention is not as helpful as the simple treatment of rest. Until scientific and longitudinal research proves otherwise, rest remains the number one treatment option recommended by health professionals. Modern medicine is a blessing, yet it can also create feelings of impatience and frustration when it fails to heal one’s bodies in a rapid way. One of the best things that a trainer or health professional can do for an individual struggling with MTSS is to simply encourage and educate them on the importance of being patient and letting their bodies heal.

Finally, the lack of consensus on effective treatment methods should not discourage future studies in the area of MTSS. Though rest seems like the best current treatment method, there may be a revolutionary treatment discovery that is right around the corner. Future studies will likely produce more transferable and reliable results if larger sample sizes are used, placebo effects are accounted for, and long-term follow-up is maintained. Medial tibial stress syndrome is an injury that is worthy of large-scale research because of the number of people it effects and its potentially negative effects on healthcare and the general health of society.

References

Beck, B. R. (2016). Exercise-Induced Leg Pain. Retrieved February 5, 2019, from https://www.acsm.org/docs/default-source/files-for-resource-library/basics_exercise-induced-leg-pain.pdf?sfvrsn=8c62186b_2

Becker, J. A., Richardson, B. M., Brown, S. T., & Richardson, B. M. (2016). A stepwise approach to exertional leg pain. *Journal Of Family Practice*, 65(10), 672-679.

Becker, J., Nakajima, M., & Wu, W. (2018). Factors contributing to medial tibial stress syndrome in runners: a prospective study. *Medicine & Science in Sports Exercise*., *50*(10), 2092-2100. https://doi.org/10.1249/MSS.0000000000001674

Bennett, J. E., Reinking, M. F., Pluemer, B., Pentel, A., Seaton, M., & Killian, C. (2001). Factors Contributing to the Development of Medial Tibial Stress Syndrome in High School Runners. *Journal of Orthopaedic & Sports Physical Therapy,31*(9), 504-510. doi:10.2519/jospt.2001.31.9.504

Bonanno, D. R., Landorf, K. B., Munteanu, S. E., Murley, G. S., & Menz, H. B. (2017). Effectiveness of foot orthoses and shock-absorbing insoles for the prevention of injury: A systematic review and meta-analysis. *British Journal of Sports Medicine*, 51(2), 86.

Brushøj, C., Larsen, K., Albrecht-Beste, E., Nielsen, M. B., Løye, F., & Hölmich, P. (2008). Prevention of overuse injuries by a concurrent exercise program in subjects exposed to an increase in training load: A randomized controlled trial of 1020 army recruits. *The American Journal of Sports Medicine, 36*(4), 663-670. doi:10.1177/0363546508315469

Bubbico, A., & Kravitz, L. (n.d.). Eccentric Exercise: A Comprehensive Review of a Distinctive Training Method. Retrieved from https://www.unm.edu/~lkravitz/Article folder/eccentricUNM.html

Carr, K., Sevetson, E., & Aukerman, D. (2008). Clinical inquiries. How can you help athletes prevent and treat shin splints?. *The Journal Of Family Practice*, *57*(6), 406-408.

Craig, D. I. (2008). Medial tibial stress syndrome: evidence-based prevention. *Journal Of Athletic Training*, 43(3), 316-318. doi:10.4085/1062-6050-43.3.316.

Dutton, M. (2017). *Duttons Orthopaedic examination, evaluation, and intervention*. New York: McGraw-Hill Medical.

Exercise is Medicine. (2019). Retrieved from http://www.exerciseismedicine.org/

Galbraith, R. M., & Lavallee, M. E. (2009). Medial tibial stress syndrome: Conservative treatment options. *Current Reviews in Musculoskeletal Medicine, 2*(3), 127-133. doi:10.1007/s12178-009-9055-6

Garcia, S. G., Rona, S. R., Tinoco, M. C., Rodriguez, M. B., Ruiz, D. M., Letrado, F. P., . . . Garcia, J. M. (2017). Shockwave treatment for medial tibial stress syndrome in military cadets: A single-blind randomized controlled trial. *International Journal of Surgery, 46*, 102-109. doi:10.1016/j.ijsu.2017.08.584

Gardner, P. (2003). Shin Splints. *Athletic Therapy Today*, 8(2), 52-53.

Griebert, M., Needle, A., McConnell, J., & Kaminski, T. (2016). Lower-leg kinesio tape reduces rate of loading in participants with medial tibial stress syndrome. *Physical Therapy in Sport*, 18, 62-67. 10.1016/j.ptsp.2014.01.001

Gulick, D. T. (2018). Instrument-assisted soft tissue mobilization increases myofascial trigger point pain threshold. *Journal of Bodywork & Movement Therapies, 22*(2), 341-345. doi:10.1016/j.jbmt.2017.10.012

Hamilton, N., Weimar, W., & Luttgens, K. (2012). *Kinesiology: Scientific basis of human motion*. New York, NY: McGraw-Hill.

Hamstra-Wright, K. L., Huxel Bliven, K. C., & Bay, C. (2015). Risk factors for medial tibial stress syndrome in physically active individuals such as runners and military personnel: a systematic review and meta-analysis. *British Journal Of Sports Medicine*, 49(6), 362-369. doi:10.1136/bjsports-2014-093462.

Hauser, R. A., Lackner, J. B., Steilen-Matias, D., & Harris, D. K. (2016). A systematic review of dextrose prolotherapy for chronic musculoskeletal pain. *Clinical Medicine Insights: Arthritis and Musculoskeletal Disorders, 2016*(9), 139-159. doi:10.4137/CMAMD.S39160

Mahoney, K. (2017). Stop shin splints: Don't let this common high-impact injury throw you off your fitness game. *Muscle & Fitness/Hers*, 18(3), 66.

Mercy Therapy Services. (2018, March 27). Get on Track with Proper Running Mechanics. Retrieved from https://www.mercy.net/newsroom/2017-03-30/get-on-track-with-proper-running-mechanics/

Midgley, B. (2018, September 26). The Six Reasons The Fitness Industry Is Booming. Retrieved from https://www.forbes.com/sites/benmidgley/2018/09/26/the-six-reasons-the-fitness-industry-is-booming/#671a0a0b506d

Moen, M. H., Rayer, S., Schipper, M., Schmikli, S., Weir, A., Tol, J. L., & Backx, F. J. G. (2012). Shockwave treatment for medial tibial stress syndrome in athletes; a prospective controlled study. *British Journal of Sports Medicine, 46*(4), 253. doi:http://dx.doi.org/10.1136/bjsm.2010.081992

Menz, HB (1998). Alternative techniques for the clinical assessment of foot pronation. *J Am Podiat Med Assn* 1998;88:119-29. [Photograph]

Ogbru, O., & Marks, J. W. (n.d.). NSAIDs: Drug List, Names, and Side Effects. FRetrieved February 5, 2019, from https://www.medicinenet.com/nonsteroidal_antiinflammatory_drugs/article.htm#what_are_nsaids_and_how_do_they_work

Reinking, M. F., Austin, T. M., Richter, R. R., & Krieger, M. M. (2017;2016;). Medial tibial stress syndrome in active individuals: A systematic review and meta-analysis of risk factors. *Sports Health: A Multidisciplinary Approach*, 9(3), 252-261. 10.1177/1941738116673299

Rodriguez, M. (2018, December 11). IHRSA 2018 Global Report: Health Club Industry Revenue Totaled $87.2... Retrieved from https://www.ihrsa.org/about/media-center/press-releases/ihrsa-2018-global-report-club-industry-revenue-totaled-87-2-billion-in-2017/

Rodriguez, M. (2018, December 11). Latest Data Shows U.S. Health Club Industry Serves 70.2 Million. Retrieved from https://www.ihrsa.org/about/media-center/press-releases/latest-data-shows-u-s-health-club-industry-serves-70-2-million/

Rose Physical Therapy Group. (2016, June 07). Running Assessment. Retrieved from https://rosept.com/running-assessment

Sinha, A. K., & Sharma, U. (2017). Comparison of effectiveness of kinesio taping with nonelastic taping and no taping in players with acute shin splints. *Physiotherapy - The Journal of Indian Association of Physiotherapists, 11*(1), 21. doi:10.4103/pjiap.pjiap_4_17

Stanek, J., Sullivan, T., & Davis, S. (2018). Comparison of compressive myofascial release and the graston technique for improving ankle-dorsiflexion range of motion. *Journal of Athletic Training, 53*(2), 160-167. doi:10.4085/1062-6050-386-16

Striano, P. (2013). *Anatomy of running*. Buffalo, NY: Firefly Books.

Wang, C. (2012). Extracorporeal shockwave therapy in musculoskeletal disorders. *Journal of Orthopaedic Surgery and Research, 7*(1), 11. doi:10.1186/1749-799x-7-11

Winkelmann, Z., Anderson, D., Games, K., & Eberman, L. (2016). Risk factors for medial tibial stress syndrome in active individuals: An evidence-based review. *Journal of Athletic Training,* 51(12), 1049-1052. 10.4085/1062-6050-51.12.13

Winters, M., Bakker, E. W. P., Moen, M. H., Barten, C. C., Teeuwen, R., & Weir, A. (2018). Medial tibial stress syndrome can be diagnosed reliably using history and physical examination. *British Journal of Sports Medicine, 52*(19), 1267. doi:http://dx.doi.org/10.1136/bjsports-2016-097037

Yates, B., Allen, M. J., & Barnes, M. R. (2003). Outcome of surgical treatment of medial tibial stress syndrome. *Journal of Bone and Joint Surgery*, 85(10), 1974-80.

Yates, B., White, S. (2004). The incidence and risk factors in the development of medial tibial stress syndrome among naval recruits. *The American Journal of Sports Medicine,* 32(3), 772-780.

Yüksel, O., Özgürbüz, C., Ergün, M., İşlegen, Ç., Taşkıran, E., Denerel, N., & Ertat, A. (2011). Inversion/eversion strength dysbalance in patients with medial tibial stress syndrome. *Journal Of Sports Science & Medicine*, 10(4), 737-742.