A systematic review of the conservative treatment options and their effectiveness in the treatment of medial tibial stress syndrome (MTSS)

By

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I, Zanelé Crous, do declare that this dissertation is representative of my own work in both conception and execution (except where acknowledgements indicate to the contrary).

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DEDICATION

I dedicate my research to my parents. I owe all my success to you. Thank you for your continued love and support these past six years and always booking a plane ticket for me when Durban was so far from home. Hopefully we are done wiping away my tears.

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ABSTRACT

Background: Medial tibial stress syndrome (MTSS) is a frequent lower extremity injury and a common cause of exertional leg pain in athletes and is commonly treated with conservative treatment regimes. However, there is a lack ofconservative treatment options in clinical practice that is not adequately reflected in the literature. An analysis would be able to determine the level of evidence in support of different treatment options for MTSS.

Objectives: The aim of this dissertation was to review published literature regarding conservative treatment options for MTSS and provide recommendations to sports medicine clinicians for improved treatment and patient outcomes.

Data sources: A systematic review of PubMed, CINAHL, and Scopus was conducted, using the following search terms: shin splint, medial tibial stress syndrome, tibial stress injury, exercise induced leg pain, soleus syndrome, chronic periostalgia, conservative treatment, strapping, stretching, mobilisation, KT tape, electro-modalities, ultrasound, orthoses, chiropractic, shockwave treatment, physical therapy and rehabilitation.

Study selection: All electronic or paper English articles, which possessed the required key indexing terms and represented randomised controlled study, non-randomised controlled study and observational study designs were included.

Data extraction: Blinded review of the articles was conducted by eight independent reviewers utilising the PEDro (for randomised controlled trials), NOS for (non-randomised controlled trials) and Liddle (for observational studies). This allowed the methodological rigour of the article to be ranked. This ranking was compared to a critical appraisal of the article in order to achieve an overall decision with regards to the contribution of the article to the level of evidence for MTSS.

Data synthesis: 30 review outcomes were aggregated around different clinical categories. It was concluded that the use of TENS, needling, electro-dry needling and strengthening programmes with additional interventions are moderately supported for use in the treatment of MTSS TII in clinical practice. There was evidence in support of rehabilitation programmes and conflicting evidence/no support for graded training programmes. The non-standard treatment options provided limited to moderate evidence against the use of the published interventions (orthotic and stretching, ultrasound and periosteal pecking, rest/immobilization cast,rest/phenylbutazone, rest/stretching of heel cord, rest/aspirin) in these studies, indicating that these practices should be excluded from clinical practice protocols until further research has been completed. The evidence was limited forindividual therapies (cryotherapy,

iontophoresis, phonophoresis, ultrasound, extracorporeal shockwave therapy and the fascial distortion model), whereas there was no to limited evidence in support of the MYK system of intervention.

Conclusion: The systematic review of MTSS TII revealed that the use of TENS, needling, electro-dry needling and strengthening programmes with additional interventions were found to have a moderate level of evidence, which may indicate theirappropriateness in the management of patients suffering from MTSS TII. Combination therapies or the use of individual therapies require future research in order to better define their contribution to the treatment of MTSS TII. Randomised controlled trials are the gold standard for research, as they have the greatest level of methodological quality, and should be used where possible when investigating the efficiency of interventions in the management of MTSS TII.

Key words: chiropractic, conservative treatment, kinesio tape, medial tibial stress, orthoses, and rehabilitation, syndrome, systematic review, ultrasound.

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GLOSSARY OF TERMS

Allocation bias: This type of bias arises when there is no randomisation when assigning participants to their groups in clinical trials. This may result if the investigator foresees or recognises which treatment the participant would most likely have the best outcome with (Nunan *et al*. 2018).

Case study: A case study is a detailed and in-depth study of a particular case, which is different to studying a broad group of subjects. A case series is different as it follows more than one subject (Mathes and Pieper 2017).

Citation bias: The numberof times a research study is cited seems to be predisposed to the positive results associated with said study. Therefore, a study with higher outcomes is likely to be located and included in systematic reviews (Chan *et al.* 2004).

Conservative treatment:

Conservative management is an approach to treating pain utilisingnon-surgical treatment options, such as physical therapy, medication and injection (Spine Health, 1999). Conservative treatment for MTSS includes rest, cryotherapy, strapping, stretching, use of Kinesio tape, electro-modalities, hyperbaric oxygen therapy, use of therapeutic ultrasound, orthoses or orthotics, chiropractic therapy, shockwave treatment, physical therapy and rehabilitation (Galbraith and Lavallee 2009; Rai *et al.* 2017).

Design bias: This is when the investigator does not take into consideration the inherent biases that arepredisposed in a specific type of experiment (Green and Higgins 2008).

Language bias: According to Boutron *et al.* (2019) language bias is defined as the publication of research findings that is specific to language, but is dependent on the nature and direction of the outcomes.

Leg: The anatomic region between the foot and ankle complex (subtalar and talocrural joints) and the knee (tibio-femoral joint) (Dalley, Agur and Moore 1999).

Location bias: The publication of research results in journals is dependent on the ease of accessibility or levels of indexing in ordinary databases. These are associated with the type of results that are estimated (Boutron *et al.* 2019).

Medial Tibial Stress Syndrome (MTSS):

Shin splints, also known as MTSS, are defined by the American Academy of Orthopaedic Surgeons (1995-2018) as pain along the inner edge of the shinbone/tibia. Shin splints are usually caused by repeated trauma to the connective muscle tissue surrounding the tibia. It gets further defined as 'pain and discomfort in the leg from repetitive activity on hard surfaces, or due to forceful, excessive use of foot flexors. The diagnosis should be limited to musculoskeletal inflammations excluding stress fractures and ischaemic disorders' (Moen *et al*. 2012). MTSS is classified according to a grading system (Detmer 1986), where each grade is described under the relevant alphabetical listing in this definition of terms.

Meta-analysis: A quantitative statistical technique in extracting and combining data of multiple separate but similar studies in order to test the pooled data for statistical significance from which a conclusion can be drawn (Webster 2018).

MTSS Type I: The symptoms are localised over the distal, deep posterior compartment musculature. This may involve the soleus but frequently involves the distal posterior compartment (Detmer 1986).

MTSS Type II: Type II or chronic periostalgia, is characterised by persistent pain at the junction of the periosteum and fascia rather than at the level of the bone. This condition has also been called the soleus syndrome (Detmer 1986).

MTSS Type III: With this diagnosis, the primary problem is located within the bone itself. This would include stress fractures and/or stress microfractures being frequently diagnosed (Detmer 1986).

Non-randomised control trial:

In a non-randomised experimental study, participants are allocated to different interventions using a method that is not random. The investigator manages and decides on the allocation. This can lead to bias in the results of a trial (Sedgwick 2014).

Observational studies:

Observational studies are ones where researchers observe the effect of a treatment or other intervention without trying to change who is or is not exposed to it. Cohort studies and case control studies are two types of observational studies (Song and Chung 2010).

Publication bias: This type of bias is defined as the selective publication or non-publication of research conclusions based on the significance, nature and directions of the outcome. (Chan *et al.* 2004).

Randomised control trial:

Randomised control trial (RCT) is a type of scientific experiment that aims to reduce certain sources of bias when testing the effectiveness of new treatments. This is accomplished by randomly assigning subjects to one of two groups: one receiving the intervention that is being tested, and the other (control group) receiving an alternative treatment. These groups are then compared to see if there are any differences between them with respect to a measured response. The results and subsequent analysis of the trial are used to assess the effectiveness of the intervention (Kendall 2003).

Reporting bias: A systematic misrepresentation of existing information from research caused by the selective disclosure or concealment of information by entities involved with the study design, analysis, conduct, or distribution of methods and/or findings (Green and Higgins 2008).

Review bias: There are different types of bias described in the literature that can affect a study before, during, and after the intervention. There are a number of mechanisms where a process can distort the results and the evidence support the strategies. Review bias needs to be reduced to improve the quality, transparency, and accountability of a system/study (Ross-Hellauer and Derrick 2019).

Selection bias: The selection bias is based on the outcome or analysis, but not others, which arelinked to the results (Boutron *et al.* 2019).

Systematic review: A systematic review is a critical summary of available healthcare studies, based on a critical review of their methodology, contextualised in their populations, and recruited and pitted against the outcomes achieved in the study. They are used to provide a level of evidence and used to make informed recommendations for healthcare (Lefebvre *et al*. 2011).

Translation bias: Birbili (2000) states that when data is collected, and the findings are presented in one language, the translation that is made after that could contain bias. This is because the translators involved need to make translation-related decisions. These decisions have an impact on the validity and relate to the linguistic competence of the translators and the translators' knowledge of the study.

CHAPTER ONE INTRODUCTION

1.1 INTRODUCTION TO THE STUDY

Medial tibial stress syndrome (MTSS) is a frequent lower extremity injury and a common cause of exertional leg pain in athletes (Orbetein *et al.* 2000). Patients who experience exercise induced pain along the medial part of the shin and especially along the posteromedial distal third of the tibia and the muscles posterior to the tibialbone, are said to have a condition commonly referred to as 'shin splints' (Gerow *et al.* 1993). Detmer (1986) proposed a classification for MTSS based on its aetiologies, this includes Type I (local stress fractures), Type II (periostitis/periostalgia) and Type III (deep posterior compartment syndrome). Clinically, authors have described this problem as primarily a stress fracture, a medial tibialperiostitis or a distal deep posterior compartment syndrome respectively (Rompe *et al.* 2010).

The aetiology of MTSS TII is often multi-factorial (Yates and White 2004) and may include training on hard or uneven surfaces, incorrect training techniques, an increase in training intensity, change in shoes, unbalanced muscles and biomechanical abnormalities.Clinically the aetiologies have been linked to periostalgia or tendinopathy of the tibialis posterior, tibialis anterior or soleus muscle, posterior compartment syndrome and fascial inflammation (Wilder and Sethi 2004; Craig 2008; Schulze *et al.* 2014).The pathophysiology of 'shin splint' syndrome remains unclear but it is an important performance-constraining injury among athletes that warrants careful study (Thacker *et al.* 2002). Although it is often not serious, it may be quite disabling and if not treated properly can progress to more serious complications (Rompe *et al.* 2010). The impact of MTSS TII, in athletes, varies due to the severity of the condition. In mild situations, the pain disappears within a few weeks, but it can become chronic, with pain lasting over a period of several months. In this period, the pain can make consistent training impossible for the athlete (Puranen 1974). Because of the multi-factorial causes and unclear pathophysiology of the condition, few advances have been made in the treatment of MTSS TII and current treatment options are based principally on expert opinion and clinical experience (Galbraith and Lavallee 2009).

The clinical features of MTSS TII are best described as pain felt on and around the tibia. In mild cases pain is felt on exertion but in severe cases pain is felt on rest. The soreness and dull aching pain are normally felt on the medial side of the anterior tibia whereas aching and cramping is associated with medial sided pain. Tenderness, slight oedema and thickening of

the medialsubcutaneous border of the tibia could also be noted in some cases (Winters *et al*. 2013a).

MTSS TII is diagnosed if the patients meet the following criteria: pain and tenderness localised to the distal two thirds of the medial border of the tibia at the junction of the periosteum and the fascia (Detmer 1986; Mubarak *et al*. 1982). Patients experience pain in this area, exacerbated by weight bearing or physical activity and which is most often relieved by rest (Detmer 1986).

Multiple studies have shown that imaging modalities such as X-rays, magnetic resonance imaging, computed tomography or bone scans do not accurately differentiate between athletes with and without clinically diagnosed MTSS TII (Moen *et al.* 2012). As long as the pathogenesis of MTSS TII is not fully understood, it does not seem logical to use imaging in the diagnosis of MTSS TII, as its reliability has never been investigated; and sensitivity and specificity in the context of an uncertain pathogenesis remain unknown (Wilder 2004).

Since there is no instrument to measure injury severity and treatment outcomes, healthcare professionals are uncertain how to treat MTSS TII best (Winters *et al.* 2013a).They attempt to target preventative and treatment interventions for MTSS TII within the context of limited understanding about the pathogenesis, diagnosis and measurement of outcomes (Winters *et al.* 2013b). This makes it difficult for clinicians to accurately diagnose and effectively treat this common injury.

This has also led to several new studies emerging between 2009 and 2017, investigating the effects of extracorporeal shockwave therapy, lower-leg stockings and strengthening and stretching exercises in addition to a graded running programme (Gomez Garcia *et al*. 2017). Smith *et al.* (2014) had five intervention groups (ice application, aspirin intake, phenylbutazone, calf-stretching exercises and plaster walking cast). Rompe *et al.* (2010) investigated the effectiveness of orthoses in addition to a walk to running programme versus a walk to running programme only,whereas, Saxena *et al.* (2017) investigated the difference between low-energy laser treatment and placebo laser treatment. No significant differences were found between any of the investigated interventions in these three RCTs (Rompe 2010; Smith *et al.* 2014; Saxena *et al.* 2017).

Therefore, it remains unclear which intervention is the most effective in the treatment of MTSS TII both prior to the review by Winters (Rompe *et al.* 2010; Winters *et al*. 2013) and subsequent to this with the additional publications. With the challenge of comparing MTSS TII populations and outcomes between MTSS TII studies as most of the treatment studies use different measures to evaluate injury severity and treatment outcomes, a meta-analysis is not possible (Liberati *et al.* 2009; Winters 2013). In addition, one can question the use of meta-analyses as

the clinical outcome measures used to assess patient improvement outcomes, as these have not been validated for their specificity and sensitivity in MTSS TII patients (Moen *et al.* 2012). By contrast, a systematic review is designed to locate, critically appraise and synthesize the best available evidence relating to a specific research question to provide informative and evidence-based answers; especially in a context where interventions and the clinical outcome measures vary (Hewlett *et al.* 2006; Lefebvre *et al.* 2001). The purpose of this systematic review is to present health care practitioners with the most current information and provide recommendations regarding MTSS TII to improve treatment and patient outcomes for this common injury. This information can then be combined with the physicians'professional judgment to make decisions about how to best diagnose and treat the athlete (Boland, Cherry and Dickson 2013).

1.2 RESEARCH QUESTION

According to the literature (De la Fuente *et al.* 2019; Gomez Garcia *et al.* 2017; Griebert 2016; Smith *et al.* 2014), few advances have been made in the treatment of MTSS TII (De la Fuente *et al.* 2019). Current treatment options remain based on clinical experience (Schulze *et al.* 2014), which results in the use of treatments that are not supported by published evidence (Schulze *et al.* 2014; Winters 2017).Therefore, it remains unclear whether currently used treatments are clinically effective (Winters 2013). Therefore, this research asked: What level of evidence exists for the use of conservative treatment options for medial tibial stress syndrome Type II?

1.3 AIMS AND OBJECTIVES

1.3.1 Aim

The aim of this study was to determine the level of evidence available for the conservative treatment of MTSS Type II, by using an evidence-based, non-biased critical analysis of previously conducted studies.

1.3.2 Objectives

Objective one

The first objective was to determine the level of methodological rigour of studies investigating conservative treatment of MTSS Type II.

Objective two

The second objective was to determine the level of evidence for conservative treatment and link this with the clinical outcomes for MTSS Type II.

Objective three

The third objective was to make recommendations for further investigations (RCTs/n-RCTs) to investigate effective conservative treatment of MTSS Type II.

1.4 RATIONALE AND BENEFITS OF THE STUDY

According to the medical dictionary for the Health Professions and Nursing (2012), medial tibial stress syndrome (MTSS) TII is defined as pain and tenderness after strenuous running that is found along the medial aspect of the tibia. This may result from micro-tears of tendons or muscles and/or the inflammatory reaction around the periosteum (Rompe *et al.* 2010; Detmer 1986). A common term for MTSS is 'shin splints' (Health Professions and Nursing 2012). According to Winters *et al.* (2013) a more accurate definition is an overuse injury or repetitive-stress injury of the 'shin' area. A variety of stress reactions of the tibia and muscles that surround it occur due to the body being unable to heal correctly in response to repetitive muscle contractions and tibial strain (Galbraith and Lavallee 2009).

MTSS TII is an injury that occurs commonly in the middle to lower end in the tibia and is one of the most common causes of exertional leg pain in athletes and military soldiers (Galbraith and Lavallee 2009). The incidence of MTSS TII in athletes and soldiers is between 4% and 35% (Moen *et al.* 2009). Korkola and Amendola (2001) estimated that MTSS TII accounts for 60% of all lower limb pain syndromes in the general population. MTSS TII can be restricting and if not treated properly will progress to more serious complications such as stress fractures or small 'cracks' in the bone (Yates and White 2004). According to Galbraith and Lavallee (2009) MTSS TII is not caused by a single-factor and involves various exercise errors and biomechanical abnormalities.

Treatment options that are currently available in the literature and most used include extracorporealshockwave therapy, orthotics or change in running shoes, Kinesiotape and exercise combined with taping (Gomez Garcia *et al.* 2017; De la Fuente *et al.* 2019; Griebert 2016; Smith *et al.* 2014). However, for the most part current treatment options remain based on clinical experience and may include rest, applying ice, taking anti-inflammatory pills or applying it in the form of a gel, physiotherapy, ultrasound and local friction (Schulze *et al.* 2014). It remains unclear which treatment(s) is/are most effective (Winters 2013).

Practitioners utilise what they think is best or what has worked for them in the past in the absence of evidence-based information regarding the treatment of MTSS TII (Ardern *et al.*

2017). This means that different practitioners may utilise these treatments based on their experience or training – for example a physiotherapist might use acupuncture as seen in Knight (2010) or a podiatrist might use orthotics as seen in Bonanno (2018).

This has three associated problems (Green 2005):

1. There are no general guidelines for the treatment and where necessary return to play/work criteria for patients suffering from MTSS TII (Cooper *et al.* 2005).
2. There is limited informed consent, i.e. the patient and the practitioner have very little information to develop accurate, appropriate and evidenced protocols for the patient and the patient has very little reliable information from which to choose options in terms of informed consent (Dhai and McQuoid-Mason 2010).
3. The treatment protocols become 'hit and miss' protocols with some working and others not (Green 2005). This leads to both the practitioner and patient (especially an athlete) becoming frustrated and incurring additional expenses in terms of addressing the clinical problem (Andrews *et al.* 2013).

To complicate the three points above, there have been few advances made in the treatment of MTSS TII in the last 10 years (De la Fuente *et al.* 2019).

The purpose of this dissertation was to review published literature regarding conservative treatment options for MTSS TII via a systematic review method. According to Mulrow (1994) systematic reviews are used to evaluate and rate studies to determine their contribution to literature. Systematic reviews also establish whether scientific findings are consistent and can be generalised across populations, settings, and treatment variations (Liberati *et al.* 2009; Moher *et al.* 2009).

This will provide practitioners with the different types of conservative treatments, indicating which ones have the most evidence in support of their use (Moher *et al.* 2009) and which ones are most clinically effective in the treatment of MTSS TII. This will improve (Liberati *et al.* 2009; Dhai and McQuoid-Mason 2010):

1. Guideline formation.
2. Informed consent and associated patient specific treatment protocol development.
3. Actual physical treatment of MTSS TII and the resultant patient satisfaction.

1.5 LIMITATIONS

A contextual limitation based on Detmer's classification (1986), is that the studies included in this systematic review only address, treat and review clinical responses to MTSS TII, therefore this systematic review will assess only this MTSS type.

A notable limitation in this study's methodology was that only English articles or articles that had been translated into English were used because of time, translation bias and cost constraints; however this is one of the pragmatic limitations of any systematic review, which is difficult to overcome (Birbili 2000; Clarke 2007; Green and Higgins 2008). Therefore, an unknown percentage of articles may not have been included in this systematic review (Clarke 2007). It is suggested that in future systematic reviews, in order to reduce the potential for language bias; that translation be accounted for and utilised (although this is subject to translation bias (Odgaard-Jensen *et al.* 2011)), to ensure the greatest potential for the inclusion of all articles within this particular context and thus into a future systematic review (Liberati *et al.* 2009; Moher *et al.* 2009).

Publication bias is defined as the selective publication or non-publication of research conclusions based on the significance, nature and directions of the outcome. (Chan *et al.* 2004). These publications are usually available in the peer review literature and in the grey literature. These studies typically show a good clinical outcome and were therefore published. It needs to be considered that when a conclusion is drawn in a systematic review, that it is contextualised with the knowledge that the outcomes may collectively show a favourable result when in fact this could have been negated if all publications were available in the peer review or grey literature domains (Büttner *et al.* 2020).

This study was not intended to be a meta-analysis (Dagenais and Haldeman 2011). This study was structured in order to collect, critically review, categorise according to levels of evidence and present available conservative treatment options in the context of MTSS TII (Green 2005), so that it only addressed methodological rigour of previously published articles (Clarke 2007). This however does not preclude the use of previous meta-analyses for understanding an article's conceptual and statistical relationship when contextualising the information gleaned in a systematic review analysis (Dagenais and Haldeman 2011).

1.6 CONCLUSION

Therefore, this chapter presented a summary of the literature, and indicated the area of study in this dissertation, while offering objectives, rationale, and aims behind the study. Chapter Two discusses a detailed literature review pertaining to this study, with Chapter Three

definingthe research design, procedure, research sample, the involved reviewers and measurement tools and analysis. Chapter Four includes the results obtained after data collection, in which conclusions are drawn per reviewed article. In Chapter Five, a discussion of these results ispresented per intervention for MTSS TII and a discussion of the criteria for ranking evidence per intervention is provided. Chapter Six offers conclusions based on this study and recommendations drawing this study to an end.

CHAPTER TWO LITERATURE REVIEW

2.1 INTRODUCTION

This chapter gives a brief insight into the history of Medial Tibial Stress Syndrome Type II (MTSS TII) and focuses on the conservative treatments that are used to treat this condition. Specific information relating to conducting a systematic review such as literature search, literature synthesis and systematic reviews is included in the discussion in order to underpin the methodology presented in Chapter Three.

2.2 MEDIAL TIBIAL STRESS SYNDROME

2.2.1 Introduction

A common exercise-related injury seen in the world of athletics, endurance sport and military recruits is known as Medial Tibial Stress Syndrome (MTSS) TII (or 'shin splints,' the layman's term for this condition). MTSS TII is an overuse injury that occurs through exercise or physical activityand is characterised by its symptoms of pain felt spontaneously or on palpation (tenderness) (Becker, Richardson and Brown 2016). This pain is often found along the posteromedial tibial border or the medial side of the lower leg above the ankle. It can occur in any place along this border, but usually 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, depending on the severity (Yamasaki 2019). The symptoms of MTSS TII are typically only present when exercising but in severe cases may progress to remaining at rest or while doing daily life activities (Yates and White 2004). MTSS TII is most generally seen in runners but also found in other high activity sports suchas soccer, football, basketball and dancing (Galbraith and Lavallee 2009).

To better understand the condition of MTSS TII the following section covers the anatomy of the region followed by the aetiology of the condition and its clinical presentation.

2.2.2 Anatomy

The region between the ankle and the knee joint or anatomically 'the leg' is made up of four compartments: anterior, lateral, deep posterior, and superficial posterior muscle compartments, which are separated by the tibia, fibula, and dense fascial layers (e.g. syndemosis) and intermuscular septae.

The anterior and posterior medial tibial crests is where the deep fascia attaches and it extends from the knee to the ankle, blending into the periosteum. The dense superficial fascia and the anterior compartment fascia are well developed along the posterior medial and anterior tibial crests serving as important zones of attachment for the muscles involved in MTSS TII (Herring 2006). These are the posterior tibialis, flexor digitorum longus, soleus and tibialis anterior muscles.

These muscles primarily help stabilise the lower leg and foot and aid in pushing off while running (Griebert *et al.* 2016). The tibialis anterior and posterior (Table 2.2) are also responsible for stabilising the medial arch of the foot.

The periosteum is a membrane that covers the outer surface of all bones. Bone and periosteum are connected through Sharpey's fibres (strong collagen fibres also known as bone fibres) (Dalley *et al.* 1999). Crural fascia, or deep fascia of the leg is fused with the periosteum over the outer or superficial surface of the bone and therefore tethers to the Sharpey's fibres. Crural fascia forms a complete investment or fascial sheath to the muscles (Dalley *et al.* 1999). As muscles hypertrophy, they place increased load on the crural fascia, which has been associated with MTSS TII and is thought to be the cause of traction-induced injury in MTSS TII (Stickley *et al*. 2009). This is evidenced inthat MTSS TII symptoms can be associated with anatomical structures surrounding the muscles and is not limited to the muscles only (Hall 2010).

Table 2.1: Muscles most commonly involved in MTSS

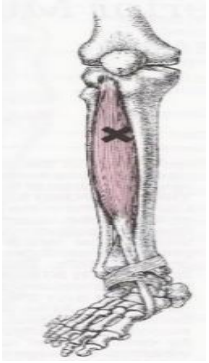
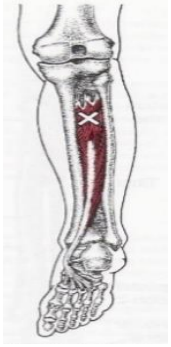
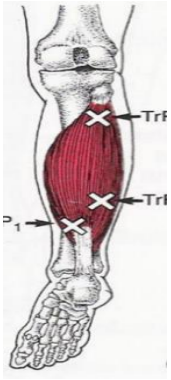
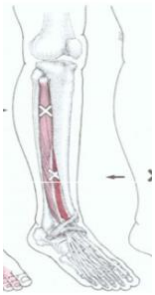
Muscle	Proximal attachment	Distal attachment	Innervation	Action	Picture
Anterior tibialis	Lateral condyle and superior half of lateral surface of tibia and interosseous membrane	Medial and inferior surfaces of medial cuneiform and base of 1st metatarsal	Deep fibular nerve (L4,L5)	Dorsiflexes ankle and inverts foot	 **Figure2.1: Anterior tibialis**
Posterior tibialis	Interosseous membrane; posterior surface of tibia inferior to soleal line; posterior surface of fibula	Tuberosity of navicular, cuneiform, cuboid and sustentaculumtali of calcaneus; bases of 2nd, 3rd and 4th metatarsals	Tibial nerve (L4,L5)	Plantar flexes ankle; inverts foot	 **Figure2.2: Posterior tibialis**
Soleus	Posterior aspect of head and superior quarter of posterior surface of fibula; soleal line and middle third of medial border of tibia; and tendinous arch extending between the bony attachments	Posterior surface of calcaneus via calcaneus tendon	Tibial nerve (S1,S2)	Plantar flexes ankle independent of position of knee; stabilises leg on foot	 **Figure 2.3: Soleus**
Flexor digitorum longus	Medial part of posterior surface of tibia inferior to soleal line; by a broad tendon to fibula	Bases of distal phalanges of lateral four digits	Tibial nerve (S2,S3)	Flexes lateral four digits; plantar flexes ankle; supports longitudinal arches of foot	 **Figure 2.4: Flexor digitorum longus**

Table adapted from Dalley, Agur and Moore 1999; Figures adapted from Travell, Simons and Simons 1999.

2.2.3 Aetiology

The aetiology or cause of MTSS TII remains unclear as health professionals and their studies have produced incongruous results on what causes this condition (Beck 2016; Becker, Nakajima and Wu 2018).

The first hypothesis states that MTSS TII may be caused by forces that are sent through the muscles named in Table 2.1 and through the deep crural fascia. As the load increases and the muscles are no longer able to respond to the increasing load, the load is transferred to the sheath and fascia. This subsequently results in fatigue in the deep fascia attachment sites posteromedially eventually leading to a traction induced inflammation of the periosteum (Robertson 2003; Becker, Nakajima and Wu 2018). This is explained as a repetitive traumatic aetiology, resulting in the muscles or deep crural fascia pulling on the periosteum (or the connective tissue that covers the long bones in the body) (Beck 2016). This inflammatory response is due to tension force across the fascia and eccentrically contracting muscle tendon-unit. Any muscle tendon-units involved in an overuse system will eventually lead to MTSS TII (Oloff 1994; Robertson 2003).

A second hypothesis states that MTSS TII could be a sign of bone remodelling failure, similar to what is seen in stress reactions or stress fractures (Becker, Nakajima and Wu 2018). Physiologically, bone remodelling occurs by long term bending/stressing of a long bone; usually secondary to the lack of muscle or fascial support (as it is fatigued). This stimulates it to increase its cross section by promoting osteoblast activity under the periosteum to lay down more bone (Wolff's law) (Hall 2010). When training is continually increased in intensity or frequency, the osteoblast activity is activated to initiate this adaptive process. If however the intensity or frequency increases beyond the osteoblastic re-modelling process, then micro-damage occurs, resulting in cortical breaks, inflammation, callus formation and micro-fractures (Beck 2016). It is suggested that if the accumulated damage done to bone is left unrepaired, it will lead to MTSS TII (Winters *et al.* 2018).

These different hypotheses have reinforced the classification provided initially by Detmer (1986), in which Detmer (1986) classified MTSS pathogenesis into three components according to the tissues involved.

Table 2.2 contains type, classification and clinical features of MTSS (Detmer 1986; Noakes 2001; Winters *et al.* 2013b):

Table 2.2: Type, classification and clinical features of MTSS

Type	Classification	Diagnostic sub categories	Clinical features
I	Local stress fractures (bone). This type is characterised by a stress reaction on the inside border of the shinbone. A stress reaction is a precedingstage to a stress fracture (Rai *et al.* 2017).	Acute symptoms	Pain felt on and around the tibia. In mild cases, pain is felt on exertion but in severe cases pain is felt on rest. Soreness and dull aching pain is normally felt on the medial side of the anterior tibia whereas aching and cramping is associated with lateral pain. Tenderness, slight oedema and thickening of the subcutaneous border of the tibia can also be noted in some cases (Winters *et al.* 2013b).
II	Periostitis/periostalgia (Periostial) This is characterised by irritation of the periosteum of the tibia at the point where the Soleusand Tibialis posterior muscles are attached (Rai *et al*. 2017).	Acute, subacute and chronic phases within MTSS Type II	
III	Deep posterior compartment syndrome(muscular tissue)	Chronic symptoms	

2.2.4 Pathophysiology

There are two (see Section 2.2.3) theories that exist regarding the pathogenesis of MTSS TII. The most common theory is 'traction-induced' periostitis of the tibia due to tibial strain when under a load leading to crural fasciitis or periostitis (Winters 2017). When the load applied exceeds a certain threshold, the periosteum could become inflamed (Winters 2017). These clinical entities are thought to be as a result of increasing fatigue of a variety of the tibialis anterior, tibialis posterior, flexor digitorum longus and soleus muscles, placing increasing strain on the respective tendons, syndesmosis and/or the periosteum (Smith, Coates and Creaby 2014). There is uncertainty as to whether the proximal origins of the lower leg muscles insert at the site where MTSS TII occurs (Winters 2017).

The second theory includes a local tibial bone overload injury (Winters 2017). There seems to be evidence that shows that tibial stress injuries could be involved in MTSS TII. This includes periosteal remodelling and stress reactions of the tibia (Galbraith and Lavallee 2009). By contrast, these clinical entities are thought to be as a result of increasing fatigue of a variety of the tibialis anterior, tibialis posterior, flexor digitorum longus and soleus muscles, placing increasing strain on the tibial structure. In addition, these tibial stress injuries seem to be compounded by chronic repetitive loads that lead to abnormal strain and bending of the tibia (Smith, Coates and Creaby 2014). Using insights from Frost's Utah paradigm, it can be concluded that micro-damage occurs when bone strain surpasses the modelling threshold

(Moen 2012; Frost 2001). Under normal physiological reactions, micro-damage will encourage remodelling. Repetitive strains may provoke accumulation of micro-damage leading to injury, in the absence of a remodelling response (Mori and Kawaguchi 2001). However, in a study at Indiana University of six biopsies done on athletes with MTSS TII, linear micro-cracks were found in 66, 6%, no diffuse micro-damage was seen and only one prospective remodelling (Winters *et al.* 2019). Based on these findings Winters *et al.* (2019) suggested that if micro-damage stays unrepaired, the accumulation may be the cause of MTSS TII in active individuals.

However, an author indicates that it is possible there may be a mixture of two or three of these structures that result in or are affected by MTSS TII (Yates 2004) and thus may not be classifiable as per Detmer's 1986 classification. Although, it seems to be possible that MTSS TII is made up of different aetiologies, MTSS TII could be considered to be caused by a sequence ofincreasing stress reactions to bone (Galbraith and Lavallee 2009).

Therefore, a summary of the pathogenesis in simple terms, that seems to be agreed upon bythe majority of the literature, is outlined in Figure 2.5:

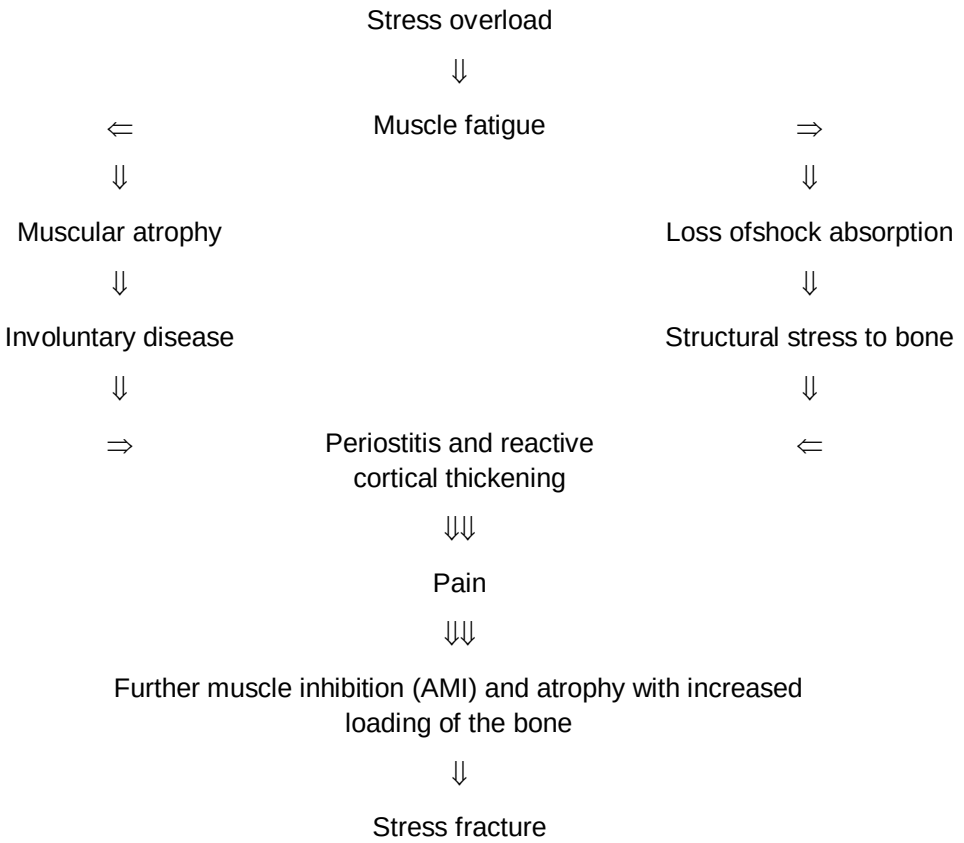


Figure 2.5: Flow diagram showingMTSS TII process

Adapted from Travell, Simons and Simons 1999.

2.2.5 Clinical Presentation

The area that is most involved in overuse pain in the leg is a localised tenderness of the distal two thirds of the tibia on the posteromedial border (Yates and White 2004). According to Oloff (1994), MTSS TII is commonly classified diagnostically with respect to duration, location, and severity of symptoms:

Duration of symptoms is divided into acute (less than 2 weeks), subacute (2 to 6 weeks), and chronic (more than 6 weeks).This seems to concur with the later work of Noakes (2001), who identified exertional shin pain through four phases of injury and connects this to the frequency/intensity of training over time. In the first and second phase, there is discomfort and stiffness in the calf after exercise. If training continues, the discomfort comes while the patient exercises. In the third phase, the person tries to push through the pain while exercising, but if they continue without treatment, the pain becomes severe enough to stop the person from enjoying their training. During the fourth and final phase, the person experiences extreme pain and even walking can be unbearable. The pain intensifies over days. Initially pain passes after rest but recurs after running. Later on, the pain persists after athletic activity (Saxena, Fullem and Gerdesmeyer 2017).

Location of symptoms are grouped on the posteromedial side in MTSS TII. The most common pain presentation is along the posteromedial border and is produced over the lower two thirds of the leg over an area of ≥ five centimetres (Noakes 2001).
Severity of the MTSS TII, which seems to follow the criteria set out by Noakes (2001):

- Grade 1: This is characterised by pain on palpation of involved tibial crest, with no symptoms during daily activity or running.
- Grade 2: Indicates discomfort mainly after running but not during a run. Some mild discomfort may be present at first during running.
- Grade 3: Patients have pain while running withremaining discomfort after running.
- Grade 4: Patients are symptomatic whilewalking and are unable to run comfortably.

When taking a patient history, MTSS TII can be identified when the patient experiences exercise-induced diffuse pain that is present along the posteromedial or anteromedial aspects of the lower limb (distal two thirds of the leg), during or after exercise (Winters 2017).

The diagnosis can be confirmed when there are no other possible causes that can explain the recognisable pain (viz. a diagnosis by exclusion) (Winters 2017).

2.2.6 Contributing Risk Factors

The risk/contributing factors can be categorised into intrinsic (anatomical variations and physical fitness) factors or extrinsic (environmental) factors that associate with different sports (Winkelmann *et al.* 2016). Thacker *et al.* (2002) proposed, that in MTSS TII the intrinsic factors could include: a lack of running experience (inadequate warm-up, introducing speed work or hill training, sudden increase in total mileage and inadequate weight training), competitive running, previous injury, excessive weekly running distances, body mass index and poor physical condition (decreased strength, poor flexibility, imbalance between the quadriceps and hamstrings and muscle fatigue). Galbraith and Lavallee (2009) also state that altered proprioception should be considered as a risk factor in patients that have MTSS TII re-injury.

According to the twenty one studies the authors reviewed in Winkelmann *et al.* (2016) the nine biomechanical intrinsic risk factors that were best supported by evidence included: increased body mass index (BMI), increased ankle plantar flexion range of motion (ROM), decreased ankle dorsiflexion ROM, increased lowering of navicular on weight bearing (established with the navicular drop test (Magee 2014)), increased ankle eversion ROM, increased ankle inversion ROM, increased quadriceps angle, increased hip internal rotation ROM, and increased hip external rotation ROM. The strongest predictive risk factors that were found, were increased BMI, increased navicular drop test, greater ankle plantar flexion ROM and increased hip external ROM (Winkelmann *et al.* 2016; Yamaski 2019).However, another study indicated that decreased hip abduction, decreased ankle plantar flexion and an increased subtalar inversion were risk factors for developing MTSS TII (Winters *et al.* 2013a).

The extrinsic factors include type of sport, always running on cambered roads, hard running surface or uneven terrain, shoes and in-shoe orthoses (Thacker *et al.* 2002).

2.2.7 Diagnosis of MTSS TII

In order to clinically diagnose patients, the following criteria need to be met (Detmer 1986; Noakes 2001):

The acute stage has characteristics of pain, redness, heat, swelling and loss of function. The patient with MTSS TII typically experiences pain at rest or when active in the acute stage, or when stress is applied to the area that is affected. As opposed to the chronic stage where pain increases with and persists after training.

Pain localised over the anterior, middle and distal thirds of the tibia, between 4 and 12cm from the medial malleolus at the junction of the periosteum and the fascia.On examination, pain at this location is the most common and reliable finding that is more noticeable after exercise.

(Detmer 1986). Pain is exacerbated by weight bearing or physical activity and relieved by rest (Detmer 1986).

The presence of 'tender spots", arising from the new periosteal layer which is felt when applying firm finger pressure on the medial distal third of the tibia. Swelling may be noted over the tendon, teno-periosteal junction and surrounding musculature (Noakes 2001).

The diagnosis is focused principally on the history, as outlined above and physical examination, in which active resisted plantar flexion may produce pain, but maintain normal arterial pulses (therefore excluding vascular pathology and/or compartment syndromes (MTSS TIII)) and present with a normal neurological examination (therefore excluding compartment syndromes, which generally show decreases in principally the dermatome and myotome grading) (Moen *et al.* 2012). If exertional leg pain is experienced without sensory or motor loss, MTTS II should be considered (American Academy of Orthopaedic Surgeons 1995-2018).Tenderness over the medial posterior edge of the tibia often made worse with a motor exam and pain present in daily living indicates MTSS TI (Kiel and Kaiser 2019).

When assessing the patient's risk factors, Section 2.2.6, should be taken into consideration. If any of these tests mentioned below are positive and are associated with the clinical presentation linked to duration, severity and location of the complaint, it could lead to a positive diagnosis of MTSS TII (Winkelmann *et al.* 2016; Yamaski 2019):

Studies found that an increased BMI could be a risk factor. Heavier individuals place increased strain on the muscles controlling foot movement and this could lead to muscle fatigue that could lead to periostitis. However, caution needs to be applied as most people who develop MTSS TII are athletes. Athletes tend to have a higher BMI because of increased muscle mass. Increased BMI, irrespective of fat or muscle, can result in pronation of the foot and can then lead to MTSS TII. Pronation via the navicular drop test has been linked to the development of MTSS TII (Winkelmann *et al.* 2016; Yamaski 2019).

Navicular drop test (Magee 2014) needs to be done on patients. This test involves locating and marking the navicular. The patient is then asked to place weight on the foot. If the navicular drops below the marking that was made (Hyde and Gengenbach 2007) this may show an increased likelihood of pronation of the foot (tendency to flat footedness).

A postural assessment should be conducted to identify any compensating patterns. Common compensating patterns that could lead to MTSS TII are caused by hyperpronation, pes planus (flat footedness) and a leg length discrepancy (Winkelmann *et al.* 2016; Yamaski 2019; Martinez *et al.* 2020).

Flexibility of ankle plantar flexion and dorsiflexion need to be completed with the use of a goniometer (Hyde and Gengenbach2007; Winters *et al.* 2013a; Winkelmann *et al.* 2016; Yamaski 2019).

External rotation range of motion of the hip should be considered (Hyde and Gengenbach 2007; Winkelmann *et al.* 2016; Yamaski 2019).

Various studies have shown that imaging modalities such as X-rays, MRI's, bone scans, computed tomography and ultrasound do not accurately establish between people with and without MTSS TII (Wilder and Sethi 2004; Winters 2019).

In a cross-sectional study done on 51 participants it was shown that MTSS TII can be reliably diagnosed using history and clinical examination in athletic populations with exercise-induced lower leg pain (Winters *et al.* 2016a).

MTSS TII is seen as a clinical condition. It is therefore necessary for clinicians to make a reliable diagnosis (Winters 2017), based on the clinical presentation and the exclusion of other diagnoses (Souza 2009). To facilitate an integration of the known clinical information and allow effective assessment of the patient with a conclusive diagnosis, Winters (2019) has developed a six step standardised history and physical examination approach to diagnosing MTSS TII. The first step is used to establish if there is pain along the medial tibial border. The patient is then asked what relieves or provokes the pain (pain should be provoked by physical activity). The athlete is then asked about any adjacent areas of pain. The third step is to request the athlete to characterise the pain as 'burning', 'cramping' or 'pressure-like' calf pain. These signs most likely point to chronic exertional compartment syndrome and would result in the patient being treated for such. To confirm the type of compartment syndrome, step four excludes numbness or pins and needles in the foot during exercise, as this could also indicate chronic exertional compartment syndrome. During the physical examination step five involves palpating the posteromedial border of the tibia for a recognisable pain extending for more than five centimetres along that osseous border. In the final step (Step six), the practitioner should confirm that there are no signs and symptoms present that could be indicative of a severe pathology (Winters 2019).

2.2.8 Differential Diagnoses

A thorough case history and physical examination are usually adequate to exclude the differentials (Souza 2009). Where the pain is located, size of the area where pain is determined and pain provocation and reduction need to be included when differentiating between the different overuse lower leg injuries (Winters 2017).

The most common complication of MTSS TII and therefore a clinical differential that needs to be considered is a **stress or compression fracture** of the tibia (MTSS TI). A tibial stress fracture is a hairline fracture of the bone of the leg that is caused by repetitive stress. It is a form of bone fatigue caused by repetitive loading (Winters 2017).This fracture will present itself very similarly to MTSS TII as tenderness along on the anterior tibia or along the anterior tibial crest. Pain is often sinister and is felt at the beginning and after strenuous exercise. Pain is often more focal in athletes with MTSS TII, and can be pin-pointed with one finger (Walden 2019). It is difficult to differentiate between stress fractures (MTSS TI) and MTSS TII as this type of fracture is not visible on X-ray until it begins to heal and the callus formation becomes visible (Yochum and Rowe 2005). Patients who are suspected of having a stress fracture are advised to rest for four weeks before taking an X-ray (Walden 2019). Stress fractures should be suspected when focal pain is experienced on palpation and pain upon tapping (Winters 2017).

Acute or chronic exertional compartment syndromes (MTSS TIII) are often confused with MTSS TII. Compartment syndrome is a painful condition that occurs when pressure within the muscle sheath increases to a dangerous level.

Acute compartment syndrome is seen as a medical emergency as it can lead to permanent muscle damage if it is left untreated. This is normally caused by sudden severe injury. Symptoms of acute syndrome include pain on stretching (passive and active), muscle tightness, rubor tense skin, and burning or tingling sensation on the skin.

Chronic exertional compartment syndrome (CECS) is not an emergency and is normally caused by athletic physical exertion. Symptoms of chronic compartment syndrome include numbness (decreased sensation), ‘burning’, ‘pins and needles’ in the foot during exercise, ‘cramping’, difficulty moving the foot (due to pain inhibition) and visible muscle bulging. In order to diagnose exertional compartment syndrome, the pressure in the fascial sheath compartments are measured before and after exercise. If the pressure remains high after exercise, the patient has compartment syndrome (Mayo Clinic 2020).

The pain associated with compartment syndrome usually terminates quickly when a provoking activity is stopped, where pain in MTSS TII tends to loiter for a couple of hours to days (Winters 2019). Compartment syndrome only affects nerves, arteries and veins in the compartment that is affected, whereas in the case of MTSS TII, nerves, arteries and veins are not normally affected (Winters 2017).

In older or diabetic athletes, **peripheral vascular disease** (PVD) should be considered as a differential diagnosis. PVD is a disorder of blood circulation that causes the blood vessels outside of your heart to narrow and spasm (Haslett *et al.* 1999). Symptoms are pain, fatigue

and ‘cramping’ in the legs, especially during exercise (Haslett *et al.* 1999). Pain often improves with rest. With PVD, legs can turn blue or pale, swelling can be seen, there may be weak or absent pulses, skin ulcers that do not heal and muscles feel ‘numb and heavy’ (Haslett *et al.* 1999). These symptoms are not found in MTSS TII (Giorgi 2016). On physical examination, a patient presenting with PVD can have bruits and decreasing blood pressure in the affected limb (Haslett *et al.* 1999). The blood pressure is taken in the ankle and is compared with the blood pressure in the patient’s arm (ankle-brachial index) (Aboyans 2012). Ultrasound techniques, such as Doppler ultrasound or angiogram can be used by a medical professional to identify blocked or narrow blood vessels (Mayo Clinic 2020).

Although **popliteal artery entrapment syndrome** (PAES) is rarely seen in athletes, it should be a differential when examining patients with lower leg pain (Haslett *et al.* 1999). PAES has two main causes: an anatomic variation of the triceps surae or hypertrophy of the gastrocnemius and/or the popliteal muscle. Both result in compression of the artery in the popliteal fossa during exercise (Haslett *et al.* 1999). Athletes with PAES experience pain during exercise, burning and cramping in the posterior lower leg muscle group. Paraesthesia is reported in some patients. PAES will affect all distal pulses compared to MTSS TII (Winters 2017).

Effort-induced venous thrombosis is defined by local muscle cramps and repetitive exertion that leads to vessel injury and eventually develops into a deep vein thrombosis (Haslett *et al.* 1999). The patient will develop swelling and pain in the lower limb after exercise. MTSS TII tends to cause pain on the medial side of the calf, while venous thrombosis commonly causes pain posterior to/ middle of the calf (Tak and Tak 2013).

When an athlete is experiencing loss of motion or loss of sensation, **peroneal nerve entrapment** should be considered (Haslett *et al.* 1999). The patient may also experience numbness or tingling on the top of the foot, a foot that drops, dragging toes when walking and weakness of the feet or ankles (Haslett *et al.* 1999). This is different to MTSS TII as the patient does not experience pain at rest or while exercising (Yang *et al.* 2006).

If the patient is not responding or the clinician is uncertain, then further imaging, compartment pressure measurements, and vascular and nerve conduction studies are required to lead to the correct diagnosis (Haslett *et al.* 1999; Winters *et al*. 2013a).

2.2.9 Treatment Phases

Once a diagnosis of MTSS TII is reached, the next step is the development of a treatment/maintenance plan. MTSS TII symptoms are unpredictable and the return time to sport is drawn out. To decrease symptoms, rest could be used for most patients. However, a patient-relevant outcome is much more than just pain relief. Many randomised control trials

have a follow-up duration of three months but nine to twelve months may be more reasonable (Winters 2018).

Health care professionals are required to identify three stages of treatment in dealing with MTSS TII: the **acute stage**, the **sub-acute stage** and the **chronic stage** (Galbraith and Lavallee 2009).

Goals in the acute phase of MTSS TII require control of the inflammation, minimising pain and swelling, limiting pain during certain positions or activities, maintaining aerobic fitness and maintaining integrity of the soft tissue (Dutton 2017). For years, many clinicians have advocated a simple and traditional treatment approach when dealing with MTSS TII in the acute phase. This approach consists of rest, ice application and a graded approach back to activity (Carr and Sevetson 2008). The most utilised treatment options in clinical practice are rest, ice on the affected area for 15-20 minutes or using non-steroidal anti-inflammatory drugs (NSAIDs). These drugs help decrease inflammation in the acute phase (Winters 2013; Beck 2016). In addition, the American Academy of Orthopaedic Surgeons (2018) suggests a minimum of seven to ten days of rest from pain-inducing activities. They advise that athletes maintain their aerobic fitness levels by doing cross-training activities such as cycling or pool-running. Some athletes may require two to six weeks rest to fully recover. Supplementary physical therapy modalities such as electrical stimulation, ultrasound, soft tissue mobilisation, whirlpool baths and unweighted ambulation may be used in this stage (Galbraith and Lavallee 2009).

The sub-acute phase of MTSS TII is distinguished in how it is treated, by a return to pain-free active and passive range of motion and an overall decrease in pain. Although the pain is decreased, the athlete is still not fully healed in this stage as stress to the area suffering with MTSS TII will still cause pain and discomfort (Dutton 2017). This stage of treatment focuses on many of the risk factors predisposing the patient to MTSS TII, so as to limit their impact, remove them altogether and/or address them in a manner so as to negate their influence if they cannot be removed. If the athlete passes through the acute stage, the sub-acute phase concentrates on return to activity by changing training programmes and focusing on correcting any biomechanical issues that the athlete may have (Winkelmann *et al.* 2016; Yamaski 2019). Cross-training is used because of the low-impact nature that assists to reduce stress to the MTSS TII affected region, but also benefits the patient. Excellent cross-training options in this phase include pool running, riding a stationary bicycle, elliptical machines and swimming (Galbraith and Lavallee 2009). Patients should be advised to refrain from running hills or running on uneven or extremely hard surfaces in this sub-acute phase (Pernas 2019). Athletes should also be advised to reduce their intensity and duration of runs by 50% (Yamasaki 2019).

The chronic phase of MTSS TII treatment is similar to the acute and sub-acute phase; the only difference is that the applied rest and active rest is longer. With the chronic phase of MTSS TII, caution needs to be taken to avoid having the condition lead to stress fractures. If a patient has long-term chronic MTSS TII with radiographic changes indicative of more than periosteal involvement, the presence of stress fractures may need to be confirmed (Galbraith and Lavallee 2009).

2.2.10 Treatment Options Underpinning the Different MTSS TII Stages

2.2.10.1 Prevention

The best key to treat MTSS TII is prevention – most often this is the focus of care after the initial episode of MTSS TII. This is because athletes with MTSS TII are highly vulnerable to re-injury, especially if the intrinsic (e.g. muscle imbalance, alignment abnormalities) and extrinsic (e.g. training errors, poor technique) factors are not corrected. Patients who are at risk need to be educated on proper injury prevention and develop appropriate rehabilitation programmes (Beck 2016).

It seems that MTSS TII can be prevented by correcting risk factors through assessment before an injury occurs. According to Winkelmann *et al.* (2016), they reported that the best way to prevent MTSS TII is to identify risk factors before the athlete starts to train, rather than waiting until they show symptoms.

In Section 2.2.6, certain contributing risk factors were mentioned. These may be prevented if a runner goes to a health care professional to assess them before they start a programme that is suitable for them and/or increase their training level (Bonanno *et al.* 2018). The Functional Movement Screen can be used as a pre-participation physical screen to help health care professionals screen patients for any risk of injury and/or dysfunctional or performance-limiting movement pattern (Minick *et al*. 2010). All previous injuries need to be resolved and if there are weaknesses anywhere, a strengthening programme should be included prior to starting their running (Martinez *et al.* 2020). Athletes who are involved in competitive running need to prioritise rest days and cross training (Pietrzak 2014). When a patient presents with biomechanical risk factors, it would be beneficial for them to consult with a podiatrist to see if custom made inserts or insoles could reduce their risk factors (Naderi 2019). However, there is no evidence that shows a reduction in MTSS TII symptoms when these risk factors are addressed.

2.2.10.2 Rest

Rest is prescribed for any activities that cause the patient pain, discomfort or swelling as a result of MTSS TII. This may be in the form of passive rest or active rest (Choi *et al.* 1994).

Passive rest means a period of total rest without any physical activity. Passive rest is not prescribed for patients with MTSS TII (Arslan *et al.* 2017). By contrast, active rest is prescribed for two to four weeks (Carr and Sevetson 2008). Active rest is when light exercises (swimming or cycling) are incorporated into the training regimen, to compensate for the inability to perform normal activities that would induce the MTSS TII. This allows the normal recovery process to start without extra stress on the injured area (American Academy of Orthopaedic Surgeons 2018).

2.2.10.3 Cryotherapy, Thermotherapy and Contrast Therapy

Cryotherapy, also known as the application or use of ice, is recommended by health care workers (Hall 2010). It is believed that ice will decrease swelling, limit pain and reduce inflammation (Hubbard and Denegar 2004). The most common method is applying the ice to the area of pain for about 15-20 minutes or until there is perceived numbness without burning or skin irritation, directly after physical exercise (Gailbrath and Lavallee 2009; Yamaski 2018). However there is no evidence beyond the anecdotal use of cryotherapy in clinical practice.

Thermotherapy is not advised in the acute phase of MTSS TII. It is believed that heat in the subacute phase will decrease the tension in the muscle and relax the muscle (Shadduck 2009), however there is no evidence to support the use of thermotherapy in patients with MTSS TII.

Contrast therapy involves switching between cryotherapy and thermotherapy a few times within a set time. The benefits of contrast therapy includes: improvement in circulation, reduction in swelling, decrease in inflammation and a decrease in muscle soreness (Vaile, Gill and Blazevich 2007). However there is no evidence that supports these benefits when used on patients who present with symptoms of MTSS TII.

2.2.10.4 Rehabilitation, Stretching, Strengthening and Proprioception

At the outset, in a patient presenting with MTSS TII, a reduction in activity intensity should be considered. In a case study reported by Miranda *et al.* (2019), one female participant diagnosed with MTSS TI and TII was treated by reducing her exercise intensity. The patient improved clinically and was still asymptomatic two years after treatment. Changing the training routine by decreasing the exercise intensity was believed to have decreased the stress reaction leading to recovery in this patient (Miranda *et al.* 2019) and may have initially assisted the patient in enabling the treatment inventions to take effect. This should then be followed by a period of re-integration into activity with a scaled approach to frequency and intensity of the activity/activities that the patient is required to participate in based on his/her sport.

In support of this, a randomised controlled trial in forty-eight patients with plantar fasciopathy suggested that stimulating the mechanical properties of the fascia through heavy slow-load exercises reduces pain to a greater degree than shoe inserts (Rathleff *et al.* 2015). Therefore, a combination of graded tibial loading exercises and ankle plantar flexor strengthening exercises may be of benefit in athletes with MTSS TII (Winters 2019). However this suggestion requires further clinical investigation, although it concurs with Wolff's Law and the physiological principles that underpin the restoration of fascia and tissues like the periosteum and Sharpey's fibres (Tortora and Derrickson 2018).

This is further supported in that, in order to prevent muscle fatigue (one cause of MTSS TII (Robertson 2003; Beck 2016; Becker, Nakajima and Wu 2018)) literature supports gastrocnemius-soleus stretching and eccentric calf exercises (Knight 2010). Stretching can be done either statically or dynamically with focus on increasing foot dorsiflexion (Loudon and Dolphino 2010; Winters *et al.* 2013b). When static stretches are done, a fixed position should be held for one to three minutes at a time to get a positive effect (De Vries 1961). Exercises should mainly focus on strengthening the muscles that invert and evert the foot (Loudon and Dolphino 2010; Winters *et al.* 2013a).

Additionally, from a neuromuscular recruitment vantage point, athletes could also benefit from developing core stability with strong abdominal, gluteal and hip muscles. When these core hip muscles are strengthened, it can improve running mechanics, which will prevent overuse injuries in the lower limb reducing the likelihood of MTSS TII (Galbraith and Lavallee 2009). In concert with this, it has been reported that proprioceptive training is highly beneficial in neuromuscular re-education (Martinez *et al.* 2020). The most basic exercises that can be done are those using a wobble or balance board. An athlete that works on their proprioception can increase the joint's movement and create postural stability allowing the muscles maximum productivity. This is thought to assist the body to adapt to different terrains when running and decrease re-injury (Galbraith and Lavallee 2009). These neuromuscular approaches are supported by the development of the Myokinesthetic System/functional movement assessment, which is a global postural assessment to identify compensatory patterns that may lead to MTSS TII (Martinez *et al.* 2020). The basis of this system states that continued alignment in a non-optimal position and repeated movement patterns can lead to musculoskeletal conditions (Sahrmann 2001). The myotome of the nerve root that was affected by the postural imbalance is then repeatedly stimulated by the clinician. The repetition stimulates mechanoreceptors to normalise kinetic chain function and decrease pain and disability (Martinez *et al.* 2020). The reliability and validity of Myokinesthetic System has been partially tested (Sahrmann 2001). In a case report by Thistle (2018) where one participant was treated with the MYK system, the patient was cleared at six weeks to participate in her sport

due to significant decrease in pain and a demonstrated improvement in the patient's overall function.

Given the many approaches to rehabilitation above, there seems to be agreement in the literature that the patient should have a graded return to the activity with phased increases in intensity and frequency (for example, running should be approached by a loading consistently approach, with the athlete slowly starting and never increasing their distance by more than 10% per week). This is important in avoiding flare ups and re-injury (Winters 2019). Another study indicates that increasing the load by 30% may be safe (Damsted *et al.* 2018). A recent review by Smith *et al.* (2017) suggests some pain while loading is beneficial, compared to reducing the load to where the athlete experiences no pain. Based on clinical experience from Winters (2019) the author recommends not exceeding a pain score of two on a zero to ten pain scale while performing physical activity.

Notwithstanding the above literature in support of rehabilitation, stretching, strengthening, mobilisation and manipulation in the treatment of MTSS TII, a retrospective observational study of male and female service members with MTSS TII, it was noted that a rehabilitation programme, showed no significant changes in pain reduction (the NPRS) (Meulekamp *et al.* 2016). Other outcomes measures are therefore needed to review the effectiveness of these various clinically pragmatic protocols that are being utilised in MTSS TII. Additionally, it needs to be considered that Winters (2017) noted in a systematic review that rehabilitation programmes that focus on bone recovery seem most suitable as MTSS TII is most likely a bony overload injury. Winters (2017) noted that stretching, mobilisation and rehabilitation leads to the muscle applying tension on the bone. Increased stress on a bone facilitates bone healing which results in bone recovery. The limitation however resides in the fact that clinical measurement in changes related to this outcome may be clinically inaccurate (Wilder and Sethi 2004; Winters 2019) and expensive. Also measuring bone recovery, may not correlate with the pain complaints that the patient presents, making it difficult to motivate for this clinical measurement outcome to the patient.

2.2.10.5 Manual Therapy (Including Manipulation and Mobilisation)

Dysfunction in the kinematic chain may be corrected through manual therapy (Gyer *et al*. 2019; Petersen and Bergman 2002). The different therapies include manipulation, mobilisation and various manual physical therapies (Vernon and Schneider 2009). These are used to correct musculoskeletal abnormalities of the spine, sacroiliac joints, pelvis, extremities and other muscle imbalances (Knight 2010; Brantingham *et al*. 2012). These therapies help to regain full range of motion, improve symmetry of soft tissue and muscles, and allow the body to function as a unit (Sievers 2019).

In terms of MTSS TII, Austin (1996) states that adjustive techniques can be used to enhance muscle relaxation, circulation and pain reduction (Leach 2004). In a case study with one male participant, spinal manipulation as well as extremity manipulation was used in conjunction with other interventions. The patient was able to complete a marathon after 12 weeks of care, however causality is difficult to determine between manipulation and return to full activity as multiple interventions were applied (Austin 1996).This doubt is further implied in the study by Sievers (2019), who found that the relationship between previous incidents of medial tibial pain, ankle dorsiflexion and hip internal/external rotation in track and field athletes was not present (Sievers 2019). This questions the need for joint manipulative/mobilisation procedures as a component of care in patients with MTSS TII.

This contrasts a systematic review that concluded that MTSS TII could potentially benefit from manipulation and ischaemic pressure for immediate pain relief but there is limited evidence for long-term pain relief (Knight 2010; Vernon and Schneider 2009).Therefore, more studies into evaluating the effectiveness of manipulation and mobilisation in the treatment of MTSS TII are needed.

Other forms of manual therapy that are employed in clinical practice include ischaemic compression (practitioner applied and patient applied) (Knight 2010; Vernon and Schneider 2009), active release (George *et al*. 2006), passive release (Park *et al.* 2010) and dry needling options (Payne 2007) directed at the muscular component of MTSS TII.

Self-myofascial release, better known as foam rolling can be used to improve flexibility, recovery and athletic performance (Schroeder and Best 2015). This manual therapy technique can be used to release tight fascia of the lower leg (Alfayez *et al.* 2017). In a study done by Aune *et al.* (2019) on 23 elite soccer players it showed that dorsiflexion range of motion improved when foam rolling was done daily on the gastrocnemius. However, when this was compared to eccentric training, possible sustained improvement may present in comparison to foam rolling. This may be related to the active component of muscle activation in eccentric training as compared to the passive muscle involvement in foam rolling. This assertion however requires further investigation.

Another method to address the muscular component in MTSS TII is dry needling, which is applied by a solid needle that is inserted to stimulate a relative area (Travell, Simons and Simons 1999). Needling for MTSS TII can be applied in two ways – to relieve muscle spasm (dry needling (Travell, Simons and Simons 1999)) and to reduce periosteal inflammation (periosteal pecking (Robertson 2003)) – each of which include a therapeutic effect of pain suppression. This is affected through mechanical stimulation, which results in central pain suppression (Gyer *et al.* 2019; Melzack and Wall 1976), in addition to the fact that deep

stimulation of the needle leads to increased blood flow to the area being stimulated. This was evidenced in a MTTS TII clinical trial by Robertson (2003), where it was found that the periosteal pecking group achieved a significantly lower pain score than the control group with regard to the pain disability index (n=44). This was supported by a follow on clinical trial with 45 participants, where it was found that periosteal pecking helps to decrease inflammation and swelling (Payne 2007), which are most likely the causes of the pain (Becker, Nakajima and Wu 2018).

Mobilisation is defined as slow movement of the joint within its normal range of movement (Weerasekara *et al.* 2019). The mechanism of changes seems unclear but it has been proposed by Mullligan *et al*. (2015) in his positional fault hypothesis, that mobilisation corrects a trivial bony incongruity which could have been the source of the patient's pain. In a study done by Weerasekara *et al.* (2019) on patients with tennis elbow (insertional tendinopathy), it was noted that mobilisation was superior to no treatment and had a better long term outcome compared to corticosteroid injection. They also found that patients who were in the mobilisation group sought less additional treatment. In terms of MTSS TII there is no research on the use of mobilisation.

Lastly a fascial distortion model (FDM) addresses the local changes in the lower extremity fascia. It applies targeted manual techniques in non-specific areas which then decreases pain and reduces functional impairments with this symptom complex (Typaldos 1994). FDM is most effective in the acute stage of MTSS TII and its treatment (Thalhamer 2018). Therapy remains until full exercise can be tolerated or there is no pain (Schulze *et al.* 2014). In a prospective case control study with 32 participants it was noted that after the first FDM treatment, the level of pain that was felt was drastically reduced compared to follow up treatments. Thirteen percent of patients reported no symptoms after the initial FDM treatment. Fifty percent of patients reported that they were free of symptoms after three weeks (Schulze *et al.* 2014). According to Thalhamer (2018) there have not been any clinical trials or studies done on the fascial distortion model, which is a significant weakness in the clinical application of this intervention.

2.2.10.6 Kinesio Tape and Other Strapping Techniques

There are different kinds of tape that can be used to strap with. There is traditional tape, that ranges from elastic to rigid and then there is Kinesio tape (Huang *et al.* 2011). Each type of tape has different benefits (Griebert *et al.* 2016).

Kinesio tape imitates the thickness of human skin with its wave-like grain. It is stated that when Kinesio tape is applied with the correct tension, it lifts the soft tissue and fascia, allowing for a potential space below the area of application (Huang *et al.* 2011). The potential space allows

proper circulation and realignment of the fascial tissue, which normalises muscle function and improves symptoms of MTSS TII (Murray 2000). It has been found that Kinesio tape has an immediate beneficial effect on strength, force-sense error and active range of movement. However, the short term effects of Kinesiotape (during and after activity) and the long term implications have not been documented (Griebert *et al.* 2016; Sharma and Sinha 2017). In a study done by Rajaraman and Shroff (2018) on 30 marathon runners, a statistically significant difference was noted due to the effect of Kinesio taping and its effects in helping to alleviate pain by increasing the vascular supply to the painful area. This lead to faster running times and a more comfortable run. The Kinesio tape is believed to help hold the posterior tibialis muscle in position and reduces possible friction caused by muscle movement against the shin bone.

The above principles were seen in the case study, where it was found that when tape is combined with exercise, the support from the tape aids in normal muscle actions. Therefore the patient experienced less pain (Jovicić *et al.* 2014). The findings of a different study involving 40 participants demonstrated that when Kinesio tape was used on individuals diagnosed with MTSS TII, there was a decreased rate of medial plantar loading. This suggests it benefits the patient in that it slows pronation and reduces injury forces. The Kinesio tape did not have any effect on healthy participants (Griebert *et al.* 2016).

Often patients with shin splints are strapped according to the low-dye strapping model that assists in supporting flat feet in patients. The strapping supports the medial arch, which reduces the load on the plantar fascia and limits the internal rotation of the tibia, both of which are thought to increase the tension on the tibialis posterior leading to shin splints (Griebert *et al*. 2016; Jovicić *et al.* 2014). This pragmatic application of strapping to support the biomechanical chain however, requires further investigation in order to determine its clinical effectiveness as well as how it achieves its outcomes.

2.2.10.7 Combination of Interventions

Pragmatically the case studies that are reported for patients suffering from MTSS TII, tend to reflect treatment programmes that include several treatment interventions (Austin 1996; Thistle 2018). Although these treatment programmes most accurately reflect clinical practice, it does not allow for the understanding and extrapolation of information regarding the effectiveness and clinical efficacy of any one intervention (Dagenais and Haldeman 2011). This therefore limits the collective understanding of the individual treatment modalities.

2.2.10.8 Electro-Modalities

Electro-modalities can be classified into different treatment options. These include but are not limited to extracorporeal shockwave therapy (ESWT), transcutaneous nerve stimulation

(TENS), electro-needling, radial soundwave therapy and therapeutic ultrasound (Lindsay *et al.* 1990; Wilder 2014).

Extracorporeal shockwave therapy (ESWT) uses shockwave generation in the area where MTSS TII is most severe. These shockwaves have shown to start tissue repair and regeneration. This has the potential to decrease recovery time and reduce pain of an athlete. The application parameters for MTTS TII in a study done by Gomez Garcia *et al.* (2017) was a single session of 1500 pulses at an energy flux density of 0.20 MJ/mm^{2}and a frequency of 5 Hz generated by an electromagnetic device. In this study of 42 military personal, it was found that the ESWT group showed a significantly greater improvement compared to the control group with regard to the visual analogue scale (VAS) at rest. A study done by Moen *et al.* (2012) indicated that the time it took for patients to recover fully was shorter in the ESWT group compared to the athletes only performing a graded running programme. When 90 participants could choose between a home training programme or the same programme with low energy ESWT, it showed that after 15 months, 85% of participants in the treatment group and 46% in the control group could return to their running at their pre-injury state. This study provides evidence that ESWT is safe and was clinically effective for up to 15 months after injury (Rompe *et al.* 2010). However, these results are limited due to the fact that this study did not include randomisation, placebo groups or sham therapy.

Radial soundwave therapy and ESWT are similar in their actions. The difference is radial 'shockwave' generates sound waves. This requires the need for increased regularity of MTSS TII treatments and more than double the pulses at each session, resulting in a higher energy flux density and a higher frequency (Saxena *et al.* 2017). The results of the case study were limited as the radial soundwave therapy was applied within a programme of treatment and not in isolation. Therefore, it is difficult to determine the degree of contribution to the improvement of the MTSS TII (Saxena *et al.* 2017). A similar study was done on four ballet dancers, indicating a decrease in pain noted at two months from baseline with a 4.8 VAS score. This indicates that Radial Extracorporeal Shock Wave Therapy may be effective in ballet dancers (Tutté and Galin 2016).

Therapeutic ultrasound has two effects: heating and mechanical (Kitchen and Bazin 2007). These effects decrease inflammation, decrease muscle pain and cramps, promote healing and increase the suppleness of muscles (Van Lingen 1998). The heating effect also leads to pain relief (Kitchen and Bazin 2007). For acute MTSS TII treatment, ultrasound is most effective three or more times a week with 10 minutes for each session (Kitchen and Bazin 2007; Van Lingen 1998). In a clinical trial with 28 patients, it indicated that neither the subjective nor the objective results showed any benefit from using ultrasound therapy for individuals diagnosed with MTSS TII (Van Lingen 1998). Ultrasound was effective in a clinical

trial to reduce pain but did not increase the individual's active range of motion (Smith *et al.* 1986).

The therapeutic effect of **TENS** decreases pain and inflammation due to a pain suppressing effect that inhibits mechanisms in the central nervous system (Kitchen and Bazin 2007). This helps to stimulate the release of neurotransmitters that contain opioid peptides that inhibit pain (Kitchen and Bazin 2007). These neurotransmitters also increase the blood flow to the area, which helps with the natural recovery of these specific areas that are targeted. In practice this can be used to decrease pain, decrease inflammation and assist recovery (Kitchen and Bazin 2007; Robertson 2003; Payne 2007).

Electro-needling is when a solid needle is inserted into a tender spot and is then connected to TENS by crocodile clips (Travell, Simons and Simons 1999). The electric stimulation is then applied to the affected area. Combining dry needling with TENS allows the electric stimuli to penetrate the skin better therefore reaching a deeper and larger target level. This leads to targeting a bigger inflamed area and thereby improving the recovery rate. In the case of MTSS TII it helps improve and speed up the treatment (Kitchen and Bazin 2007; Payne 2007). In a study done by Payne (2007) 45 patients were grouped into three different treatment groups: TENS, needling and electro-needling. All three groups showed improvement at the end of the trial. Due to the numerous limitations that included small sample size, opportunity for observer bias, no control group and no standard electrical parameters, the outcomes need to be accepted with caution for these three specific treatments. However, when periosteal pecking combined with therapeutic ultrasound was compared to only therapeutic ultrasound in the treatment of MTSS TII, in Robertson (2003) it was noted that the combination of treatments are more effective. The only drawback to this study is that data was collected within a period of two weeks and there were no long-term follow up consultations available.

Low-level laser is the production of specific frequencies and wavelengths (Farivar *et al.* 2014). Laser can block pain and inflammatory molecules in small tendons and large muscles. A range of wavelengths are used to increase the regeneration and repair process in structures (Nissen *et al.* 1994). Laser can also stimulate fibroblast formation leading to increased wound healing. Based on the decreased pain and inflammation when using low-level laser, this could be an effective treatment of MTSS TII (Farivar *et al*. 2014). In a study done by Nissen *et al.* (1994) no difference was noted between the treatment and sham groups on the ability to return to duty after two weeks.

2.2.10.9 Hyperbaric Oxygen Therapy

Hyperbaric oxygen therapy defined as a treatment inside a hyperbaric chamber in which patients breathe 100% oxygen (Lam *et al.* 2017). When 100% oxygen is administered and the

pressure is elevated to sea level, an increased oxygen supply to hypoxic tissues has multiple beneficial healing effects on tissue in the body (Lam *et al.* 2017). Daily hyperbaric oxygen therapy was given for 50 days to 50 young male army recruits in a study done by Rai *et al.* (2017). Four months after treatment ceased, 43 had rejoined their military training with no pain. Seven recruits indicated pain on walking and received a second session of treatment and three months post treatment were still pain free.

2.2.10.10 Non-Steroidal Anti-Inflammatory Drugs (NSAIDS) and the Application of Medication for MTSS TII

NSAIDs can be used in different forms. They can be taken in pill form or can be applied in the form of a gel (National Pharmaceutical Association 2004). These drugs, once administered, can reduce the inflammation in the body (National Pharmaceutical Association 2004). As hypothesised, MTSS TII involves inflammation, therefore this type of medication may help in the acute phase in the absence of contra-indications for use of NSAIDs (Winters 2017). This assertion has however yet to be tested in clinical trials as its pragmatic use in clinical practice is founded on the assumption that the reduction in inflammation due to the NSAIDs will aid MTSS TII patients in resolving their condition. Additionally the use of NSAIDs is usually in conjunction with other interventions, so its efficacy and effectiveness in resolving MTSS TII is unknown. This is particularly problematic, as many patients perceive potential benefit from this intervention even in the face of side effects that this intervention carries. Therefore, an assessment of the risk-benefit ratio should be considered.

Some practitioners use muscle relaxants to assist with MTSS TII. Muscle relaxants are used to prevent and reduce muscle spasms and spasticity by reducing muscle activation (Babarinde *et al.* 2017). However, there is no evidence in how useful muscle relaxants are specifically for MTSS TII.

Patients who have not benefited from all available conservative treatment have other options before considering surgery or giving up sport. A sub-periosteal **ultrasound-guided injection** of 15% **dextrose** along the length of the symptomatic area could be of benefit. In a prospective case series that included 18 participants, participants indicated a significant improvement in their MTSS TII at an 18 week follow up and a desire to return to sport but not at pre-injury level at a mark 18 weeks and one year later (Padhiar *et al.* 2011). **Cortisone** injections have successfully been used to treat injuries in the lower limb (James *et al.* 2007). There are newer methods available, such as **platelet-rich plasma** and **autologous blood** injections, which stimulate a healing response in injured tissue (Rai *et al.* 2017). In the case of MTSS TII surgeons have proposed to inject the short plantar ligaments to treat laxity and poor mechanics that could add to hyperpronation (James *et al.* 2007).

However, Rai *et al.* (2017) reported that there are no randomised controlled trials to support these different injection techniques for MTSS TII. In a presentation of two cases involving women who received local injections of corticosteroids for treatment of MTSS TII, there was no positive effect noted. Furthermore, considerable tissue atrophy and hypopigmentation of the skin around the injection site was observed (Loopik *et al*. 2016).

2.2.10.11 Footwear, Sportswear and Ergonomic/Orthotic Supports

It is indicated that using the correct footwear can reduce the incidence of MTSS TII (Yamaski 2019). The key factor in choosing shoes is looking for shock absorbing soles to reduce forces that are applied to the lower limb. When a running shoe is selected, the shoe should have a perfect fit with a stable heel counter (Galbraith and Lavallee 2009). Custom insoles could also be made to decrease the mean pressure distributed across the foot in order to diminish tibial stress on the athlete's leg (De la Fuente *et al*. 2019). There are certain forms of footwear that can help with the risk factors mentioned in Section 2.2.6; namely increased BMI, increased navicular drop, increased ankle eversion and ankle inversion (Elattar *et al.* 2018). The effect of these biomechanical changes in the patient with MTSS TII can be reduced with the use of the right footwear (Yamaski 2019).

Compression devices are believed to support and stimulate the gastrocnemius muscle pump, increasing venous return and thereby decreasing leg oedema (Prandoni *et al.* 2004). This allows athletes to perform at the same intensity with less cardiac stress. It may decrease muscular vibrations caused by ground contact on the feet. It could provide protection against leg injuries and improve recovery post-exercise. A study done by Bovenschen *et al.* (2013) studied the effect of compression stockings on lower leg volume and leg complaints in runners during and after exercise. This study was inconclusive, due to a small sample size. The stockings seemed to reduce lower leg swelling after running but did not make a difference to the medial leg pain. Compression stockings are utilised in clinical practice to reduce swelling during activity, improve muscle support and decrease the vibration of tissues secondary to the ground reactive forces (in e.g. running). Therefore it stands to reason that these assertions may assist a patient with MTSS TII in terms of resolving their condition. However, limited research has been done to support this pragmatic approach to the clinical treatment of MTSS TII.

Literature indicates that an athlete with MTTS TII and biomechanical changes present in their foot and ankle complex may benefit from orthotics (Galbraith and Lavallee 2009). Semi-rigid or flexible orthosis would be beneficial for an individual suffering from pes planus or excessive pronation. Forefoot or rear foot malalignments may need a more tailored orthotic (Larsen, Weidich and Leboeuf-Yde 2002; Johnston *et al.* 2006). In a prospective study done on 306

naval participants, it was noted that the study focused on discussing the risk of developing injury in great detail. The recording and reporting of intervention methods became secondary and were not fully discussed (Bonanno *et al.* 2018). In a study done by De La Fuente *et al.* (2018) it was found that the participants who used the custom insoles that distributed the pressure did reduce the impact after rehabilitation of MTSS TII during running. A study done on 23 patients found that 15 participants had a 50% improvement in NPRS score and eight did not experience a 50% improvement in NPRS score (Loudon and Dolphino 2010). In a study done on 100 men it showed that the foot-pressure distribution pattern in the participants with MTSS TII was returned to normal with the use of foot orthotics (Naderi *et al.* 2019). However no comment was made on the clinical changes that occurred due to the orthotic use. In a prospective, randomised, controlled intervention trial by Larsen *et al.* (2002) it was found that wearing custom-made biomechanical shoe orthoses has a positive clinical outcome in young military men with MTSS TII.

The only time crutches might be needed is during a time of temporary non-weight bearing and rest (i.e. severe acute phase). A pneumatic brace may be recommended in severe cases of MTSS TII or when a tibial stress fracture may be indicated (Moen *et al.* 2010). Johnston *et al.* (2006) investigated the use of a leg brace and a rehabilitation programme to determine a difference in time to run and finish an 800 meter lap without pain. Time was not significantly different compared with the control group who did not wear a brace.

2.2.10.12 Surgical Intervention

If all other treatments of MTSS TII fail, surgical treatment is recommended. However, this should be a last resort as there is not much available research on surgical interventions (Yamaski 2019). In a study done by Yates *et al.* (2003) success rates varied between 29%-86%. Limitations in the study by Yates *et al.* (2003) and other studies like this (Holen *et al.* 1995; Couture and Karlson 2002) included determining the effectiveness of the intervention through appropriate outcomes or clinical measures, and the small sample (as few individuals undergo surgery). During the surgical procedure a 2 cm wide strip of periosteum was removed, after which the patient was advised to use crutches for two weeks and after three weeks may resume running in a graded/phased approach. In the study by Yates *et al.* (2003) they found a decrease in symptoms after surgery. The authors mentioned that only 59% of the first subjects reported on their post-operative outcomes. Therefore the level of improvement may be biased in that it is possible that those that regressed did not complete the post-operative outcomes. It was also noted that although athletes reported that their symptoms decreased they could not return to their full pre-operative level of activity. Winters (2019) noted that surgery seems an improbable treatment approach to manage MTSS and should be avoided as a first-line treatment. Nevertheless, surgery could be an option for those who have had

MTSS TII symptoms for more than 12 months and had no relief with the application of conservative treatment. However, athletes must be counselled that full recovery to athletics may not be possible (Yamaski 2019).

2.2.11 Prognosis

Based on the unclear pathogenesis, the difficulty in ascertaining a clear clinical diagnosis and the lack of specific information around the treatment of MTSS TII, there is a large area of uncertainty that surrounds the clinical prognosis of MTSS (Winters 2017). In one controlled study, it was indicated that females with MTSS have a slower recovery time; a mean of 89 days to recovery compared to 64 days for men (Moen *et al.* 2012). In the same study, it was concluded that in order to run 18 consecutive minutes with a pain score of lower than four (out of ten), recovery would consist of 40 to 120 days.However, according to Winters (2017) it is possible that the period of return-to-sport is longer than this proposed day count definition of recovery for the majority of patients.This is possibly due to the fact that the most consistent indicator for improvement is pain, which is not directly linked to or representative of the biomechanical loading model that predisposes the patient to MTSS TII to start with. In addition, the prognosis is often confounded in that patients are known to revert back to old habits, postures and routines in addition to failing to complete full rehabilitation processes after the resolution of their pain. These two points are further complicated by the fact that it is currently impossible to give athletes a detailed and correct prognosis on their recovery and the amount of time before they can return to sport (Winters 2017).

2.2.12 Conclusion

As seen in Section 2.2.10.14, conservative treatment is recommended for 12 months before surgery is considered. Health care workers prefer conservative treatment but with so many different options, and strong evidence for a specific treatment lacking, it is unclear which is the best treatment method to use in clinical practice for MTSS TII.

Practitioners are required to base their treatment on the current best evidence in applying informed consent principles (Melnyk and Fineout-Overholt 2011), allowing patients to make informed choices (Dhai and McQuoid-Mason 2010) and making decisions themselves on the application of the most appropriate care models in the care of patients (Dagenais and Haldeman 2011). The lack of evidence in support of treatment modalities for use in the treatment of MTSS TII makes the clinical decision making process more difficult, potentially allowing for decisions that follow a ‘hit and miss’ principle of patients presenting with MTSS TII (Green 2005). Additionally, it becomes the responsibility of the practitioner to continually critically review the literature for updates in how MTSS TII may be treated for the best clinical outcomes. When this fails, the clinicians often revert to focussing on treating a ‘pathogenic’

structure and applying the appropriate modality, which may not be reasonable in all clinical circumstances (Winters 2018). Alternatively the clinicians apply the principle of treating the patient with any and all modalities available to them in the hope that the combination of effects are likely to result in resolution of the clinical condition (Knight 2010; Pietrzak *et al*. 2014; Sathe 2017). Neither of these instances are necessarily applicable to the patient context and neither can guarantee a high likelihood of resolution of the MTSS TII that the patient presents with.

When there is evidence available, then the clinician needs to understand and interpret this information correctly and accurately, which is compounded by the fact that most randomised control trials suffer with a high risk of bias and often focus on pioneering treatments which leave simple and effective interventions understudied (Winters 2018). It is often unclear in many of the studies as to the required inclusion criteria and it is therefore unknown whether pathology is present in MTSS TI and MTSS TII (Andrews *et al.* 2013). When the hypothesised treatment is focused on treating a 'pathogenic' structure it may not be measured by outcomes that reasonably measure its intended effect (Green 2005). And finally, as MTSS TII is commonly seen as a condition in which over loading is the leading cause, some study types (e.g. observational studies) often include the management of loading, whereas with randomised control trials this is never described (Winters 2018).

In addition, and given the above discussion on the multiple interventions for MTSS TII, it would seem that the majority have little evidence in support of their use and it would be more beneficial for clinicians to have a summary of the evidence available to treat MTSS TII. Winters (2019) states that in the absence of good evidence, practitioners should prioritise evidence from observational studies and clinical reasoning. The reality of practitioners in practice is that they will apply what they think is best, based on what they know or studied in their degree. Research studies are being done regularly on different treatments and their effectiveness, which will provide more accurate information on interventions in the future. The reality of this is unless practitioners read the publications, they are not able to provide patients with proper evidence-based informed consent and up-to-date appropriate treatment. Therefore, this limits the potential clinical outcomes of patients. Thus, this study aims to provide a summary that would allow practitioners to implement the recommendations of the literature for the benefit of the patients and would also provide medical aids, third party payers and others with a vested interest in patient health outcomes with a readily available resource (Liberati *et al.* 2009; Dhai and McQuoid-Mason 2010). This study provides evidence-based general guidelines for treating patients with MTSS TII. Furthermore, there will be informed consent, as both the patient and the practitioner will have adequate information to select the best intervention option. This will also lead to less frustration in athletes and more patient satisfaction (Thornton 2017).

Therefore, clinicians require a systematic review that contains the levels of evidence in support of MTSS TII treatments and their clinical effectiveness. In the next section (Section 2.3) the most common methods used to review studies will be given focussing specifically on the method utilised in this study.

2.3 SYSTEMATIC REVIEW

Moher *et al.* (2009) defined a systematic review as an unambiguous technique that attempts to identify, appraise and synthesise all the empirical evidence that meets pre-specified eligibility criteria to answer clearly articulated question. According to the Cochrane Collaboration (2011) systematic reviews in principal review the extent and level of research evidence. Researchers conducting systematic reviews use obvious methods aimed at decreasing bias, in order to produce more reliable findings that can be used to inform decision-making (Green and Higgins 2011).

Literature needs to be reviewed, as this process plays an important part of appropriate healthcare provision. In this context a literature review is defined as a critical summary and assessment of the current understanding of knowledge of a particular topic (Cano 2002). Literature reviews are grouped into three different categories: narrative, systematic and meta-analyses (Hemingway and Brereton 2009).

- Narrative reviews of literature (also referred to as overviews or traditional/standard reviews of literature) function to critically summarise literature available on a certain topic (Hemingway and Brereton 2009). Although these reviews are functional, they tend to be deficient, because they are often not peer-reviewed, and their results are often not reproducible and subject to personal bias and knowledge (Onwuegbuzie 2016). Additionally, it has been observed that literature reviews may be prejudicial, in that it is trouble-free for the author to pick and cite studies, which support their own opinions and beliefs, and it is rare that literature reviews describe the selection, inclusion and assessment of the specific literature (Babbie and Mouton 2001).
- Systematic reviews seem to replace narrative reviews and expert opinion, as the request for review of literature, with the same rigour as primary research increases (Hemingway and Brereton 2009). Systematic reviews are seen as the gold standard to synthesise the findings of a number of studies, which investigate the same question or disciplines (Boland, Cherry and Dickson 2013). In order to guarantee that systematic reviews conducted are of the best methodological quality, an approved scientific process has been developed (Hemingway and Brereton 2009; Liberati *et al.* 2009).

Systematic reviews follow steps and always require the definition of the problem or question, identify and critically assess the available evidence, synthesise the findings and draw the relevant conclusions (Boland, Cherry and Dickson 2013). A systematic review is a critical summary of available healthcare studies, based on a critical review of their methodology, contextualised in their populations recruited and pitted against the outcomes achieved in the study. They are used to provide a level of evidence and used to make informed recommendations for healthcare. (Lefebvre *et al.* 2011). The limitations of a systematic review are that they are affected by publication bias, language bias, allocation bias, citation bias, design bias, location bias, review bias, reporting bias, selection bias and translation bias (Boutron *et al.* 2019). According to Winters and Weir (2017) publication bias can be reduced if extensive grey literature searches are conducted. They claim that unpublished studies can greatly change effect estimates in systematic reviews.

- Meta-analysis: As defined by the Cochrane Collaboration (2011) is the use of quantitative statistical techniques within a systematic review, which combines the results of the included studies for statistical significance. When two separate studies have a consistent treatment outcome, this type of study can be used to identify this common effect. When the effect differs from one study to the next, meta-analysis may be used to identify the reason for the variation (Borenstein *et al.* 2011). A meta-analysis is useful as it provides an estimate of the relation in a population, estimates are more accurate than a systematic review because of the increased data, hypothesis testing and bias associated with publications can be looked into and it resolves irregularities in research. There are however, a certain number of limitations linked to this type of study, which includethe inclusion of studies that are deficient in internal, external, construct and statistical validity, studies with small sample sizes and lastly, heterogeneity of methods used in studies that may lead to flawed readings and outcomes (Ioannidis and Lau 1999). In addition to the above, it is also a requirement in a meta-analysis that there is at least one outcome measure that is similar to all the studies in order for statistical inferences to be made, thus excluding studies that do not conform to this requirement.

Therefore, knowing that the studies within the MTSS TII domain of research were not likely to meet the requirements of a meta-analysis, it was decided that the best outcome method for both a review of the literature as well as the evaluation of evidence would be a systematic review (Gopalakrishnan and Ganeshkumar 2013).

2.3.1 Procedure for a Systematic Review

When starting a systematic review, the researcher is required to identify a suitable healthcare question or problem. This specific question/problem needs to recognise the objectives of the review, including:

- The evidence that will be addressed or the type of study that is being done (Hemingway and Brereton 2009).
- The criteria of inclusion and exclusion for this study are developed by using the objectives of the systematic review (Hemingway and Brereton 2009).
- A search of the available literature is conducted.

Different styles of literature are included in the search (Lefebvre *et al.* 2011). Published and unpublished literature are diligently searched in order to attain studies which are relevant to the systematic review, and which fall within the inclusion and exclusion criteria determined by the objectives. Database searches need to include as many as available in order to reduce location bias in the review (Boutron *et al.* 2019). Afterwards, a hand-search and searches based on the reference lists of full text articles or other systematic reviews may also be conducted (Hemingway and Brereton 2009).

Once this search has been conducted on multiple databases, and all possible studies that are relevant are identified, they are then reviewed in a selection process for eligibility to be included in the study. Often, studies which are of poor quality will be excluded and later discussed in the study report. This is called a synthesis of the best evidence or exclusion bias. Exclusion bias is defined as the bias that is introduced when a selection is made of individuals, groups or data for analysis, in such a way that proper randomisation is not achieved (Tierney and Steward 2005). This leads to the obtained sample not being representative of the population that is intended to be analysed in a systematic review. Another option is to include all studies, both bad and good, in a review, which leads to a comprehensive synthesis of evidence around a specific topic (Chan *et al.* 2004). All the data from the study will be sourced and extracted into data tables by way of reviewer feedback. The articles that are included are typically reviewed against published criteria by a minimum of two individual reviewers (Green and Higgins 2011; Hemingway and Brereton 2009; Liberati *et al*. 2009).

There are various scales used to test the methodological rigour of each article included in this study (Liberati *et al.* 2009; Moher *et al.* 2015). Typically, these scales are designed to assess a particular study type. This will now be discussed below.

Systematic analysis of randomised controlled trials

The Centre for Reviews and Dissemination (Liberati *et al.* 2009) describes RCTs as group trials, where suitable applicants are randomly assigned to two or more groups: one receiving the intervention that is being tested, and the other (control group) receiving an alternative treatment. They then receive treatment according to the group they were assigned to, and assessments between the different groups are measured to assess the effectiveness of the intervention (Kendall 2003).

Scales utilised to evaluate the RCTs:

RCTs are evaluated using the PEDro scale (PEDro scale 1999).The following additional scales can also be used to measure the methodological rigour: Jadad Scale, Maastricht scale, Reisch Scale, Tyson scale. These were not used in this dissertation as they mostly do not apply to manual therapy and may not be sufficiently developed or tested for their reliability and validity (Olivo *et al.* 2008).

The PEDro scales demonstrates 'fair' to 'excellent' inter-rater reliability for RCTs. The inter-rater reliability for this scale has indicated it boosts with an agreement rating of more than two raters in a group.There is sufficient evidence for construct validity for this scale and the sum of all of its parts can categorise between high-quality and low-quality trials (Cashin and McAuley 2020).

Discussion of the PEDro Scale (PEDro scale 1999):

The PEDro Scale comprises 11 specific criteria, with each criterion being used to establish the study's methodological strength. For each fulfilled criterion, one point may be awarded, with a maximum score of 11 and a minimum score of zero. By awarding a point for each fulfilled criterion, each reviewer achieves a score out of 10 and a mean score is calculated. This is achieved through calculating the end score for each of the three reviewers. The methodological rigour of the study can be assessed by considering the mean score. Should a score of 11 be attained, the highest level of methodological rigour can be assumed. Conversely, should a mean score of zero be achieved, an indication of the lowest level of methodological rigour can be assumed (PEDro scale 1999).

Systematic analysis of Quasi-experimental trials

Non-randomised control trials containing experimental study participants are allocated to different interventions using a method that is not random. The investigator manages and

decides on the allocation. This can lead to bias in the results of a trial (Sedgwick 2014). **Pre-post-test experimental studies** are described as pre-post studies where the contrasts between results of the participants, prior to and after treatment or intervention are documented (Green and Higgins 2008). **Interrupted time series** are planned to administer several treatments or interventions over a period that is 'interrupted' commonly by the intervention or treatment that has been decided on (Green and Higgins 2008).

Scales utilised to evaluate the Quasi-experimental studies:

Quasi-experimental studies are evaluated using the Newcastle-Ottawa scale (Wells *et al.* 2003). The following additional scales can also be used to measure the methodological rigour: Cowley scale, Downs scale, Thomas scale, Zaza Scale. Based on the design of this particular study, these additional scales were not chosen due to their lack in being applied to manual therapy, style of reporting, external validity and the power of the scale (Quigley *et al.* 2018).

Discussion of the New-Ottawa scale (Wells *et al.* 2003):

The Newcastle-Ottawa scale (NOS) contains three sub-sections, viz. selection, comparability and exposure. These sections contain eight items/questions. Points are awarded for each item. Selection and exposure can each be awarded a maximum of one point per item, while comparability may be allotted a maximum of two points. A study may be allowed a maximum of nine points. By awarding a point for each fulfilled criterion, a mean score is calculated. This is achieved through calculating the end score for each of the three reviewers. The methodological rigour of the study is assessed by considering the mean score. Should a score of nine be attained, the highest level of methodological rigour can be assumed. Conversely, should a mean score of zero be achieved, an indication of the lowest level of methodological rigour can be assumed. (Wells *et al.* 2003).

The reliability of the NOS ranges from fair to almost perfect. The validity and the association of the sum of all the parts in the NOS score between two or more in a group amounts from fair to moderate (Hou *et al.* 2010).

Systemic analysis of observational studies

Observational studies can be classified as either a case report, case series or cohort study. Both of these studies are non-comparative and have a small sample size (Deeks 2003).

A **case report** is defined as the smallest publishable unit and consists of a singular patient that follows the clinical course. This may include specific exposures, symptoms, signs, outcomes and interventions. A **case series** is defined as an accumulation of individual case reports into one publication. **Cohort studies** are described as studies where the behaviour of

the researched participants are observed over a period of time, without any influence from the researcher (Deeks 2003).

Scales utilised to evaluate the observational studies:

Observational studies can be evaluated using the Liddle scale (Liddle *et al.* 1996). The following additional scales can also be used to measure the methodological rigour: NICE Methodology Checklist for case control, Newcastle-Ottawa Scale, SIGN. Due to the wide variable inconsistency, possible bias and that some of these tools cannot be applied to manual therapy, it was decided to not use these tools for this study (Sanderson *et al*. 2007).

Discussion of the Liddle scale (Liddle *et al.* 1996):

The Liddle scale is made up of criteria that are set out in question form to assist the reviewer in identifying whether the researchers have addressed possible opportunities for bias in the design and conduct of the study or review. In the checklist for intervention guidelines and recommendations, evaluation criteria are also in the form of questions, which aid the reviewer in assessing whether appropriate procedures have been followed to ensure the guidelines or recommendations will benefit (and not harm) the target population. This scale has no right or wrong answers and is based on what the reviewer thinks is correct. Evaluation criteria are coded according to the extent to which the criteria are fulfilled. This scale has a high risk of bias (Liddle *et al.* 1996).

Lang and Kleinjnen (2010) states that there is no gold standard that is used to evaluate whether scales for observational studies are of the correct quality (external and internal validity).

Once each of the articles have been reviewed by the above scales and their level of rigour have been determined, comments can be made regarding the contribution of each article in terms of the evidence it provides in support or not in support of the intervention that was tested.

Table 2.3: Possible ranking outcomes of the individual articles reviewed in this study

	Good methodological rigour	**Poor methodological rigour**
Good Clinical Outcomes	A well designed study that supports positive clinical outcomes for the intervention tested	A poorly designed study that supports positive clinical outcomes for the intervention tested
Poor Clinical Outcomes	A well designed study that does not support positive clinical outcomes/shows no change or negative clinical outcomes for the intervention tested	A poorly designed study that does not support positive clinical outcomes/shows no change or negative clinical outcomes for the intervention tested

Thereafter, the articles may be grouped per intervention for MTSS TII. This collection of articles can then be evaluated in terms of the collective evidence that they present with regard

to the intervention tested. There are several possible mechanisms by which this can be done, viz. the system suggested by Foley *et al.* (2003), the AGREE system presented by Dagenais and Haldeman (2011) or the GRADE system presented by Brozek *et al.* (2009). These will be discussed below.

Evaluation of evidence

MTSS TII will be discussed and graded according to a grading system. Each of these grading systems rank evidence based on a specific domain:

- Foley *et al.* (2003) – this grading system utilises a scoring system divided in level of evidence (five stage level) and then denotes whether the evidence is conflicting or not. However, this scoring system is generally utilised in the context of post stroke (neurological insult) and the specific context of shoulder rehabilitation in these patients. This system only utilised randomised control trials.
- Dagenais and Haldeman (2011) – this grading system utilises a scoring system divided in level of evidence (six levels of evidence) and then denotes whether the evidence is conflicting or not. This considers that manual therapy interventions are generally impossible to blind and therefore does not allow for a no evidence category, so is in general more lenient. This scoring system is generally utilised in the context of manual therapy.
- GRADE system (Brozek *et al.* 2009) – this grading system utilises a scoring system divided in level of evidence (three grades) and then denotes whether the evidence is conflicting or not. This considers the manual therapy interventions, but is more strict in terms of the grades (viz. they are stricter in terms of the conclusions that can be drawn based on the available evidence). For example, Foley *et al.* (2003) or Dagenais and Haldeman (2011) may require two RCTs to show good evidence, whereas this grading system requires three. This scoring system is generally utilised in the context of clinical interventions and practice.

Foley *et al.* (2003) along with Dagenais and Haldeman (2011) uses a grading of evidence that is welcomed by health care providers and is less complex compared to the Cochrane GRADE system (Brozek *et al.* 2009). The GRADE system focuses on providing a uniform method when creating healthcare guidelines. This leads to a higher level of complication.

Foley *et al.* (2003) and Dagenais and Haldeman (2011) include a category which incorporates a tool to indicate whether the evidence offered, agrees or conflicts within the clinical category being assessed. This leads to the possibility of the researcher indicating that there is no evidence accessible by the articles in the specific clinical category.

2.4 CONCLUSION

As can be seen from the presentation in Chapters One and Two, systematic reviews provide a summary of the evidence available, by showing the methodological rigour of single studies (scale review of the article/study) and groups of studies within a particular domain (e.g. the use of manipulation in the treatment of MTSS TII which may have several case studies, a randomised controlled trial and a non-randomised trial as evidence) which is relevant in determining whether scientific findings are consistent and reproducible across various factors (populations, settings, treatment variations) and take into consideration the findings for an independent topic, such as MTSS TII.

This allows for clinical practitioners to keep up to date with current knowledge (Hemingway and Brereton 2009; Green 2005; Mulrow 1994). Systematic reviews are also useful in that they provide a starting point for the development of standard clinical guidelines for practice (Moher *et al*. 2009); as engaging evidence from trustworthy research, in the form of a systematic review (for MTSS TII), secures the best practice and standardisation in health care practice (Green 2005).

It is predicted that the results found through a rigorous systematic review process has increasing benefits for several stakeholders (Büttner *et al.* 2020).

- Health care professionals use them to update their clinical decisions (Ardern *et al.* 2017), improve the informed consent process in their practices and allow for the empowerment of patients as they have access to appropriate information in which to consider their further care options (Dhai and McQuoid-Mason 2010). Additionally, the 'hit and miss' approach becomes minimised and the prognosis for individual patients becomes easier to define (Green 2005).
- Researchers depend on these reviews to see knowledge gaps in current literature (Cooper *et al.* 2005). According to Mulrow (1994) the main use of systematic reviews is to improve hypotheses via identification and justification, and to identify issues in previous studies, which will then show weaknesses for future studies to address. This permits systematic reviews as an important step in research, in order to promote future studies, with strengthened methodological quality and therefore strengthened evidence-based outcomes.
- Health policymakers use them to update practice legislation and guidelines (Andrews *et al.* 2013). Lastly, patients are empowered by these reviews that evaluate the benefit and harm of possible outcomes of the existing management tools (Hewlett *et al.* 2006).

A systematic review of the conservative management of MTSS TII may act to recommend the use of conservative interventions, by demonstrating cheaper and better clinical care (Hemingway and Brereton, 2009). Conservative care is often the first protocol in management of MTSS (Pietrzak 2014; Smith, Coates and Creaby 2014; Bonanno *et al.* 2015). Therefore, this study, through a systematic review (Moher *et al.* 2009), will allow an evidence-based quality assessment of conservative interventions available, thereby helping clinical practitioners with clinical decision-making.

In a similar context, Winters *et al.* (2013a) completed a systematic review concerning the treatment of MTSS. However, this review only considered 11 trials (Winters *et al.* 2013a) which included only randomised controlled clinical trials and non-randomised controlled clinical trials that were evaluated with particular reference to effects on pain, time to recover or global perceived effect.

Pressure for evidence-based protocols that are cost effective are increasing (Dagenais and Haldeman 2012). More patients are taking the complementary and alternative therapies route (National Centre for Complementary and Alternative Medicine 2004; National Pharmaceutical Association 2004), which are mostly conservative therapies, in the management of conditions such as MTSS TII. When practitioners do not have clear guidelines, they are obligated to address MTSS TII in practice without prescribing conservative evidence-based management protocols (Moen *et al.* 2012; Schulze *et al.* 2014; Martinez *et al.* 2020) before they consider surgical intervention. There is a small amount of literature and clinical trials that support invasive use (Galbraith and Lavallee 2009). This leads to a clinical dilemma. The treatment of patients should involve the patients' best interests and not medical schemes and other stake-holders' best interests (Dagenais and Haldeman 2012). A systematic review looking at the most effective conservative treatment for MTSS TII would help in developing patient outcomes for therapists and other healthcare practitioners, which have clear guidelines in one place with high-quality information to treat this complex condition.

CHAPTER THREE RESEARCH METHODOLOGY

3.1 INTRODUCTION

In this chapter the methodology that was used in this study is described and the search for the literature is outlined. This chapter identifies the study selection, defines the exclusion and inclusion criteria, and describes how the data was extracted and evaluated, and the synthesis of the results.

3.2 STUDY DESIGN AND APPROVAL

Quantitative paradigm study using a systematic review approach without the completion of a meta-analysis. This systematic review based on the PRISMA statement (Liberati *et al.* 2009; Moher *et al.* 2009), was approved by the Research and Higher Degree Committee (RHDC) of the Durban University of Technology (DUT) (Appendix A). This study did not need approval from the Institutional Research Ethics committeeas the RHDC has the responsibility of level one studies, i.e. studies that do not involve human participants (Appendix A). A systematic review does not need participants to partake in the study. The study required the assistance of reviewers but they were not seen as participants (Boland, Cherry and Dickson 2013).

3.3 PERMISSION OBTAINED

1. Approval from the Faculty Research Committee at the Durban University of Technology was required prior to the initiation of the study protocol involving the review of articles and reviewer selection (Appendix A).
2. Agreement from the selected reviewers was established using a Memorandum of Agreement (MoA) (Appendix B).
3. Copyright permissions were obtained prior to the distribution of articles to the reviewers (Appendix C).
4. The study was registered with PROSPERO (Appendix D).

3.4 CHARACTERISTICS OF THE ARTICLES TO BE INCLUDED IN THE REVIEW

Based on the aims and objectives of this study the following inclusion/exclusion criteria were developed:

3.4.1 Inclusion of Citations

1. All relevant citations had to be available in electronic format in order to obtain the citations (Green and Higgins 2011).
2. Citations required the following relevant keywords: Treatment such as 'conservative treatment', 'strapping', 'stretching', 'mobilisation', 'KT tape' ,'electro-modalities', 'ultrasound', 'orthoses', 'chiropractic', 'shockwave treatment', 'physical therapy' and 'rehabilitation' and one of the following:'medial tibial stress syndrome', 'shin splints', 'exercise induced leg pain', 'periostitis', 'soleus syndrome', 'chronic periostalgia' (Galbraith and Lavallee 2009; Winter *et al.* 2013).

3.4.2 Exclusion of citations

1. Any citation that could not be obtained by the researcher and/or the librarian, viz. an opinion paper, web articles and unpublished studies (Green and Higgins 2011).

3.5 PRELIMINARY SEARCH

3.5.1 Database Search

A literature review was conducted on multiple search engines/databases: PubMed, Scopus and CINAHL using the relevant key search terms in order to obtain citations that were in accordance with the established inclusion and exclusion criteria.

3.5.2 Search Terms

The following key terms were searched to identify articles relevant to the research:

a) 'medial tibial stress syndrome', 'shin splints', 'exercise induced leg pain', 'periostitis', 'soleus syndrome', 'chronic periostalgia' (Galbraith and Lavallee 2009; Winter *et al.* 2013).

And

b) 'conservative treatment', 'strapping', 'stretching', 'mobilisation', 'KT tape' ,'electro-modalities', 'ultrasound', 'orthoses', 'chiropractic', 'shockwave treatment', 'physical therapy' and 'rehabilitation' (Galbraith and Lavallee 2009; Winter *et al*. 2013).

Table 3.1 contains the total number of citations per search engine:

Table 3.1: Total number of citations per search engine

Search engine	CINAHL	PubMed	Scopus
Citation number	36	50	142

The above citations were further screened in order to identify which articles met the relevant inclusion and exclusion criteria. A process of removing the 70 duplicate articles was initiated.

3.6 STUDY SELECTION OF ARTICLES

Citation lists were generated from the above database search (Table 3.1) which was further reviewed by the researcher (Appendix E) to identify articles, which fell within the inclusion criteria. Full abstracts of the articles were then obtained.

3.6.1 Inclusion and Exclusion of Abstracts

Inclusion of abstracts

1. The abstract had to comply with the inclusion and exclusion criteria stated in step one.
2. It had to comply with the relevant search terms such as: ‘conservative treatment’, ‘strapping’, ‘stretching’, ‘mobilisation’, ‘KT tape’ ,’electro-modalities’, ‘ultrasound’, ‘orthoses’, ‘chiropractic’, ‘shockwave treatment’, ‘physical therapy’ and ‘rehabilitation’ and one of the following: ‘medial tibial stress syndrome’, ‘shin splints’, ‘exercise induced leg pain’, ‘periostitis’, ‘soleus syndrome’, ‘chronic periostalgia’ (Galbraith and Lavallee 2009; Winter *et al.* 2013).
3. Studies had to be in English or translated to English.
4. The types of studies included in this review included randomised controlled trials, non-randomised controlled trials, case studies and case reports.

Exclusion of abstracts

1. Non- English abstracts/articles (Green and Higgins 2011).
2. The abstracts that stated that the treatment was applied to non-human or child participants.
3. The abstract that stated that the treatment was not conservative (see glossary of terms) in nature.
4. An abstract that stated that the initially screened citation was actually a systematic review, commentary paper or meta-analysis.

Table 3.2 contains the total number of included abstracts per search engine:

Table 3.2: Total number of included abstracts per search engine

Search engine	CINAHL	PubMed	Scopus
Abstract number	4	3	27

3.6.2 Full Text Article per Search Engine

This step included reviewing the above abstracts (Table 3.2) as full text articles to identify whether they adhered to the inclusion criteria.

Inclusion criteria

1. The articles had to be in English or translated into English in order to prevent translational bias (see glossary of terms) and reduce time and cost involved in translating non-English articles (Green and Higgins 2011).
2. Articles had to be acquired from an electronic source in order to access their citations and abstracts or be convertible to an electronic medium.
3. Articles obtained from databases within the DUT library and external networks were included.

Exclusion criteria

1. Any non-English articles due to translational bias (see definition in definitions list), reduce time and cost involved in translating non-English articles (Green and Higgins 2011).
2. Previously conducted systematic reviews and literature reviews, government gazettes, blogs, websites or articles containing any expert opinions (Liberati *et al.* 2009; Harris 2013).
3. Studies conducted on non-human/ child participants.
4. Duplicate studies found during the search process.

Table 3.3 indicates the number of full text articles identified per search engine:

Table 3.3: Number of full text articles identified per search engine

Search engine	CINAHL	PubMed	Scopus
Number of articles	3	1	18

The final number of articles included in this review, prior to this hand search is 24.

3.7 SECONDARY HAND SEARCH

A hand search was conducted in compliance with the inclusion and exclusion criteria found in steps one to three above, in which further relevant articles were searched for inclusion into this systematic review. The external reviewers each received a list of articles for inclusion into this study and they could source and supply further articles that they deemed appropriate for inclusion into this systematic review.

Table 3.4: Hand search article process and results

Numberfound	Abstracts searched	Full article	Used
17	14	10	10

These articles were further assessed to produce a master list of articles (Appendix F), which included those articles that fell within the inclusion criteria, but excluded the duplicated articles. The articles reflected in the master list were then divided into study types (NRCTs, RCTs and observational studies).

Table 3.5 indicates the number of final articles per study type:

Table 3.5: Number of final articles per study type

Study type	RCT's	NRCT's	Observational studies (Case reports/ Case series)
Full number of articles included	8	9	13

At review stage, one article was excluded on consensus, based on the nature of MTSS TII in this study (i.e. it was deemed that the anterior tibialis was involved where all other studies included involvement of the posterior tibialis muscle). Therefore, the number of articles per study type is as follow: RCT=8, NRCT=9 and Observational studies=13.

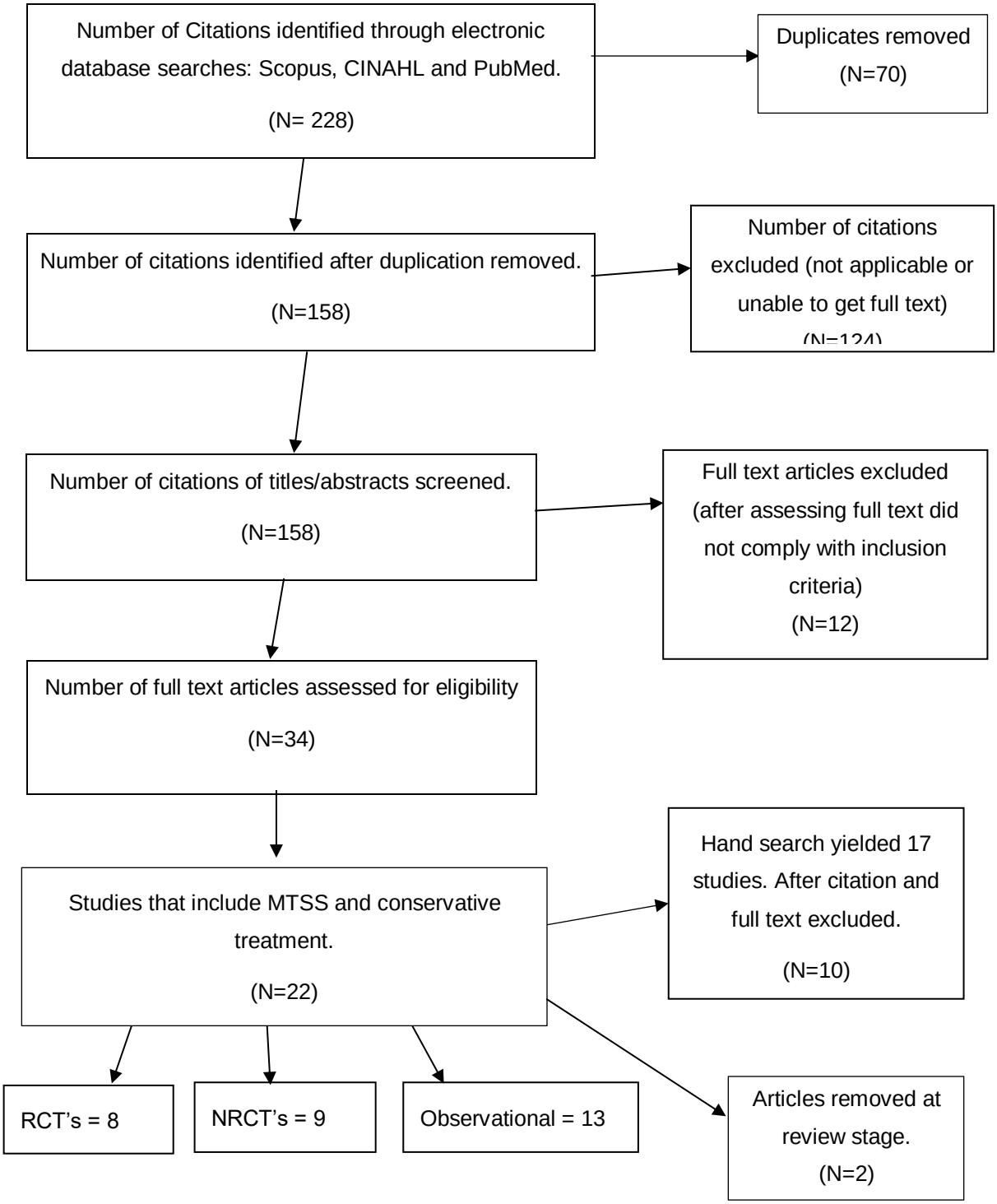


Figure 3.1: Flow diagram illustrating search strategy based on the PRISMA statement (Appendix G)

3.8 QUALITY ASSESSMENT

3.8.1 Study Types and Measurement Tools

There are various scales used to test the validity and reliability of each article included in this study (Liberati *et al.* 2009; Moher *et al.* 2015). Each study type has a specific set of scales used to review a particular field of study. Studies were allocated by study type divisions, for assessment purposes and according to:

A. Randomised Control Trial – The PEDro Scale (Appendix H) was used to assess the RCTs. A total number of eight RCTs were included in this study.

According to Moher *et al.* (2009) the PEDro Scale achieved a rating for individual scale items of 'fair' to 'substantial', with the overall PEDro Scale score achieving a reliability rating of 'fair' to 'good', with a total ICC score of 0.56 reported. Moher *et al*. (2009) therefore found that the PEDro Scale is adequate for use in calculating the quality of RCTs, and for use in systematic reviews.

Randomised controlled trials were reviewed using the PEDro Scale (1999). The PEDro Scale consists of 11 individual criteria. Each section is employed to establish the methodological strength of the study being reviewed. One point is awarded per criterion fulfilled. This means that a maximum score of 11 or a minimum score of zero can be achieved.

The criteria comprising the PEDro Scale are as follows:

1. Inclusion criteria and selection of participants is described.
2. Random allocation of participants to their study group.
3. Concealment of allocation to groups.
4. Study groups are similar at baseline, specifically, with regards to prognostic indicators.
5. All participants were blinded as to the intervention they received.
6. Therapists administering therapy were blinded.
7. All assessors who measured at least one key outcome were blinded.
8. Measures of at least one key outcome were obtained from 85% or more of the participants allocated to the groups.
9. All participants, from whom measures were taken, received treatment/were allocated to the control group. In the event that this was not the case, data for at least one outcome was analysed by 'intention to treat'.

10. Statistical comparisons (between control and intervention group) for at least one key outcome is reported.

11. The study provided point measures (measure of the size of the treatment effect), as well as measures of variability (standard deviations, standard errors, confidence intervals, interquartile ranges/quantile ranges and ranges)for at least one key outcome.

For each question that was sufficiently fulfilled (on a literal reading of the trial report), a point was awarded. A mean score was then calculated for a minimum of two reviewers. Therefore, the mean score indicates the methodological rigour of the study. The highest possible level of methodological rigour is a mean score of eleven and the lowest possible level of methodological rigour is a mean score of zero.

B. Non-Randomised Control Trial – The Newcastle-Ottawa Scale (NOS) (Appendix I) was used to assess the NRCTs in this study. A total of nine NRCTs were included in this study.

The Newcastle-Ottawa Scale has been approved by the Cochrane Collaboration (Green and Higgins 2011) who established that the Newcastle-Ottawa Scale was easy to use and suitable for use in systematic reviews.The verification and the inter-rater reliability of the NOS were rated as being strong, achieving an ICC of 0.94 by Wells *et al.* (2003).The review and improvement of this scale has continued (Wells *et al.* 2003).

C. The Newcastle-Ottawa Scale was used to review the non-randomised controlled trials (Wells *et al.* 2003). The Newcastle-Ottawa Scale is divided into eight items, that are subdivided into three categories, viz. selection, comparability and exposure.

For each of these eight items, there is a diversity of response possibility; only one response (a, b, or c, etc.) is to be selected, the comparability section is the only exception, where one, two or no response can be selected. One point is then granted for each item, excepting comparability, which allows for two points to be granted. Nine points is the maximum that one study can be granted.

The individual criteria for the Newcastle-Ottawa Scale are as follows: (Wells *et al.* 2003)

- **SELECTION:**
    - Is the case definition adequate?
        - Some independent validation is required (e.g. more than one person/record/time/process to extract information/reference

toprimary record source such as X-rays or medical/hospital records) – One point awarded.

- Record linkage (e.g. ICD codes) or self-report with no reference to primary record.
- No description.

- Representativeness of the cases:
  - All eligible cases with outcome of interest over a defined period of time, all cases in a defined catchment area, all cases in a defined hospital or clinic, group of hospitals, health maintenance organisation, or an appropriate sample of those cases (e.g. random sample) – One point awarded.
  - Not satisfying requirements in part (a) or not stated.
- Selection of controls. This item assesses whether the control series used in the study is derived from the same population as the cases and essentially would have been cases had the outcome been present:
  - Community controls (i.e. same community as cases and would be cases if had outcome) – One point awarded.
  - Hospital controls, within the same community as cases (i.e. not another city) but derived from a hospitalised population.
  - No description.
- Definition of controls:
  - If cases are first occurrence of outcome, then it must explicitly state that controls have no history of this outcome. If cases have new occurrence of outcome, then controls with previous occurrences of outcome of interest should not be excluded – One point awarded.
  - No mention of history of outcome.

- **COMPARABILITY**
  - Comparability of cases and controls on the basis of the design or analysis
    - A maximum of two points can be awarded in this category. Either cases or controls must be matched in the design and/or confounders must be adjusted for in the analysis. Statements of no

differences between groups or that differences were not statistically significant are not sufficient for establishing comparability.

- **EXPOSURE**
    - Ascertainment of exposure
        - Secure record – One point awarded.
        - Structured interview where blind to case/control status – One point awarded.
        - Interview not blinded to case/control status.
        - Written self-report or medical record only.
        - No description.
    - Same method of ascertainment for cases and controls
        - Yes – One point awarded.
        - No.
    - Non-response rate
        - Same rate for both groups – One point awarded.
        - Non respondents described.
        - Rate different and no designation.

For each criterion that was adequately fulfilled, a point is granted. A mean score was calculated from the end score for each of the reviewers. A higher mean score means a better methodological rigour of the study. A mean score of nine shows the highest possible level of methodological rigour was obtained. A mean score of zero indicates the lowest possible level of methodological rigour.

D. Observational Studies – The Liddle Scale (Appendix J) was used to assess the observational studies in this study. A total number of 13 observational studies were included in this study.

The Liddle scale was developed using The Method for Evaluating Research and Guideline Evidence (MERGE) principals (Liddle *et al.* 1996). MERGE uses a transparent and standardised method of approach to advanced reviewing of scientific evidence. This method was evolved in order to evaluate the quality of evidence of studies and to standardise, in order to guarantee consistency by people using the scale. MERGE was developed by the New South Wales Health Department with input

from the Cochrane Collaboration, countless epidemiologists and clinicians. The MERGE checklist has been embraced by the Scottish Intercollegiate Guidelines Network as the accepted method of evaluation of observational studies.

The overall assessment of quality is determined by the different evaluation criteria and a judgement about the relative importance of each source of bias. This will include to what extent potential biases may collectively influence results. The totality of the criteria of the scale allows for overall assessment of the publication under review. Therefore, the Liddle scale is a straight-forward approach to evaluating evidence and establishing the quality of a study, based on sound epidemiological principles (Liddle *et al.* 1996).

The analysis of case studies/case series and observational studies are discussed together in this discussion.The Liddle scale (Liddle *et al*. 1996) is used to review both study types, with only one criterion that is different which is shown below.The Liddle scale is composed of 12 individual criteria, for case studies/series and 13 individual criteria for observational studies.

- The satisfaction of each criterion is done with the use of codes:

Table 3.6 contains coding for evaluation criteria – Liddle scale:

Table 3.6: Coding for evaluation criteria – Liddle scale:

Evaluation criteria are coded according to the extent to which the criteria are fulfilled	**Code**
Criterion entirely fulfilled	a
Criterion mostly fulfilled	b1
Criterion mostly not fulfilled	b2
Criterion not at all fulfilled	c
Criterion not described adequately to classify as a, b1, b2 or c	?
Criterion not applicable	n/a

Adapted from: Liddle *et al.* 1996.

Table 3.7 contains the description of Codes A, B1, B2 and C – Liddle scale:

Table 3.7: Description of Codes A, B1, B2 and C – Liddle scale

Low risk of bias	A	All or most evaluation criteria from the checklist are fulfilled. Where evaluation criteria are not fulfilled, the conclusions of the study or review are thought very unlikely to alter.

Low-moderate risk of bias	B1	Some evaluation criteria from the checklist are fulfilled. Where evaluation criteria are not fulfilled or are not adequately described, the conclusions of the study or review are thought unlikely to alter.
Moderate-high risk of bias	B2	Some evaluation criteria from the checklist are fulfilled. Where evaluation criteria are not fulfilled or are not adequately described, the conclusions of the study or review are thought likely to alter.
High risk of bias	C	Few or no evaluation criteria fulfilled. Where evaluation criteria are not fulfilled or are not adequately described, the conclusions of the study or review are thought very likely to alter.

Adapted from: Liddle *et al*. 1996.

The criteria composing the Liddle scale are as follows:

- Adequate description of participants, in terms of time, place and person.
- Percentage of individuals that refused to participate.
- Measurement of outcomes in standard, valid and reliable way.
- Measurement of outcomes same for the intervention and control group.
- Factors, excluding the intervention, are comparable between the intervention and control groups.If these factors are not comparable, are they adjusted for in the analysis?
- Percentage of loss to follow-up.
- Analysis is by intention to intervene/treat. This criterion only applies to case studies/series.
- Homogenous results between sites (if study is a multicentre/multisite study).
- Extent that study minimised bias.
- Overall effect of study as the result of the tested intervention.
- Are there any practical or ethical issues that prevented an RCT being carried out?

The awarding of an ‘A’ indicated that the criterion reviewed had the strongest possible methodological rigour, in comparison to an ‘I’, which indicates the weakest possible methodological rigour. Strength of methodological rigour is ranked in decreasing strength in the following order: A, B1, B2, C and I. An ‘n/a’ was reported in the event that the criterion did not apply to the study being reviewed.

The feedback from the minimum number of reviewers is accumulated and forms a summary of evidence. This summary is discussed with relevance to the clinical effectiveness, feasibility, appropriateness and meaningfulness of the intervention being reviewed. At the end of the review the findings of the review are discussed, putting the data processed into context, and

discussing factors such as methodological quality and outcome of the studies (Hemingway and Brereton 2009).

3.8.2 Reviewers

Anonymity was upheld throughout the review process. No reviewer was made aware of the names of the other reviewers. The names of the reviewers were not made public. Should the study be eligible for a publication, the reviewers will have the opportunity to consent to their participation in the development of the publication. This will have resulted in the inclusion of their names as authors on the paper. See Memorandum of Agreement for further details (Appendix B). No comments made on this study will be directly linked to a specific reviewer. Any reviewer who is also an author on one of the selected articles for review, was not allowed to review their own study to reduce bias.

Identification of reviewers for this study

Identification of researchers was conducted based on the findings of articles as outlined in the research procedure above. Reviewers were chosen based on their interest and knowledge pertaining to medial tibial stress syndrome/ lower leg injuries and conservative treatment and rehabilitation. Special interest groups were contacted which were systematic review specific e.g. Cochrane collaboration centres and Institute for Work and Health (IWH). Also, special interest groups who are musculoskeletal/orthopaedic specific, e.g. Orthopaedic Research Society and International Society of Orthopaedic Centres. In order to prevent bias, author and reviewer affiliation to topic and publications have been taken into consideration.

Table 3.8 Indicates the reviewers:

Table 3.8: Reviewers

4	Reviewers	Highest Qualification	Research Experience	Academic Experience	Clinical Experience	Publication experience
1	Reviewer 1 And Reviewer 2 And Reviewer 3	PhD DC	X X	X X	X X	X X
2	Reviewer 4 And Reviewer 5 And Reviewer 3	PhD M. Tech	X X	X X	X X	X
3	Reviewer 6 And Reviewer 7 And Reviewer 3	PhD DC	X X	X	X X	X X
4	Reviewer 8 And Reviewer 9 And Reviewer 3	PhD M. Tech	X X	X X	X	X

The above reviewers were contacted via email once the proposal was approved at Faculty Research Community (FRC), to ascertain their interest in this systematic review and to outline the following points, by means of the Memorandum of Agreement (MoA) (Appendix B):

1. Introduction and description of study.
2. Research procedures – outlining the role and expectation of the reviewers.
3. Process anonymity and blinding.
4. Resolution of research and reviewer discrepancies.
5. Projected timelines for above procedures.

The reviewers received the MoA via email and had to read and sign the agreement if they agreed to adhere to the study protocols outlined. The reviewers were expected to either scan and fax or attach a secured pdf version of the signed agreement to the researcher, as well as stating their qualification and attaching a biosketch. Upon receipt of the signed MoA, the reviewers received the allocated articles and had to send a follow up email to confirm receipt of such articles.

The reviewers each had a nine weeks deadline to review the articles (see Section 3.7) following which they were required to return their findings to the researcher via email. Note that the reviewers were asked to submit their results to the research supervisor to ensure that the researcher was not privy to review outcomes of the other reviewers.

3.9 ARTICLE ALLOCATION

Article allocation was evenly distributed between the groups as illustrated in Table 5. Each review group had one PhD and one Masters level researcher in order to reduce bias, balance experience (clinical, research and academic) and ensure that a variation of experience exists within a group to improve the significance of agreement.

If a reviewer was an author of one of the included articles, it was vital to ensure that this reviewer did not review their own study as this could skew the review process, which would result in biased conclusive findings (Moher 2015; Sanz-Cabanillias *et al.* 2017). If the external reviewers included additional articles (as per the hand search) to the review list, these articles were distributed to the reviewers equally.

Table 3.9 indicates article allocation:

Table 3.9: Article allocation

Groups	Reviewers	Article allocation
1	Reviewer 1 And Reviewer 2 And Reviewer 3	1-8
2	Reviewer 4 And Reviewer 5 And Reviewer 3	9-16
3	Reviewer 6 And Reviewer 7 And Reviewer 3	17-24
4	Reviewer 8 And Reviewer 9 And Reviewer 3	25-30

3.10 REVIEWER INSTRUCTIONS

Following the allocation of the articles to each reviewer, the reviewer also received the respective checklist and scales pertaining to the selected study type they were reviewing. The scales were accompanied by their relevant set of instructions and explanations in order to clearly understand how the scales should be used. If there was any issue regarding interpreting the explanation or the scales, the reviewer was available to further explain how to use the scales (Moher 2015). In addition, the reviewers were also guided in terms of how they are to submit the information that they generate for purposes of efficiency for the researcher's ability to analyse the data.

As stated in the research procedure under reviewer appointment, this process was a blinded procedure in order to reduce any possibility of bias and to ensure reviewer independence (Moher *et al.* 2015).

Copyright was obtained through the DUT copyright office to distribute the articles to the reviewers (Appendix C). Reviewers were requested to confirm receipt of articles along with a confirmation of understanding and interpreting checklists and scales. A reminder was provided at week three and week six as a reminder that the reviews were expected back by week nine.

Whilst the external reviewers were partaking in the review process, the researcher was conducting independent reviews of the 30 articles. If the external reviewers provided their results/findings prior to the week nine submission date, the research supervisor was the recipient of the results and only handed the results to the researcher once their individual review process was concluded. This was to prevent any form of bias from occurring.

Upon the completion of the review process, individual articles were reviewed in terms of the review outcomes. Homogeneity is required amongst review outcomes in order to provide a clear and concise review report. Variations of any sort (including by one point) resulted in the researcher meeting with the reviewer group to discuss the allocation of that singular point on a particular scale. Once an agreement had taken place, a new rating was allocated for this review.

3.11 DATA REDUCTION AND ANALYSIS

The individual articles were critically analysed and individual strengths and weaknesses were identified using the above scales. Upon receipt of review outcomes from the external reviewers, the data was captured on an excel spreadsheet. Majority consensus was used to rank and link specific outcomes from each study type. A compilation of a tabulated review outcome and a chapter detailing a discussion of results (Chapter 4) took place. The evidence

is ranked in Chapter 5. An unbiased conclusive report of results took place in order to appropriately describe the evidential findings from the above process.

The data was ranked and analysed according to reviewer response to the appropriate scales. Analysis of discordance between reviewers was subjected to Cohen's Kappa statistics. The final results was presented in Chapter 4.

A final overview of the evidence assessing the conservative treatment options of medial tibial stress syndrome is further discussed and graded according to Dagenais and Haldeman, Brozek *et al.* or Foley *et al.* in Chapter 5.

Foley *et al*. (2003) proposed that the level of evidence and the strength of evidence for multiple articles can be established. Foley *et al.* (2003), Dagenais and Haldeman (2012) and GRADE system (Brozek *et al.* 2009) all consists of levels of evidence. These specific levels are used to portray the strength or degree of evidence within a specific clinical grouping. Due to the contextual specificity of the study by Foley *et al.* (2003), this study focussed on the approach of Dagenais and Haldeman (2011) and the GRADEsystem (Brozek *et al.* 2009). In addition, the latter two are more complementary in application and allow for a balanced grading of evidence between them.

3.12 DATA EXTRACTION

This occurred in three stages:

Stage one

Reviewers had to submit the results from their reviews to the researcher. The researcher then inserted the results into tables for the feedback data. Data tables were in accordance with the criteria of the scales (viz. Nos, PEDro and Liddle) to allow for data input from all reviewers. This was used to evaluate the similarity and discordance between reviewer feedback, as well as the chance to provide a total score to be ranked.The total rank score was based on majority consensus. Therefore it was considered unnecessary to perform statistical analysis for this study (Liberati *et al.* 2009; Moher *et al.* 2009).

Stage two

The following information was extracted by the researcher from the articles (Harris 2013):

- Form of measurement.
- Frequency of measurement.
- Duration of study.

- Number of participants.
- Assessors blinded.
- Control used.
- Randomisation of participants.

This was assembled in a table and each article was investigated in terms of its clinical outcomes.

Stage three

As the ranking that was given by the reviewers was received and the strengths and weaknesses of each article was assessed, it allowed for the discussion of the clinical outcomes in the context of the methodological quality of the corresponding study.

3.13 DATA SYNTHESIS

Following the review process in Section 3.11, articles were grouped into clinical categories (e.g. shockwave, orthotics, multiple methods). MTSS was then discussed for that specific category. According to the levels of evidence, the strength of evidence for the grouped articles, can be discovered. Grade system (Brozek *et al.* 2009) and Dagenais and Haldeman (2012) provided three levels of evidence. The degree or strength of evidence within a specific clinical category was described in these three levels. There are three successive categories, which provide a method to show whether the evidence agrees or disagrees within the category that is discussed. Another option helps the researcher show that no evidence is presented by the articles in this specific clinical category.

In Chapter Five the above results were assessed for the use of these categories and MTSS. It then provides a benchmark for health care professionals to evaluate the use of conservative treatment in clinical practice.

3.14 CONCLUSION

In this chapter, the methodology that was used to conduct this study was described. This chapter will be followed by the presentation of the individual article reviews in chapter 4 and the consolidated evidence for the interventions in chapter 5.

CHAPTER FOUR RESULTS

4.1 INTRODUCTION

This chapter contains the feedback collected from the reviewers. Each article was reviewed by three people. The feedback from the reviewers has been placed into tables that are entitled 'Tabulated Feedback Data'. Tabulated feedback data can be found for each individual study, which was reviewed and have been grouped into the corresponding study types (RCTs, NRCTs, observational studies and CSs). In these tables, the overall ranking of each study is presented as well as overall percentage agreement between the reviewers. Following the data table, a second table for each study includes the analysis of each individual study. This table shows the overall percentage agreement, ranking of the study and the properties of the study, including the form of measurement, frequency of measurement, duration of the study, number of participants, blinding of the assessors, the use of a control group and randomisation of participants. The specific studies are discussed, highlighting:

- Contextual limitations as identified by authors as well as the researcher that do not form a specific criterion in the scales but may affect the outcomes of the study,
- The outcomes attained, which are contextualised within rigour of the study and
- The overall outcomes of the review of the study with a conclusion.

4.2 DATA

4.2.1 Primary Data

After the primary and secondary searches were completed, a list of final articles was compiled (Appendix F). The final articles that were included into this systematic review, were each reviewed by three reviewers, the feedback data from each reviewer was compiled into a table titled the Tabulated Feedback Data. Each table contains the feedback from each individual reviewer next to the feedback from the other reviewers and the computed majority ranking. Majority ranking is the response that was reported as the majority from the three reviewers for each individual study. The total score is confirmed from the total of the scores shown in the majority column. Percentage agreement is calculated for each criterion for the scale and represents the percentage of agreement between the three reviewers for each specific criterion. If all three reviewers agreed, a percentage agreement of 100% is given. The overall percentage agreement was calculated for each study from the percentage agreement for each criterion. Overall percentage agreements are represented when the degree of cohesiveness

between reviewers are considered to be a good level (70% and above) of overall agreement (Liberati *et al.* 2009). This indicates that reviewers had the same understanding and provided the same feedback for the criteria of the study. This shows which articles had clarity and were easy to understand and identify.

4.2.2 Secondary Data

Secondary data were obtained from different sources. These included books, referenced journal articles and systematic reviews. Most of the information was sourced from online articles, as well as through the Durban University of Technology (DUT) library.

4.3 ABBREVIATIONS

These abbreviations are specific to Chapter Four and are therefore included here as a point of reference for this chapter.

CS	:	Case study/series
CSs	:	Case studies
DPA	:	Disablement in the physically active
DUT	:	Durban University of Technology
GRC	:	Global rate of change
LEFS	:	Lower extremity functional scale
MTTS	:	Medial tibial stress syndrome
MYK	:	MyoKinesthetic
NDT	:	Navicular drop test
NPS	:	Numerical pain scale
NPRS	:	Numeric pain rating scale
NRCT	:	Non-randomised controlled trial
NRCTs	:	Non-randomised controlled trials
OBS	:	Observational study
OBSs	:	Observational studies
PROM	:	Patient-rated outcome measures
PRS	:	Pain rating scale

PSFS	:	Pain specific functional scale
RCT	:	Randomised controlled trial
RCTs	:	Randomised controlled trials
SNRS	:	Simple numerical rating scale
VAS	:	Visual analogue scale

4.4 RESULTS

The results are represented in three different sections. Sections 4.4.1 to 4.4.3 present an introduction, the examiner agreement and ranking of articles and discussion for CSs, NRCTs, RCTs, respectively.

4.4.1 Case Studies and Observational Studies Introduction

Case studies and observational studies in this review were ranked using the Liddle scale (Liddle *et al.* 1996) (Appendix J). For each of the 11 criteria, there are six different responses that could be chosen from. These codes indicate the degree to which each criterion has been fulfilled.The codes that could be selected were: ‘A’, ‘B1’, ‘B2’ and ‘C’. These represent the level at which the criteria were fulfilled and the risk of bias.

Code ‘A’ represents the criteria that are mostly fulfilled and therefore have a risk of low bias.

Code ‘B1’ represents the criteria that have some evaluation and therefore a low to moderate risk of bias.

Code ‘B2’ represents that some criteria are fulfilled and therefore have a moderate to high risk of bias.

Code ‘C’ represents that few or no criteria are fulfilled and that a high risk of bias is present.

Additionally, ‘n/a’ could be chosen, in the event that the criterion was not applicable.

If none of these codes were adequate, then ‘I’ could be selected.

The Liddle scale and its ranking are discussed in detail in Chapter Three.

4.4.1.1 Examiner Agreement and Ranking of Articles: Case Studies and Observational Studies

Table 4.1: List of table numbers for case study and observational study feedback and analysis

Tabulated feedback data table number	Analysis of article table number	Author(s)	Year	Title
Table 4.2	Table 4.3	Austin	1996	Shin splints with underlying posterior tibial tendinitis: A case report.
Table 4.4	Table 4.5	Bonanno, Munteanu, Murley, Landorf and Menz	2018	Risk factors for lower limb injuries during initial naval training: A prospective study.
Table 4.6	Table 4.7	De La Fuente, Henriquez, Andrade and Yañez	2019	Running footwear with custom insoles for pressure distribution are appropriate to diminish impacts after shin splints
Table 4.8	Table 4.9	De Vries	1961	Electromyographic observations of the effects of static stretching upon muscular distress
Table 4.10	Table 4.11	Fick, Albright and Murray	1992	Relieving Painful 'Shin Splints'
Table 4.12	Table 4.13	Jovicić, Jovicić, Hrković and Lazović	2014	Medial tibial stress syndrome: case report
Table 4.14	Table 4.15	Knight	2010	Integration of manual therapy, rehabilitation and acupuncture in the treatment of a 17-year-old male professional football player with chronic medial tibial stress syndrome
Table 4.16	Table 4.17	Martinez, Lopez, Cox,Stankevitz, Larkins, Baker, and May	2020	Exploring treatment of medial tibial stress syndrome via posture and the MyoKinesthetic system
Table 4.18	Table 4.19	Pietrzak	2014	Diagnosis and management of acute medial tibial stress syndrome in a 15 year old female surf life-saving competitor
Table 4.20	Table 4.21	Sathe	2017	Medial tibial stress syndrome: A case study
Table 4.22	Table 4.23	Saxena, Fullem and Gerdesmeyer	2017	Treatment of Medial Tibial Stress Syndrome With Radial Soundwave Therapy in Elite Athletes: Current Evidence, Report on Two Cases, and Proposed Treatment Regimen
Table 4.24	Table 4.25	Thistle	2018	Treatment of Medial Tibial Stress Syndrome Using the MyoKinesthetic System: A Case Series
Table 4.26	Table 4.27	Tutté and Galin	2016	Shin Splints: Efficacy of Radial Extracorporeal Shock Wave Therapy in Ballet Dancers. A Series Of Cases

Given the above list of case studies and case series, it is important to consider generic limitations for these studies before the details of each of the studies are specifically scrutinised.

Many case studies tend to lack in one or more of the following:

1. Patient specific data may be lacking, which makes it difficult for the reader to be able to identify the population group best matched to the outcomes obtained or the data is limited to a highly specific occupation, leisure activity or age group (Cano 2002).
2. Objective reporting outcomes are generally subjective with pragmatic reporting that often does not conform to the use of prescribed PROMS that are reliable and valid in the measurement of the condition under investigation (Thornton 2017).
3. Clarity of treatment intervention may be poor as they tend to include a multitude of treatments or a treatment programme (usually reflecting clinical practice) that does not allow for the identification of one particular intervention as being the catalyst for patient improvement or regression (Winters 2018).
4. Reported measurements of outcome measures tend to be done on an ad hoc basis and not with regular consistency as would be expected in a higher level structured study (Tierney and Steward 2005).
5. A prospective outlook as they are often retrospective in nature (Winters 2018).
6. Documentation of the clinical interaction between the patient and the doctor may be absent, yet would be required in a clinical trial (NRCT and RCT).
7. Reports on issues of researcher/practitioner bias, patient naivety and other related biases may be lacking (Onwuegbuzie 2016).

The above generic limitations result in the lack of ability to accurately replicate these studies to confirm the attained outcomes. Having stated the above, case reports and case series may present interesting outcomes, ideas or trends that warrant further investigation (Winters 2018), particularly in areas where little research has been done in the form of RCTs or NRCTs which are usually the basis for developing guidelines for practice and health care payment schemes (Andrews *et al.* 2013).

Table 4.2: Tabulated feedback data – case studies – Article 1

AUTHOR(S)	Austin. W. M.					
YEAR	1996					
TITLE	Shin splints with underlying posterior tibial tendinitis: A case report					
CRITERIA		**Reviewer 1**	**Reviewer 2**	**Reviewer 3**	**Ranking**	**Percentage Agreement**
1	Study Identification	B1	A	B1	B1	66%
2	How is the study type described?	A	A	A	A	100%
3	What interventions are considered and how are they implemented?	A	B1	B1	B1	66%
4	Is the intervention aimed at individuals or populations?	A	A	A	A	100%
5	What outcomes are considered?	B1	C	B1	B1	66%
6	What factors other than the intervention could affect the outcome?	A	C	C	C	66%
7	What are the characteristics of the population and study setting?	I	B2	B2	B2	66%
8	How many groups/sites in the study?	N/A	B1	B1	B1	66%
	TOTAL SCORE	A:4 B1:2 B2:0 C:0 I:1 N/A:1	A:3 B1:2 B2:1 C:2 I:0 N/A:0	A:2 B1:4 B2:1 C:1 I:0 N/A:0	A:2 B1:4 B2:1 C:1 I:0 N/A:0	
			OVERALL PERCENTAGE AGREEMENT			74,5%

Table 4.3: Properties of study, outcome and discussion – case study – Article 1

AUTHOR(S)	Austin, W. M.							
YEAR	1996							
TITLE	Shin splints with underlying posterior tibial tendinitis: A case report							
STUDY PROPERTIES								
Form of measurement	**Frequency of measurement**	**Duration of study**	**Number of participants**	**Assessors blinded**	**Control used**	**Randomisation of participants**	**Ranking**	**Total Percentage Agreement**
Only subjective pain on running	Not mentioned.	18 weeks. 6 weeks – in which care was administered. Then a follow up 12 weeks after care was ceased.	Case study with a single male participant. N=1	No blinding, as this was a case study.	No control group used, as this was a case study.	No randomisation, as study is a single case study.	A:2 B1:4 B2:1 C:1 I:0 N/A:0	74.5%
LIMITATIONS	Firstly, the author must be congratulated on presenting this case study in the printed literature. In terms of the limitations, it was not clear why the author chose to publish this particular case study, as the approach to treatment was not novel and the outcomes could have been anticipated based on the effects of the interventions utilised (Song and Chung 2010). This is compounded by the lack of objective measures or recorded subjective measures specific to the condition (the only form of outcome measurement that was used was pain experienced while running). It is however acknowledged, that due to the limited common understanding of MTSS TII (Thacker *et al.* 2002), there is also a limit to the number and type of appropriate PROMS that would be applicable to an MTSS TII case study (Winters 2018). Sample size and therefore the use of inferential statistics is limited in a case study, as there is only one participant. This also results in the lack of generalisable data as the outcomes are only likely to be similar in patients who, like the case study patient, are 42 years old, male and presenting with MTSS TII (reported to be as a result of increased running mileage). To complicate the interpretation of the clinical outcomes, the author used multiple different interventions in the treatment regimen. These included: flexible orthotics, long axis distraction adjustive technique to the ankles, manipulation of naviculae, cuboids and metatarsal heads							

	bilaterally, ice massage at home (unspecified frequency, duration, repetitions and temperature), adjustments to knee, hip and spine, rehabilitation of foot inverters and evertors and then the programme for slow/graded return to activity. It cannot be assumed that any one specific intervention was beneficial over another or that the chiropractic technique (manipulation) was of any benefit to the patient. At the very best, it can be considered that overall manual therapy was of benefit to this patient and that the principles of reducing load on the tibialis posterior, along with changing the efficiency of the kinematic chain and improving the tibialis posterior strength and endurance were possibly the key clinical outcomes (Brantingham *et al*. 2012).
OUTCOME	The patient encountered problems while training for a marathon. After 12 weeks of being released from care, the patient was able to complete the marathon without re-injury. The author suggested that chiropractic care (manipulation) can effectively manage MTSS TII if it is identified early and the appropriate treatment is administered. The author recommends that when treating overuse injuries, the intrinsic as well as extrinsic factors need to be looked at. He also mentions that faulty biomechanics need to be manipulated using an adjustive technique and corrected if the individual is looking for long-term relief. This is in line with the conclusions drawn at the end of the limitations above.
DISCUSSIONS	In this study there is a lack of core criteria to validate improvement of the individual's condition as related to any one specific intervention. This is because no formal form of scale or any other objective clinical measures were used to formally document the treatment protocol. The author did mention that the participant was able to complete his marathon 12 weeks after care was stopped without re-injury (short to intermediate improvement) but did not have any long-term evidence that this type of treatment was successful. This study also lacked an adequate explanation and discussion of the interventions mentioned (namely adjustive techniques/manipulation and rehabilitation of muscles in the foot), these interventions and the role they play in treating MTSS TII was not explained. The rationale for the use of these interventions cannot be assumed and the manner in which they were applied cannot be replicated based on this study, due to the lack of description and reference to previous studies.
CONCLUSION	This study achieved a ranking of A = 2, B1 = 4, B2 = 1 and C = 1, at an agreement level of 74.5% (see Table 4.2).Based on this ranking, it would indicate a good quality study with good clinical outcomes. However, based on the limitations mentioned in this table there is an impact on the reliability and validity of the study's outcome. Therefore, this study can be seen as a well-designed case study, with limited ability to identify the active intervention (i.e. the outcomes can only support the use of clinical a programme that utilises the elements that where incorporated in the reported programme) with good clinical outcomes. These outcomes therefore need further testing in a more formalised research setting to identify the active interventions that enabled the outcome achieved with this solitary patient. A RCT evaluating the usefulness of each specific treatment would provide better understanding of the benefit of these individual interventions. It is advised that a large sample group, including males and females would provide a study with more generalisable feedback.

Table 4.4: Tabulated feedback data – case studies – Article 2

AUTHOR(S)	Bonanno, D. R., Munteanu, S. E., Murley, G. S., Landorf, K. B. and Menz, H. B.					
YEAR	2018					
TITLE	Risk factors for lower limb injuries during initial naval training: A prospective study.					
CRITERIA		**Reviewer 1**	**Reviewer 2**	**Reviewer 3**	**Ranking**	**Percentage Agreement**
1	Study Identification	A	A	A	A	100%
2	How is the study type described?	A	B1	B1	B1	66%
3	What interventions are considered and how are they implemented?	C	C	C	C	100%
4	Is the intervention aimed at individuals or populations?	B2	B1	B2	B2	66%
5	What outcomes are considered?	A	A	A	A	100%
6	What factors other than the intervention could affect the outcome?	B1	A	B1	B1	66%
7	What are the characteristics of the population and study setting?	I	B1	B1	B1	66%
8	How many groups/sites in the study?	I	I	I	I	100%
	TOTAL SCORE	A:3 B1:1 B2:1 C:1 I:2 N/A:0	A:3 B1:3 B2:0 C:1 I:1 N/A:0	A:2 B1:3 B2:1 C:1 I:1 N/A:0	A:2 B1:3 B2:1 C:1 I:1 N/A:0	
				OVERALL PERCENTAGE AGREEMENT		83%

Table 4.5: Properties of study, outcome and discussion – Case study – Article 2

AUTHOR(S)	Bonanno, D. R., Munteanu, S. E., Murley, G. S., Landorf, K. B. and Menz, H. B.							
YEAR	2018							
TITLE	Risk factors for lower limb injuries during initial naval training: A prospective study.							
STUDY PROPERTIES								
Form of measurement	**Frequency of measurement**	**Duration of study**	**Number of participants**	**Assessors blinded**	**Control used**	**Randomisation of participants**	**Ranking**	**Total Percentage Agreement**
Baseline data not including a pain scale.	Prospectively documented injury over the duration of the study.	11 weeks.	n=306 naval recruits during initial defence training.	Yes	Yes	Yes	A:2 B1:3 B2:1 C:1 I:1 N/A:0	83%
LIMITATIONS	Although this study classifies itself as a randomised trial, its outcomes did not intend to treat a condition as much as identify factors that were related to the development of a variety of lower limb injuries in recruits that did and did not wear orthotics. Hence, it was classified as an observational study (Song and Chung 2010). 306 naval recruits were documented over 11 weeks during their initial defence training. Naval recruits were placed in either an orthotic group or a flat insole group (control) who were not given orthotics. The amount of injuries that occurred in 11 weeks were documented. The principle problem with the study is that there did not seem to be an assessment of the recruits in terms of whether they had previously worn orthotics of any description or had custom-made shoes for prior problems. This means that if these participants landed in the no-orthotic group, they would have developed problems during the course of the study, as they would have been at an increased risk of injury in the no-orthotic group artificially (Elattar *et al.* 2018). This would also be true of participants who did not have orthotics as their foot and lower limb structure would have resisted the effects of the orthotic used in this study (Yamaski 2019). This would also be true of participants that had congenital rigid foot deformities that would not respond well to orthotic placement (Elattar *et al.* 2018). The assertion here is made on the basis that there were differences between the injured and uninjured groups with regards to supination, pronation and normal feet, compared to all other variables reported in the same table in the study. Therefore, it is likely that the measured injury outcomes were induced because of the study design and not as a result of the orthotic being a preventative measure to decrease the rate of injury in these participants. Additionally, the authors noted that the foot pressure was measured in its static form and not in dynamic form. This may also have been part of the problem in providing correct orthotics for the various participants as a static assessment provides only some of the required information to correctly decide on the appropriate orthotic (Larsen *et al.* 2002). They advise that future studies should measure the dynamic lower leg function when looking at the biomechanics and investigating risk of injury. For the best application of an orthotic a combination of static and dynamic assessments allows for determining the effects of placed orthotics (Larsen *et al.* 2002). This also							

	implies that one limitation of the current study is that the use of standardised orthotics may also not have been appropriate and therefore further observational studies utilising the static and dynamic measures as well as custom orthotics in the same context may deliver different results. Another point is that this study mainly looked at healthy young males and females, as they are representing the Australian navy. This study may not be generalised to older naval recruits or for that matter the general population. It is important to include varying populations in studies as older and female military recruits are at greater risk of enabling injuries to the lower limb during initial training (Knapik *et al.* 2013). In addition to the above, the recruits are a specialised group of individuals undergoing training that is above the normal average for a patient seen in practice, therefore there would be limited generalisability of the results. The study does however assist in alerting practitioners to possible factors that may contribute to the various conditions that were noted as an outcome in the study. The authors must be credited for attempting to standardise different factors, training loads, clothes and shoes, sleep schedules, diet and health care. It is however unclear whether this was achieved given that the training requirements would have been different given the height and innate strength of one individual compared to another. Reporting on the attempted standardisation in the study would have been useful for the reader to gauge to what extent the inherent physical characteristics of each individual as well as their interaction with the environment played a role in the outcomes attained in this observational study. From a subjective vantage point, it also needs to be considered that there may have been over-reporting of injuries, given that literature states that males tend to report higher levels of injury and are more susceptible to reporting pain than females (Gordon 2019). However in females, the converse is true, but this is negated by the fact that they are structurally/physically less developed for training compared to men and thus, their reported figures may be more accurate as the under-reporting may be corrected with the increased likelihood of injury (Zolin, Stuetzer and Watson 2013). Lastly, it must be noted that the outcome is rather more a prospective predictive study than a randomised trial. RCTs normally contain individuals who are randomly assigned to different treatment groups. These groups of people all received different treatments and therefore were assumed to have different outcomes. Therefore, not considering pre study risk factors could result in one group being predisposed to reporting injury as a result of a certain risk factor and not due to the intervention. It could lead to reporting anomalies and incorrect causality attribution. As mentioned before this RCT only included naval recruits. This type of athlete might also have different risk factors compared to members of the public. This study would have been of great benefit if the normal population had been divided into two groups as well (one receiving the intervention and one not) and then the amount of injuries between the different groups had been compared within the context of confounding variables. As the study focused on discussing the risk of developing injury in great detail, the recording and reporting of intervention methods became secondary and were not fully discussed. Therefore, there was less information on the form of measurement used and the improvement/regression of participants over time as a result of the intervention.
OUTCOME	This study was used to identify risk factors that develop in the lower leg during defence training in naval recruits who were involved in a randomised trial. The results showed that a combination of age and orthotic group allocation identifies a risk factor with 78% accuracy. These two predictor variables were the only two associated with prospective injury in the total sample that met the required p value ($p<0.05$). Age met the required values (18-25 years of age) but according to the study, the absolute difference between the groups was small and potentially artificial. The mean age for participants who develop injuries was 22 compared to the mean age of 21. Seeing that this study

	was done on naval recruits, most individuals were fairly young. This affects the outcome as one year is suspected to not have significance when looking at a young age (Pransky *et al.* 2005). Orthotics group allocation contained clinical meaningful difference between the groups. These injured participants had a lower chance of being allocated foot orthoses over flat insoles (40% vs 53%). The main objective of this RCT stated that foot orthoses reduced the risk of injury by a third. Based on the limitations discussed above, this type of conclusion from the authors should be accepted with caution as the comparison does not include a control group that did not receive an active intervention. The main focus was not testing the use of the foot orthoses and therefore this outcome is not reliable. Lower limb injury cannot be accurately predicted from health questionnaires, fitness results and clinical assessments in naval recruits undertaking initial defence training (Pransky *et al.* 2005). The use of a predictive tool like the FMS™ may have been more appropriate.
DISCUSSIONS	This study lacks fundamental criteria to show the clinical effect of incorporating foot orthoses compared to a flat insole in highly athletic populations. The conclusion that was reached in this study is only valid in the specific context seeing that the intention to treat was not the main focus. There is also no explanation or further recordings done on the use of orthotics and how practitioners would be able to use this type of intervention in practice. Although the authors mentioned that age was a predictor to injury, it was noted in limitations that the participants in this study were young naval recruits. Their mean age was very low and comprised the only available data. Additionally the outcomes of the study need to be accepted with caution as the confounding variables that could have been responsible for the small absolute differences between the groups (noted in the study as being potentially artificial), were not adequately controlled for. This implies that the extrapolation of the protective effect of orthotics is unclear. This prospective study appears to focus on providing an expert and clinical opinion on risk factors leading to injury/protective effect of orthotics, rather than a scientific methodological study assessing a clinical intervention by subjective or objective measures. In their opinion, it was important to show what certain risk factors have the highest risk to lead to injury (which was resultantly inconclusive).
CONCLUSION	This study was a prospective study, focusing mainly on risk factors during initial defence training of naval recruits that have been documenting clinically, and therefore has poor capability to comment on clinical outcomes as a result of an intervention. The limited control of confounding variables led to an inability to comment on risk factors between participant groups. This study was ranked with A = 2, B1 = 3, B2 = 1, C = 1 and I = 1 with an agreement percentage of 83% (see Table 4.4). This would indicate a poor study with inconclusive outcomes for or against the use of the orthotics in the treatment of MTSS TII. A future study in risk factors identification should look at using objective measures for training loads, clothes and shoes, sleep schedules, diet and health care given that would contribute to the risk of injury. An RCT should look at appropriately controlling for confounding variables in order to accurately test the clinical impact on MTSS TII as a condition (this also requires the inclusion of only MTSS TII patients in the study).

Table 4.6: Tabulated feedback data– case studies – Article 3

AUTHOR(S)	De la Fuente, C., Henriquez, H., Andrade, D. C. and Yañez, A.					
YEAR	2019					
TITLE	Running footwear with custom insoles for pressure distribution are appropriate to diminish impacts after shin splints					
CRITERIA		**Reviewer 1**	**Reviewer 2**	**Reviewer 3**	**Ranking**	**Percentage Agreement**
1	Study Identification	A	A	A	A	100%
2	How is the study type described?	B1	A	B1	B1	66%
3	What interventions are considered and how are they implemented?	A	B1	B1	B1	66%
4	Is the intervention aimed at individuals or populations?	C	C	C	C	100%
5	What outcomes are considered?	B2	B1	B2	B2	66%
6	What factors other than the intervention could affect the outcome?	N/A	B1	N/A	N/A	66%
7	What are the characteristics of the population and study setting?	I	B2	B2	B2	66%
8	How many groups/sites in the study?	B1	B1	B1	B1	100%
	TOTAL SCORE	A:2 B1:2 B2:1 C:1 I:1 N/A:1	A:2 B1:4 B2:1 C:1 I:0 N/A:0	A:1 B1:3 B2:2 C:1 I:0 N/A:1	A:1 B1:3 B2:2 C:1 I:0 N/A:1	
			OVERALL PERCENTAGE AGREEMENT			78,75%

Table 4.7: Properties of study, outcome and discussion– case study – Article 3

AUTHOR(S)	De la Fuente, C., Henriquez, H., Andrade, D. C. and Yañez, A.							
YEAR	2019							
TITLE	Running footwear with custom insoles for pressure distribution are appropriate to diminish impacts after shin splints							
STUDY PROPERTIES								
Form of measurement	**Frequency of measurement**	**Duration of study**	**Number of participants**	**Assessors blinded**	**Control used**	**Randomisation of participants**	**Ranking**	**Total Percentage Agreement**
Pressure distribution	1 measurement after 6 weeks of rehabilitation..	6 weeks of rehabilitation.	20 patients	No	Yes. Only half of the participants received cushioned insoles.	Yes	A:1 B1:3 B2:2 C:1 I:0 N/A:1	78,75%
LIMITATIONS	A given limitation in this study is that there was no analysis for confounding variables that was performed with regards to the possible interaction between physical and social characteristics of the sample patients (these could include age, weight, previous injury (intrinsic factors), sports participated and cross training (extrinsic factors)) (Pourhoseingholi *et al*. 2012). Patients with certain characteristics could influence the outcome based on said characteristics (e.g. the older the patient, the increased chance that it would take longer than six weeks to respond to the insole placement and attendant interventions as compared to a younger patient). Although the study includes a control group, it is not a true control (as the patients were their own controls - pre-post experimental design). Therefore, these comparisons were pragmatic comparisons, which would more accurately reflect clinical practice but do not aid in providing evidence for or against the use of a particular intervention. In addition, it also reflects in a manner not dissimilar to a collection of case studies that have been grouped together, with means and averages drawn across the group. Although the study is consistent in terms of the manner in which the participants passed through the study (unlike retrospective case series), the ability to control variables that affect individual responses cannot be accounted for as would an NRCT or RCT based study. This study mainly focused on 10km runners treated with traditional rehabilitation after MTSS TII development, which makes the population tested limited to a recreational running group as compared to an elite athlete or a first time runner. In addition to limiting the participants to only runners which precludes the ability of the study outcomes to be applicable to other sporting interactions. Finally, the use of specialised digital equipment as an outcome measure provides a limitation in that this is not readily available in clinical practice. However, its use enabled the outcome of indicating that the use of cushioned insoles seemed to be able to attenuate the pressures and vibrations experienced, along with a six week rehabilitation programme. Working on the basis that the tibialis anterior and posterior are involved in MTSS TII development, it is impossible to be able to indicate if it was the custom insoles or rehabilitation programme that corrected the over pronation leading to a correct pressure distribution.							

	Lastly, seeing as no clinical form of measurement is used, it is difficult to establish how well the participants recovered, determine the correlation between clinical symptomatology and the changes in pressure distribution, or identify what type of pain they were experiencing before they started the study once they had completed the rehabilitation programme and at the time of measurement. Objective clinical outcome measurements would have been beneficial in this study.
OUTCOME	In this study it was found that the use of custom insoles distributed the pressure and reduced the impact along with rehabilitation of MTSS TII during pre and post running tests. This could lead to adding protection during the reinstatement phase of injured runners (De la Fuente *et al.* 2019). This was particularly seen in that the spectrum of frequencies was reduced when using custom insoles between certain frequencies (5.8 HZ-40.5) but there was no change if the frequency was higher or lower. This potentially indicates that more recalcitrant conditions may not be responsive, but without clinical outcomes this suggestion is in need of further testing.
DISCUSSIONS	The key finding of this study states that there was a decrease in impact when a custom cushioned insole was used on 10 km runners who had MTSS TII. This type of athlete is not general to the public and therefore it would not be feasible to use this type of intervention when looking at people who participate in different sports. The outcome of this study was not based on a single intervention seeing that there was the use of orthotics as well as a rehabilitation programme. To effectively test the use of orthotics or the rehabilitation programme (or the components of the programme), it should be considered to include one intervention, within a trial that includes a control group that does not receive intervention (and that is homogenous with the intervention group) and that extraneous variables are better controlled. Additionally the trial should include a number of clinical outcome measures in addition to the digital data from the 3-axis ADXL 345 accelerometer, so as to enable correlation between the clinical and digital findings that would make this study more relevant to clinical practice.
CONCLUSION	Given that the pre-post experimental structure of this study has many limitations that are in concert with those of a case series that is prospective in nature, in addition to the fact that there were at least two identified interventions (insoles and rehabilitation) and the rehabilitation consisted of medication, stretches, strengthening, electro-modalities and footwear modification, it is impossible to assert that any one intervention provided the outcomes attained. Additionally, there is no manner in which to ascertain whether the treatments were synergistic or antagonistic in nature, therefore either enhancing or detracting from their overall contribution to the outcome of the study. Finally, however, the most important limitation in terms of the study is the clinical applicability of the outcomes that is not a measurable reality in clinical practice. This means that the outcomes of this study cannot be contextualised in the practice setting in any meaningful way due to the lack of a clinical outcomes measure anchor to allow for interpretation of the changes noted on the 3-axis ADXL 345 accelerometer. Given the above contextual limitations as well as the outcomes of the review by the blinded reviewers that ranked this study as A = 1, B1 = 3, B2 = 2, C = 1, I = 0 and N/A = 1 with a total percentage agreement of 78,75%, this relatively well structured article provides evidence in support of changes due to orthoses combined with rehabilitation, but provides no support for clinical changes in the patient's condition as a result of the interventions.

Table 4.8: Tabulated feedback data– case studies – Article 4

AUTHOR(S)	De Vries, H. A. 1961. Electromyographic observations of the effects of static stretching upon muscular distress					
YEAR	1961					
TITLE	Electromyographic observations of the effects of static stretching upon muscular distress					
CRITERIA		**Reviewer 1**	**Reviewer 2**	**Reviewer 3**	**Ranking**	**Percentage Agreement**
1	Study Identification	I	B1	I	I	66%
2	How is the study type described?	I	B1	B1	B1	66%
3	What interventions are considered and how are they implemented?	I	B1	I	I	66%
4	Is the intervention aimed at individuals or populations?	A	A	A	A	100%
5	What outcomes are considered?	B1	B1	B2	B1	66%
6	What factors other than the intervention could affect the outcome?	B2	B2	B1	B2	66%
7	What are the characteristics of the population and study setting?	I	B1	I	I	66%
8	How many groups/sites in the study?	N/A	N/A	N/A	N/A	100%
	TOTAL SCORE	A:1 B1:1 B2:2 C:0 I:4 N/A:1	A:1 B1:5 B2:1 C:0 I:0 N/A:1	A:1 B1:2 B2:1 C:0 I:3 N/A:0	A:1 B1:2 B2:1 C:0 I:3 N/A:1	
			OVERALL PERCENTAGE AGREEMENT			74,5%

Table 4.9: Properties of study, outcome and discussion – case study – Article 4

AUTHOR(S)	De Vries, H. A.							
YEAR	1961							
TITLE	Electromyographic observations of the effects of static stretching upon muscular distress							
STUDY PROPERTIES								
Form of measurement	**Frequency of measurement**	**Duration of study**	**Number of participants**	**Assessors blinded**	**Control used**	**Randomisation of participants**	**Ranking**	**Total Percentage Agreement**
Edin model 220 electrocardiograph.	Before and after stretching.	One day.	9	No	No	No	A:1 B1:2 B2:1 C:0 I:3 N/A:1	74,5%
LIMITATIONS	This very early study was designed as a pre-post experimental study, which by virtue of its design has a limitation in that all the data recording was done in one day with one application of the intervention. This implies that there is no short-term or long-term outcome of the intervention on participants recorded by the author. It is possible that the duration of one day was insufficient in determining the effects of static stretching on muscles, as compared to the natural history of MTSS TII (Becker, Nakajima and Wu 2018). Thus, although the measures were completed on MTSS TII patients, the experiment set out to determine if a static stretch could reduce muscle spasm as measured indirectly by muscle activity. Secondly, the participants were not uniform throughout. They were all athletes but participated in different sports and the muscles may be variably and differentially affected. This study included participants with upper and lower limb injuries. (n=4 for MTSS TII patients). Therefore, given that different muscles react differently to static stretching based on the activity of spasm causation, the load carrying capacity of the muscle and the fatigability of the muscle, this study in effect for MTSS TII only represents four patients. This is not only a small number from which to draw conclusions, but also these conclusions are only relevant to MTSS TII patients that are young college athletes that participate in gymnastic sports. Therefore, it may be possible to suggest that the response of the muscle to static stretching is particular to this population group and muscles that have had limited direct trauma as compared to an older athlete or general population group. As there was a limited number of tests conducted we are unable to say whether this is due to the stretches being applied or due to the fact that the patients might have just been in a relaxed state or assumed a relaxed state after the exercise period (i.e. it is difficult to ascertain whether the post reading measured the post exercise relaxed state or the effects of the static stretch or both. However it is reasonable to assume that it may have been both). This could possibly have been differentiated more effectively by testing, exercising the patient, testing, testing after a short period of rest, applying a static stretch and then testing again in one group or testing, exercising the patient, testing, applying a static stretch and then testing followed by testing after a short period of rest.							

	The author noted partial to full decrease in symptoms after the session, done over the course of one day. Follow-up treatments or comments from participants were not recorded on any formal PROM (Yeomans and Yeomans 2000) or documented for statistical analysis. Lastly, this study only showed that a distressed/spastic/hypertonic muscle (as evidenced by increased muscle activity readings) can relax after one session of static stretching. This does not indicate whether this in any way resolves or assists in resolving the underlying clinical condition (MTSS TII). It also does not indicate how long this altered state of the muscle is present and whether it affects the clinical condition in the immediate, short or long term.
OUTCOME	In this study, it was found that structural damage in the muscular tissue does cause muscular distress after exercise. If structural damage was the factor that caused the muscles to be sore, then stretching the muscles affected is expected to send stimuli to the nervous system which would increase the motor reflex. In this study, this was not found in any cases, except for one, where the symptoms were so severe it left the limb disabled. This draws the conclusion that this study mainly tested spastic/hypertonic muscle rather than structural damage of the muscle. This indicates why there were immediate results after the intervention, as stretching is a noted indication for spastic/hypertonic muscle (Winters *et al.* 2013a). In this study, it was noted that muscle displays a higher surplus of activity after exercise. It was also established that there is a linear correlation between pain symptoms experienced and the muscle activity that is recorded; this is implying that there was some relief of symptoms after stretching.
DISCUSSIONS	Although there was a noted decrease in muscle activity and thus improvement in this report, the study lacked focus particularly to MTSS TII, as this study included upper limb patients and patients with lower limb injury. Therefore, this study lacked core criteria and focus to MTSS TII and can therefore not be extrapolated to MTSS TII patients principally due to the very small sample size that is limited to young athletes. Based on the outcome we can see that there were immediate results, but seeing that there is no further short term or long term effects recorded, this study lacks evidence to support the clinical use of static stretching beyond a single application to achieve only muscle relaxation. This experimental evidence indicates that post exercise muscle spasm exists. It is however not clear to what extent MTSS TII has a component of muscle spasm, as its pathogenesis is unclear (Winters 2017), although the presence of muscle spasm and hypertonicity has been associated with the teno-periosteal inflammation (Smith, Coates and Creaby 2014). Future studies should include more follow up sessions, to test the effect of static stretching in the short, medium and long term. This type of study would be more beneficial if they only tested participants who have MTSS TII and compared to a control or placebo group to test effectiveness and efficacy of the static stretching. Additionally, if the focus is on increasing the number of recordings done on the patients over a length of time, it can be used to verify if this type of intervention can be successful.
CONCLUSION	Given the extremely small sample size of MTSS TII patients as well as the very clear yet clinically limited pre-post experimental design, the study provides little evidence in support of the use of static stretching in patients with MTSS TII. This is also seen in the review completed by the reviewers, which indicates that this is a poor study with outcomes not supporting the use of the interventions of MTSS TII. This is further highlighted by the reviewers that ranked this study as A = 1, B1 = 2, B2 = 1, C = 0, I = 3 and N/A = 1 with a 74,5% agreement.

Table 4.10: Tabulated feedback data– case studies – Article 5

AUTHOR(S)	Fick, D. S., Albright, J. P. and Murray, B. P.					
YEAR	1992					
TITLE	Relieving Painful 'Shin Splints'					
CRITERIA		**Reviewer 1**	**Reviewer 2**	**Reviewer 3**	**Ranking**	**Percentage Agreement**
1	Study Identification	B1	B1	B1	B1	100%
2	How is the study type described?	B1	B1	B2	B1	66%
3	What interventions are considered and how are they implemented?	B1	C	C	C	66%
4	Is the intervention aimed at individuals or populations?	B1	B2	B2	B2	66%
5	What outcomes are considered?	B1	B1	B2	B1	66%
6	What factors other than the intervention could affect the outcome?	B2	C	C	C	66%
7	What are the characteristics of the population and study setting?	B2	B2	B2	B2	100%
8	How many groups/sites in the study?	C	C	B2	C	66%
	TOTAL SCORE	A:0 B1:5 B2:2 C:1 I:0 N/A:0	A:0 B1:3 B2:2 C:3 I:0 N/A:0	A:0 B1:1 B2:5 C:1 I:0 N/A:0	A:0 B1:3 B2:2 C:3 I:0 N/A:0	
				OVERALL PERCENTAGE AGREEMENT		74,5%

Table 4.11: Properties of study, outcome and discussion– case study – Article 5

AUTHOR(S)	Fick, D. S., Albright, J. P. and Murray, B. P. 1992. Relieving Painful 'Shin Splints'							
YEAR	1992							
TITLE	Relieving Painful 'Shin Splints'							
STUDY PROPERTIES								
Form of measurement	**Frequency of measurement**	**Duration of study**	**Number of participants**	**Assessors blinded**	**Control used**	**Randomisation of participants**	**Ranking**	**Total Percentage Agreement**
Pain on running.	Not mentioned.	Approximately 13 weeks.	1	No as this was a single case study.	No as this was a singular case.	No, n=1	A:0 B1:3 B2:2 C:3 I:0 N/A:0	74,5%
LIMITATIONS	The principle limitation of this study is evident in that it is a case study and in doing so represents only one patient. This does not allow for the generalisation of the findings of this study to the general MTSS TII patient population unless the population conforms to the parameters of the patient in this study (20-year-old male participant, who suffered with recurrent MTSS TII). As is germane to case studies, they usually apply multiple treatment interventions to address the patient's condition, which makes comment on the contribution from any one modality impossible to determine. What it does allow however, is the ability to indicate whether a specific treatment protocol may be helpful in MTSS TII patients and may form the basis for a future RCT or NRCT to test the assertions of the case study. The above two limitations are further complicated in that the only form of improvement measurement was subjective (reported pain on running). It is also unclear if the pain on running was reported by distance, severity, both or just an indication that it occurred. Therefore, the accuracy of improvement is difficult to ascertain and apply in clinical practice. Additionally, the lack of clarity with regards to frequency, duration and type of interventions, do not allow for the reader to contextualise the impact of the participant improvement reported in the study. This will not allow specific interventions to be supported and also does not allow for recreation of a larger study with the same parameters, and the application of the parameters in a clinical practice for patients of a similar type cannot be carried out.							
OUTCOME	Given that the patient was advised to rest for three weeks while using conservative treatment options (cryotherapy, anti-inflammation drugs, switching activities, rest), the author reports that the patient gradually returned to running, starting at a low mileage and slowly increasing it over 10 weeks. The author noted that MTSS TII developed in this patient when he switched from soft grass to a hard track too quickly. It							

	is therefore suggested that any patient with a change in turf, slowly increase their mileage on the new surface in order to avoid the development of MTSS TII or other fatigue symptoms. The author suggested that it was the multi-treatment approach that lead to success and pain free running of the athlete.
DISCUSSIONS	Although this study was successful for the 20-year-old male patient it is not generalisable to patients in general, based on the fact that not all patients meet the demographics of the patient in this case study (including the recurrence of the MTSS TII as was in the case study's patient). This may mean that the patient has a specific predisposition to the development of MTSS TII, which makes the patient more prone to the condition and is also perhaps more recalcitrant to treatment. Notwithstanding the above, the author concludes that this combination type of intervention was a success in the short term.
CONCLUSION	Given that, this 13 week case study was based on a pragmatic combination intervention for the treatment of the MTSS TII in a patient with recurrent MTSS TII problems, it is difficult to generalise the outcomes to any patient with MTSS TII and thus the study does not provide any evidence in support of individual treatment options. Also, given that the study is a case study, it is also subject to bias and autosuggestion, which does not clearly allow for the combination treatment to be shown as better than placebo (Boutron *et al*. 2019). Thus, future studies should include more participants with clearer treatment and measurement frequency, duration and specific type of interventions or combination of interventions. It should also be considered to include objective clinical measures alongside the subjective measures when assessing the effectiveness of the treatment. This is supported by the reviewers' ranking of the study. It was noted that this study achieved the following scores: A = 0, B1 = 3, B2 = 2, C = 3, I = 0 and N/A = 0 with a 74,5% agreement. These stats indicated that this is an averagely constructed study with good outcomes in terms of treatment.

Table 4.12: Tabulated feedback data – case studies – Article 6

AUTHOR(S)	Jovicić, M., Jovicić, V., Hrković, M. and Lazović, M.					
YEAR	2014					
TITLE	Medial tibial stress syndrome: case report					
CRITERIA		Reviewer 1	Reviewer 2	Reviewer 3	Ranking	Percentage Agreement
1	Study Identification	B1	B2	B2	B2	66%
2	How is the study type described?	A	B1	B1	B1	66%
3	What interventions are considered and how are they implemented?	B1	B1	B1	B1	100%
4	Is the intervention aimed at individuals or populations?	A	A	A	A	100%
5	What outcomes are considered?	A	B1	B1	B1	66%
6	What factors other than the intervention could affect the outcome?	I	I	C	I	66%
7	What are the characteristics of the population and study setting?	B1	B1	B2	B1	66%
8	How many groups/sites in the study?	B1	B1	B2	B1	66%
	TOTAL SCORE	A:3 B1:4 B2:0 C:0 I:1 N/A:0	A:1 B1:4 B2:1 C:0 I:1 N/A:0	A:1 B1:3 B2:3 C:1 I:0 N/A:0	A:1 B1:5 B2:1 C:0 I:1 N/A:0	
			OVERALL PERCENTAGE AGREEMENT			74,5%

Table 4.13: Properties of study, outcome and discussion– case study – Article 6

AUTHOR(S)	Jovicić, M., Jovicić, V., Hrković, M. and Lazović, M.							
YEAR	2014							
TITLE	Medial tibial stress syndrome: case report							
STUDY PROPERTIES								
Form of measurement	**Frequency of measurement**	**Duration of study**	**Number of participants**	**Assessors blinded**	**Control used**	**Randomisation of participants**	**Ranking**	**Total Percentage Agreement**
VAS. Five point Likert Scale. Flexibility. Manual muscle test.	Before therapy and after 5th treatment, after 10th treatment, after 15th treatment.	7 weeks	1 person	No, as this was a singular case study.	No, this was a case study with one participant.	No as n=1	A:1 B1:5 B2:1 C:0 I:1 N/A:0	74,5%
LIMITATIONS	With credit to the authors, they note the details of the combination therapy, which included physical therapy, iontophoresis of anaesthetic, low level laser therapy, ankle range of motion exercises, hamstrings and Achilles tendon stretching. The patient was also advised to get insoles, which they wore for the duration of the study. In addition, they indicate that the outcomes are related to the treatment plan and not any one individual intervention. Therefore, this study does not provide evidence for any one of these treatments for MTSS TII. Furthermore, the duration/treatment application of each treatment was not mentioned, making it impossible for this study to be recreated to either support or negate the outcomes seen in this study. Secondly, due to the lack of a clear theory on the pathogenesis as well as clear guidelines on the diagnosis of MTSS TII and its differentiation from other diagnoses, the unclear literature (Winters 2017) limits the ability of this study to draw effective conclusions regarding the patient's condition and outcome after treatment as the applied outcomes may only be an indirect measure of the condition with which the patient presented. Thirdly, a single case report cannot suggest a recommendation regarding treatment for a group of people and therefore is not efficient to be a guide for the general public. Seeing that this study only involved one participant, the author can only show success in one individual and not in the greater population of people with the same syndrome. Lastly, it was noted that a month after treatment was stopped the patient reported no discomfort. This implies that treatment outcomes were principally related to pain reduction, which when one reviews the literature is only one component of MTSS TII and does not facilitate the reduction in re-occurrence of the MTSS TII which seems to be based in biomechanical aberrations and neuromuscular changes that							

	may still be present after the pain has subsided or disappeared (Miranda *et al.* 2019). There are no further recordings mentioned in the long term, both in terms of pain or functional change.
OUTCOME	The main reason for this case report was to show the clinical effect of a possible treatment programme for an MTSS TII patient. The author noted that after the treatment the symptoms and signs of MTSS TII subsided (pain) or increased (flexibility) and according to the patient he recovered to his full functional capacity. The control check-up a month later revealed that the patient had no returning discomfort.
DISCUSSIONS	We are unable to say that any one treatment intervention was the sole reason why this patient recovered, as this study noted that there were a number of different interventions administered to this patient. This study included physical therapy, iontophoresis of anaesthetic, and low level laser therapy that was administered over the initial three weeks as 15 treatments. The patient then received rehabilitative care that included ankle range of motion exercises, hamstrings and Achilles tendon stretching. Lastly, the patient was advised to get insoles. Therefore, it cannot be concluded from the results that any one particular intervention was superior to another, although the study can make conclusions with regards to the combination of therapies used in this study. The author noted that this multi-treatment approach was successful in this patient. Due to the limitations discussed earlier, this evidence is limited when looking at a population suffering from MTSS TII. This data is only applicable to this specific data set or patients that meet the exacting requirements of this data set.
CONCLUSION	Therefore, this article provides very limited evidence and was of average design in being able to isolate the contribution of any one intervention for the purposes of treating MTSS TII. In addition to the comments and conclusions drawn by the reviewers, the ranking of this article was shown as A = 1, B1 = 5, B2 = 1, C = 0, I = 1 and N/A = 0, indicating that this study provides limited evidence. It is, however, suggested that future studies look at isolating the specific intervention modalities in NRCT or RCT study design to exact their contribution towards the overall treatment of MTSS TII (efficacy studies). In addition, the development of comparative or relative effectiveness studies would facilitate a better understanding of the synergistic or antagonistic relationship between these interventions when applied in combination sequences in clinical practice.

Table 4.14: Tabulated feedback data – case studies – Article 7

AUTHOR(S)	Knight, R. R.					
YEAR	2010					
TITLE	Integration of manual therapy, rehabilitation and acupuncture in the treatment of a 17-year-old male professional football player with chronic medial tibial stress syndrome					
CRITERIA		**Reviewer 1**	**Reviewer 2**	**Reviewer 3**	**Ranking**	**Percentage Agreement**
1	Study Identification	B1	B1	B1	B1	100%
2	How is the study type described?	B2	B2	B2	B2	100%
3	What interventions are considered and how are they implemented?	B1	B2	B1	B1	66%
4	Is the intervention aimed at individuals or populations?	C	C	C	C	100%
5	What outcomes are considered?	A	B1	B1	B1	66%
6	What factors other than the intervention could affect the outcome?	B2	B2	C	B2	66%
7	What are the characteristics of the population and study setting?	B2	B2	C	B2	66%
8	How many groups/sites in the study?	I	I	I	I	100%
	TOTAL SCORE	A:1 B1:2 B2:3 C:1 I:1 N/A:0	A:0 B1:2 B2:4 C:1 I:1 N/A:0	A:0 B1:3 B2:1 C:3 I:1 N/A:0	A:0 B1:3 B2:3 C:1 I:1 N/A:0	
			OVERALL PERCENTAGE AGREEMENT			78,75%

Table 4.15: Properties of study, outcome and discussion– case study – Article 7

AUTHOR(S)	Knight, R. R.							
YEAR	2010							
TITLE	Integration of manual therapy, rehabilitation and acupuncture in the treatment of a 17-year-old male professional football player with chronic medial tibial stress syndrome							
STUDY PROPERTIES								
Form of measurement	**Frequency of measurement**	**Duration of study**	**Number of participants**	**Assessors blinded**	**Control used**	**Randomisation of participants**	**Ranking**	**Total Percentage Agreement**
NPS. Ankle dorsiflexion. One-repetition maximum strength.	Daily	2 weeks of daily intervention. Final assessment after 2 months.	N=1. 17-year-old male professional football player.	No, this was a case study. (n=1)..	No as there was only one participant	No, this was a case study. (n=1).	A:0 B1:3 B2:3 C:1 I:1 N/A:0	78,75%
LIMITATIONS	Similar to Jovićić *et al.* (2014), the article by Knight suffers from the same limitations that are presented by a case study: 1. The small sample size is reflected in a singular patient case. This type of study is useful for discussing the role of treatment modalities, but can be biased towards successful outcome. It also is not applicable to the general patient population and therefore generalisation of the outcomes may only be applicable to patients that meet the same patient characteristics as the patient in this study. 2. The use of multiple interventions. Even though this is generally more reflective of practice, it does only allow for the outcome of the treatment programme to be established as opposed to individual treatment interventions. 3. To its advantage, this particular case study does have an intermediate follow up period, which allows for understanding the short term effects of the programme of intervention. This does, however, detract from the study being able to comment on long term effects. One significant limitation that conflicts with the discussion of the author, is the assertion that the study tested the role of acupuncture in the treatment of MTTS TII. It is noted that acupuncture was used in combination with manual therapy techniques, passive stretching and muscle rehabilitation. Therefore, it is impossible to determine the independent impact of acupuncture technique on the end outcome. Another complicating factor in being able to analyse the contribution of this article to the literature regarding MTSS TII treatment is that the treatment parameters used in the study are also not well documented. The choice of the 15 treatment sessions may have been applicable to acupuncture treatments and ensure compliance with the rehabilitation component of the programme, but would not be recommended							

	for manual therapy techniques such as manipulation or mobilisation (Vernon and Schneider 2009). It would have been more beneficial for these applications to be discussed in more detail with regards to how, where and when they were applied.
OUTCOME	The author found that the individual's NPS scores after training reduced by 60% following the intervention at two weeks and then by 100% at the final assessment after two months. His NPS scores first thing in the morning and five hours after his training session decreased by 100% at two weeks and after intervention. There was a nominal change in his ankle dorsiflexion after two weeks of intervention. However, this increased when reassessed at the final assessment. Strength in his legs increased bilaterally as seen in his one-repetition maximum strength. This indicates that acupuncture in combination with manual therapy techniques, passive stretching, biomechanical assessment and muscle rehabilitation was successful in treating this patient, who developed MTSS TII while playing professional football.
DISCUSSIONS	This case study showed positive outcomes for this type of intervention but as mentioned in limitations, it would be more beneficial if this study included more participants to test the relative effectiveness of the treatment programme against the individual treatment modalities in isolation. However, the development of relative effectiveness studies would only be possible once efficacy studies have been conducted to indicate whether the individual treatment modalities are indeed better than placebo to start with (Kaiser *et al.* 2018). Ideally, if this study wanted to test the role of acupuncture, then that should have been the only intervention they implemented to show how successful it is. Therefore, this study lacks concrete evidence when MTSS TII is treated with acupuncture.
CONCLUSION	This study, given its limitations as discussed in this table, indicates that the outcomes are not generalisable, poorly identifiable to any one intervention and poorly described making replication of the study on a larger scale difficult to reproduce. Therefore, this study's outcome is plagued by bias, lack of structural and reporting rigour and thus the impact is such that the outcomes actually contribute little to the evidence in favour or against the use of any particular modality in the treatment of MTSS TII. This is also seen in the reviewers' comments and rating of the article which shows (Table 4.14) a score of A = 0, B1 = 3, B2 = 3, C = 1, I = 1 and N/A = 0 and a 78,75% agreement. Therefore, future studies should focus on a single intervention, more participants and a control (for efficacy studies) if the role of acupuncture is to be tested.Future studies should also include clear parameters when discussing the intervention to increase the possibility of recreating another study or using the same intervention on a patient.

Table 4.16: Tabulated feedback data for group 1 – case studies – Article 8

AUTHOR(S)	Martinez, R. E., Lopez, E. B., Cox, R. W., Stankevitz, D., Larkins, L., Baker, R. T. and May, J.					
YEAR	2020					
TITLE	Exploring treatment of medial tibial stress syndrome via posture and the MyoKinesthetic system					
CRITERIA		**Reviewer 1**	**Reviewer 2**	**Reviewer 3**	**Ranking**	**Percentage Agreement**
1	Study Identification	A	A	A	A	100%
2	How is the study type described?	A	B1	B1	B1	66%
3	What interventions are considered and how are they implemented?	B1	B1	B1	B1	100%
4	Is the intervention aimed at individuals or populations?	B1	B1	A	B1	66%
5	What outcomes are considered?	B1	A	B1	B1	66%
6	What factors other than the intervention could affect the outcome?	B2	B1	B2	B2	66%
7	What are the characteristics of the population and study setting?	B2	B2	B1	B2	66%
8	How many groups/sites in the study?	B1	A	B1	B1	66%
	TOTAL SCORE	A:2 B1:4 B2:2 C:0 I:0 N/A:0	A:3 B1:4 B2:1 C:0 I:0 N/A:0	A:2 B1:5 B2:1 C:0 I:0 N/A:0	A:1 B1:5 B2:2 C:0 I:0 N/A:0	
				OVERALL PERCENTAGE AGREEMENT		74,5%

Table 4.17: Properties of study, outcome and discussion– case study – Article 8

AUTHOR(S)	Martinez, R. E., Lopez, E. B., Cox, R. W., Stankevitz, D., Larkins, L., Baker, R. T. and May, J.							
YEAR	2020							
TITLE	Exploring treatment of medial tibial stress syndrome via posture and the MyoKinesthetic system.							
STUDY PROPERTIES								
Form of measurement	**Frequency of measurement**	**Duration of study**	**Number of participants**	**Assessors blinded**	**Control used**	**Randomisation of participants**	**Ranking**	**Total Percentage Agreement**
NPRS. DPA scale.	At every visit – which correlated with the number of treatment visits.	Different for each participant. On average 1.82 weeks.	18 patients	No	No	No	A:1 B1:5 B2:2 C:0 I:0 N/A:0	74,5%
LIMITATIONS	The primary limitation of this study is the small sample size and then the further subgrouping of the patients according to the Myokinesthetic ™ assessment, which grouped patients according the identified and involved nerve root associated with the MTSS TII presentation. In addition to this, the treatment exposure (number of treatments) and the interventions applied were specific to the nerve root group into which the patient was placed. This resulted in the treatment visit means ranging from 3.00 to 23.00, with the highest number of treatments being 35 for one participant. (The total population mean was 8.06 treatments over a maximum of almost four weeks at maximum and two weeks at minimum). This variation between the participants is almost reflective of a prospective case series with a pre-post experimental design as opposed to a clinical trial. This negates the ability of this study to comment on the effectiveness of the interventions collectively for the patient population and reporting should have been concluded per individual subgroup of participants. The reporting of a case series has its limitations, as mentioned by the author of this study. The lack of a comparison or control group does not allow for the efficacy of the interventions or treatment programme to be commented on in a manner that allows comparison to change that would have naturally been possible through natural history change in the condition (Ardern *et al.* 2017). As the Myokinesthetic ™ assessmenttool has not been tested for its sensitivity and specificity when determining a patient's clinical presentation (Brody 2015), and its inter-examiner reliability has not been shown (Brody 2015), the use of this tool in relation to its applicability in the context of the MTSS TII patients is questionable. Given that this is an exploratory study, it may have been more appropriate to document the association between clinical measure of MTSS TII and the findings of the Myokinesthetic ™ assessmenttool to determine this relationship before utilising the tool as a basis for developing intervention protocols. This detracts from the study in terms of the outcomes, as the placement of patients into specific clinical groups and the development of specific treatment plans is called into question. A final limitation is one that is a combination of factors (Büttner *et al*. 2020), which include the fact that: - There were 4 different people assessing and treating the 18 participants in the study. They were all reported to be novice practitioners, with limited exposure to the Myokinesthetic ™ assessmenttool in addition to having potentially very different practice styles.							

	- The protocol for their consistent application of the assessment strategy and treatment intervention is not clear. There is no mention of a protocol or training session for these practitioners. This statement is borne out of the fact that there does not seem to have been a set number of interventions, time limit or any other measures of standardisation in this study. - The lack of accountability regarding the effects of blinding and bias is not reported in the study and therefore cannot be ruled out when considering these and the impact on the outcomes of the study. The above limitations have a significant impact on the ability of the reader to confidently accept the conclusions drawn by the authors.
OUTCOME	MYK postural analysis was used in this study to identify primary nerve root dysfunction and determine treatment parameters (i.e. nerve root) for each participant. The goal of this study was to see how effective the MYK system is in detecting and treating pain and dysfunction in patients with MTSS TII. Using this system fourteen patients were classified with an S1 nerve root dysfunction, two had multiple nerve root dysfunctions, one patient was diagnosed with L4 dysfunction and one patient had a L5 dysfunction. Notwithstanding the limitations, it was noted at the end of the treatments that 83.3% of participants indicated complete cessation of pain. The authors concluded that the results of the MYK system in this study gave the impression of beating traditional interventions while continuing exercise.
DISCUSSIONS:	While the authors noted that no other study indicated that pain can be decreased while the patient is still staying active and making a full recovery, it is also impossible to state that this was not potentially a natural history artefact in this patient population group. In addition, the claim that this does not happen in other studies is incorrect, as participants stayed active throughout treatment as seen in Rompe *et al.* (2010) and Pietrzak (2014), who treated similar population groups. Thus, given the limitations and perception that this is a prospective case series presentation with numerous categories of patients that were treated for a particular condition (MTSS TII) utilising a system that both analyses and then recommends treatment based specifically on the analysis, it is impossible to draw firm conclusions about the validity of the outcomes. The patient reported outcomes (all subjective) may have been influenced by the novelty of the system and its approach (with limited reliability, validity, sensitivity and specificity (Chan *et al.* 2004), the potential enthusiasm of the novice practitioners treating them with a new system, auto-suggestion bias stemming from the two prior points and patient expectation of the new and novel system. Therefore, given that we have no means to conclude that the response over time was not related to natural history of MTSS TII resolution and that the effects of the subjective measures did not in any manner influence the positive outcomes. It is drawn into question until further research is done to substantiate the outcome of this study.
CONCLUSION	This case series reflected poor considerations in terms of applicant inclusion, applicant homogeneity, structured procedures, and identified measurement outcomes. Although this study still has significant limitations as mentioned in this table, when it is compared to RCTs, it is not able to comment powerfully on the relevance of the MyoKinesthetic system as used in treatment for patients with MTSS TII. This study achieved the following rankings: A = 1, B1 = 5, B2 = 2, C = 0, I = 0 and N/A = 0 at an agreement level of 74,5%. Based on this ranking indicating above average methodological rigour of the case series, it would suggest that a structured MyoKinesthetic system intervention has an impact on the detection and treatment of pain and dysfunction in patients with MTSS TII. However, given the limitations and impact of the considerations noted in the discussions above, the outcomes need to be accepted with caution. It is therefore suggested that future studies should focus on structured parameters for treatment protocol (i.e. one type of nerve root dysfunction), homogenising the amount of treatments, including a larger sample size, prioritising a control group and blinding the assessors and participants.

Table 4.18: Tabulated feedback data – case studies – Article 9

AUTHOR(S)	Pietrzak, M.					
YEAR	2014					
TITLE	Diagnosis and management of acute medial tibial stress syndrome in a 15-year-old female surf life-saving competitor.					
CRITERIA		**Reviewer 1**	**Reviewer 2**	**Reviewer 3**	**Ranking**	**Percentage Agreement**
1	Study Identification	A	A	A	A	100%
2	How is the study type described?	B2	B1	B2	B2	66%
3	What interventions are considered and how are they implemented?	C	B2	C	C	66%
4	Is the intervention aimed at individuals or populations?	B1	B1	B2	B1	66%
5	What outcomes are considered?	B1	B1	B1	B1	100%
6	What factors other than the intervention could affect the outcome?	C	C	C	C	100%
7	What are the characteristics of the population and study setting?	C	B2	B2	B2	66%
8	How many groups/sites in the study?	N/A	B2	B2	B2	66%
	TOTAL SCORE	A:1 B1:2 B2:1 C:3 I:0 N/A:1	A:1 B1:3 B2:3 C:1 I:0 N/A:0	A:1 B1:1 B2:4 C:2 I:0 N/A:0	A:1 B1:2 B2:3 C:2 I:0 N/A:0	
		OVERALL PERCENTAGE AGREEMENT				78,75%

Table 4.19: Properties of study, outcome and discussion– case study – Article 9

AUTHOR(S)	Pietrzak, M.							
YEAR	2014							
TITLE	Diagnosis and management of acute medial tibial stress syndrome in a 15-year-old female surf life-saving competitor.							
STUDY PROPERTIES								
Form of measurement	**Frequency of measurement**	**Duration of study**	**Number of participants**	**Assessors blinded**	**Control used**	**Randomisation of participants**	**Ranking**	**Total Percentage Agreement**
SNRS	Initial examination followed by mid-weekly evaluation.	Four weeks that included 4 interventions. Patient was then monitored for an additional two months.	One participant	No, as this was a case study (n=1).	No, as this was a singular case study.	No, as this was a case study (n=1).	A:1 B1:2 B2:3 C:2 I:0 N/A:0	78,75%
LIMITATIONS	The only limitation mentioned by the author was that this case report included a physical examination and repeated measures that were largely dependent on subjective feedback on a SNRS whilst a personal trainer controlled conservative manual palpation of an estimated force magnitude of mild, moderate or firm. The results could therefore be affected as the patient was familiar with having to rate her pain and improvement (Shusterman 2011). This could lead to bias (Chan *et al.* 2004), as the reported outcome may represent what the patient thinks the practitioner wishes to hear as opposed to what the actual reflection of her condition is/was. In addition, the subjective perception of the personal trainer could potentially have influenced the patient who may have wanted to please the personal trainer or perceived that a specific response was being sought. Thus, the inclusion of objective improvement measures would have significantly improved the rigour of the study. This study only had one participant, a fifteen-year-old female, presenting with MTSS TII at the start of her season for life saving. She was exercising bi-daily and competing in up to 20 events over the weekends. This cannot be generalised to the public and is a unique case. This athlete had a demanding training programme that could not have been avoided for the full recovery time, in addition the programme although demanding would have had less impact if the patient had adequately prepared for the programme with gradual increase in intensity and frequency of the demands. The researcher used different interventions in the treatment regimen. These included: cryotherapy, myofascial release, ischaemic pressure, calf-stretching, initial rest from activities and a gradual return to sport programme. It cannot be assumed that any one specific intervention was beneficial over another in this patient. This shows that a multiple approach could be effective but cannot highlight a specific treatment regimen.							

OUTCOME	The participant showed a favourable outcome at the final intervention but no rating on the SNRS was mentioned. It is noted that the patient competed a week after this intervention with symptoms remaining similar. The MTTS TII symptoms were resolved gradually over eight weeks after initial consultation. The symptoms were resolving while the patient was competing but she decreased her running programme when she did not compete. Twelve weeks post injury she could follow her normal running routine without pain. Thereafter, she could train and compete asymptomatically for the rest of the season. The author noted that this type of treatment was effective in the treatment of MTSS TII for this particular participant but also mentioned that future research is needed in this sport as overuse injuries are common.
DISCUSSIONS	This patient was allowed to continue her competitions but was limited in her degree of running intensity. As mentioned in the previous study (Martinez *etal.* 2020) there are limited studies that suggest pain can decrease while the patient stays active. This patient followed a graded running programme with rest for the first week followed by walking, but could still compete. This case study approach of using multiple interventions in a patient that has a demanding training programme showed favourable outcomes over eight weeks. This outcome lacks credible substantiation, due to the sample of one, the lack of objective outcome measures, inadequate reporting of repeated measures and the implications that bias may have played a role in the resolution of the MTSS TII. In terms of the evidence that this article provides in terms of the specific interventions for MTSS TII, this is very limited as a result of the combination of interventions, in addition to the highly unique patient presentation in terms of age, gender and sport specific association implied in the article with regards to the patient. Therefore, although this study suggests a successful outcome, future studies would need to be done to see how effective this type of treatment can be and how to administer it in the various components of the combination therapy. Additionally, future studies should be focused on patients within specific sporting disciplines (e.g. lifesaving). It would be beneficial if they can increase the number of participants and create a control group to establish if this multiple intervention approach is beneficial (relative effectiveness of the interventions and programmes of interventions). This latter suggestion would require that efficacy studies have already been done and if not, that these be completed first.
CONCLUSION	This study seems to support the use of combinations of conservative treatment in the management of MTSS TII. There was extensive variation in the number of factors present in this study. If there were a control present, it would have provided some validation of the response to the intervention combinations. This study is unable to draw conclusions to determine the efficacy of individual treatments or the relative effectiveness of treatments to one another. Based on the lack of conclusion, this study is weakened and the results are in poor support of this type of treatment. This average outcome is reflected in the analysis of this case series by the reviewers in that the study was ranked poorly and achieved the following outcomes: A = 1, B1 = 2, B2 = 3, C = 2, I = 0 and N/A = 0 with an agreement of 78,75%. This study indicated that when a combination of conservative treatments is implemented with a lifesaving female, it seems to assist with the recovery of this type of participant.

Table 4.20: Tabulated feedback data – case studies – Article 10

AUTHOR(S)	Sathe, A.					
YEAR	2017					
TITLE	Medial tibial stress syndrome: A case study					
CRITERIA		**Reviewer 1**	**Reviewer 2**	**Reviewer 3**	**Ranking**	**Percentage Agreement**
1	Study Identification	B1	B1	B1	B1	100%
2	How is the study type described?	A	B1	B1	B1	66%
3	What interventions are considered and how are they implemented?	B1	C	C	C	66%
4	Is the intervention aimed at individuals or populations?	A	B2	B2	B2	66%
5	What outcomes are considered?	B2	B2	B1	B2	66%
6	What factors other than the intervention could affect the outcome?	N/A	N/A	C	N/A	66%
7	What are the characteristics of the population and study setting?	B1	B2	B2	B2	66%
8	How many groups/sites in the study?	B1	B1	B1	B1	100%
	TOTAL SCORE	A:1 B1:4 B2:1 C:0 I:0 N/A:1	A:0 B1:3 B2:3 C:1 I:0 N/A:1	A:0 B1:4 B2:2 C:2 I:0 N/A:0	A:0 B1:3 B2:3 C:1 I:0 N/A:1	
		OVERALL PERCENTAGE AGREEMENT				74,5%

Table 4.21: Properties of study, outcome and discussion– case study – Article 10

AUTHOR(S)	Sathe, A.							
YEAR	2017							
TITLE	Medial tibial stress syndrome: A case study							
STUDY PROPERTIES								
Form of measurement	**Frequency of measurement**	**Duration of study**	**Number of participants**	**Assessors blinded**	**Control used**	**Randomisation of participants**	**Ranking**	**Total Percentage Agreement**
Baseline measurement. No measurement mentioned during treatment. VAS was used afterwards.	Not mentioned	Not mentioned	1 participant	No	No as this was a singular case study.	No as there was only one participant	A:0 B1:3 B2:3 C:1 I:0 N/A:1	74,5%
LIMITATIONS	Unfortunately, no limitations were noted by the author. However, when reviewing the case study, several limitations and their impact need to be considered, these include : - The sample size in this case study was small (n = 1). The participant was a young male taekwondo player, which does not allow for generalisation to a larger population and limits the inferential statistics that could have been applied. - Another limitation of the study was the lack of structured follow-up measures after treatment or at the end of the season, to determine whether the treatment effects showed any changes after the termination of treatment. This limits the short, medium and long term clinical effect interpretation of the interventions. - The implications of bias related to the fact that the author, was seemingly also the assessor of patient progression, suggests a possibility of bias on the outcome measures. In addition, the younger age of the participant may also have resulted in the patient reporting what they expected the practitioner wanted or were influenced by their level of satisfaction of the care provided. Therefore, the use of objective measures to support subjective outcomes are always necessary to allow assessment of bias as well as the relative changes in objective and subjective measures to support/not support each other. - Finally, the treatment programme as noted by the author included rest, ice massage, transcutaneous electronic nerve stimulation, whirlpool, ankle pumps, passive stretching of the calf muscles, toe taps, static cycling, and intrinsic muscle exercises. This progressed to resisted isometrics, resistance band exercises, and active/ weight-bearing stretches of the calf muscles, stretching of the tibialis anterior, heel raises, and core-strengthening exercises. Given this extensive programme,							

	there is however a lack of detail in terms of how, when and where these different modalities were applied and what decision-making was used to stage progression.
OUTCOME	The outcome mentioned in this study notes that after a systematic approach in management, the patient returned to his taekwondo practice. It notes that on examination, the VAS was 1/10 (rest) and 3/10 (activity). It also mentioned he had reduced sleep disturbances. The patient also reported a decrease in tenderness and gave positive feedback about his exercises and training sessions.
DISCUSSIONS	From the outcomes of the study, it would seem evident that the intervention applied within the context of this feasibility study bore clinical outcomes for the participant. It would, however, be incorrect to state that this clinical response would be similarly applicable to all people who are diagnosed with MTSS TII, due to the significant limitations mentioned above. Although this study, with all its limitations, showed a good outcome for the use of multiple interventions, it cannot be used to determine the efficiency of this intervention. If there was a better understanding of the parameters that were used in this study, it would be beneficial to conduct an RCT to see the use of multiple interventions within a bigger sample size and a control group.
CONCLUSION	Based on the limitations discussed in this table, it is evident that this is a poorly constructed study but showed a good outcome. This is reflected in the reviews done by the reviewers that showed an outcome of: A = 0, B1 = 3, B2 = 3, C = 1, I = 0 and N/A = 1 with an agreement score of 74,5%. In the context of MTSS TII this study therefore provides limited/no evidence in support of this intervention for participants that have MTSS TII. It is recommended that future studies are structured to further investigate specific individual and combinations of interventions (with more participants, more detail on type of intervention and treatment, including subjective and objective outcome measures and how the patient experiences their pain throughout the study) for participants with MTSS TII.

Table 4.22: Tabulated feedback data – case studies – Article 11

AUTHOR(S)	Saxena, A., Fullem, B. and Gerdesmeyer, L.					
YEAR	2017					
TITLE	Treatment of Medial Tibial Stress Syndrome With Radial Soundwave Therapy in Elite Athletes: Current Evidence, Report on Two Cases, and Proposed Treatment Regimen					
CRITERIA		**Reviewer 1**	**Reviewer 2**	**Reviewer 3**	**Ranking**	**Percentage Agreement**
1	Study Identification	B1	B1	B1	B1	100%
2	How is the study type described?	C	B2	B2	B2	66%
3	What interventions are considered and how are they implemented?	B1	N/A	B1	B1	66%
4	Is the intervention aimed at individuals or populations?	B2	C	C	C	66%
5	What outcomes are considered?	B1	N/A	B1	B1	66%
6	What factors other than the intervention could affect the outcome?	C	C	C	C	100%
7	What are the characteristics of the population and study setting?	B1	B1	B1	B1	100%
8	How many groups/sites in the study?	B2	B2	B2	B2	100%
	TOTAL SCORE	A:0 B1:4 B2:2 C:2 I:0 N/A:0	A:0 B1:2 B2:2 C:2 I:0 N/A:2	A:0 B1:3 B2:2 C:3 I:0 N/A:0	A:0 B1:4 B2:2 C:2 I:0 N/A:0	
			OVERALL PERCENTAGE AGREEMENT			83%

Table 4.23: Properties of study, outcome and discussion – case study – Article 11

AUTHOR(S)	Saxena, A., Fullem, B. and Gerdesmeyer, L.							
YEAR	2017							
TITLE	Treatment of Medial Tibial Stress Syndrome With Radial Soundwave Therapy in Elite Athletes: Current Evidence, Report on Two Cases, and Proposed Treatment Regimen.							
STUDY PROPERTIES								
Form of measurement	**Frequency of measurement**	**Duration of study**	**Number of participants**	**Assessors blinded**	**Control used**	**Randomisation of participants**	**Ranking**	**Total Percentage Agreement**
Return to play pain free	Different for each individual.	Different for each participant.	Two participants	No assessors were blinded.	No controls were used. Both participants were in a treatment group.	No groups were used and therefore no randomisation.	A:0 B1:4 B2:2 C:2 I:0 N/A:0	83%
LIMITATIONS	Given that RSWT is a relatively new idea in the treatment of MTSS TII, the authors should be applauded for conducting their research and publishing it. This study provided some good groundwork and provided some valuable questions that future studies will be able to explore. However, it would have been better for the authors to note limitations in order to assist in aiding future researchers in the development of this area in the treatment of MTSS TII. Firstly, no objective form of subjective or objective measurements were used to record the patients' levels of discomfort, disability or clinical progression from before the start of treatment or to measure the level of improvement at the various stated intervals. The only measurement was a subjective response of the ability to return to play. This increases the bias, as these report-backs may be influenced by, amongst other issues, those related to patient expectation, patient satisfaction, and patient perception of practitioner confidence in the treatment plan, and patient perception of what the practitioner expected from the patient (Thornton *et al.* 2017). Secondly, the sample size included two young individuals that both participated in sports at an elite level and therefore cannot be extrapolated to the generalisable public with the presentation of MTSS. Furthermore, the patients were dissimilar in their presentation as one presented with MTSS TI and the other with MTSS TII. This article is reporting on two different and individual case studies that have nothing in common.A very homogenous sample (students from an elite sporting background) is a more appropriate one for a study which hopes to produce the same response for people with the same background. Therefore, it would not be appropriate for people with a different background. The fact that these athletes have different types of MTSS leads to a negative effect on sample size and makes the group non-homogenous. This results in further impact on the outcome of the study. Thirdly, the last data sets that are mentioned for the participants are at four months and six months after treatment respectively. No record of activity level, change in the ergonomics, adaptation of activity and other extrinsic factors were monitored during and after the study and							

	thus it is not possible to determine whether the outcomes are directly related to the treatment applied or the change in the external dynamics (viz. we are not aware from the manner in which the article is written as to how confounding factors were excluded when reaching a conclusion in this report). Lastly, both cases were treated with a treatment programme tailored to their specific needs (they presented with MTSS TII and MTSS TI), which precludes comparison of their clinical outcomes and may be the basis for the different lengths of time in which improvement was reported for both athletes. To complicate this, both participants received Radial Soundwave Therapy (RSWT). However, the intensity and frequency were different for each patient which supports that they had different clinical presentations, and limits the ability of the study to both compare the cases and draw conclusions. Therefore, the outcomes are participant specific, treatment programme specific and cannot be extrapolated to patients outside of those that meet similar demographic and clinical characteristics as displayed by the two participants that were reported on.
OUTCOME	Both participants were able to continue their sport and finish their season, which entailed vigorous training programmes and competition schedules. There is no mention of whether the patients were still experiencing pain and to what level, as the reported outcomes only related to the ability to participate in play. This suggests that the intervention was of benefit for these two participants.
DISCUSSIONS	This multifaceted evidence treatment approach appears to have been beneficial, but only in terms of the return to play measures utilised in the study. The clinical picture in terms of the patient presentation is unclear and its correlation to the return to play is not overt. The authors suggest that this study supports the idea that athletes can continue training even after they have been diagnosed with MTSS TII, even though arguably only the one patient had MTSS TII. The assertions made in this statement are significantly categorical but are based on a foundation of one patient and is subject to the limitations mentioned previously in this table. Thus, this study has a low level of evidence for patients with MTSS TII and the effect of RSWT. Future studies should focus on only including RSWT to test its efficacy as a singular treatment modality. Preferably, the sample size should be increased and should include people from different backgrounds. It would also be beneficial if a pain scale is introduced while the participant is continuing their training. This would be able to show if the patient experiences pain relief or only healing in this time.
CONCLUSION	Given the impact of this article representing in essence a case study of MTSS TII with a treatment programme, there are many factors that seem to detract from the ability to draw a firm conclusion that there is definitive benefit from the study interventions for MTSS TII. There is certainly a trend towards improvement which seems to be measured best by return to play and less so by actual clinical presentation. Therefore the clinical outcomes need to be accepted with caution. This is supported by a level of methodological rigour that is at best above average given the outcomes of the reviewer ranking noted as: A = 0, B1 = 4, B2 = 2, C = 2, I = 0 and N/A = 0. This publication provides some evidence in support of the treatment programme for MTSS TII, but requires extensive further testing to determine whether this can be more generalisable and consider the actual clinical outcomes in conjunction with the return to play criteria to make a comprehensive outcome available to practitioners.

Table 4.24: Tabulated feedback data – case studies – Article 12

AUTHOR(S)	Thistle, S.					
YEAR	2018					
TITLE	Treatment of Medial Tibial Stress Syndrome Using the MyoKinesthetic System: A Case Series					
CRITERIA		**Reviewer 1**	**Reviewer 2**	**Reviewer 3**	**Ranking**	**Percentage Agreement**
1	Study Identification	A	A	A	A	100%
2	How is the study type described?	B2	B2	B2	B2	100%
3	What interventions are considered and how are they implemented?	B1	B1	B1	B1	100%
4	Is the intervention aimed at individuals or populations?	B2	C	B2	B2	66%
5	What outcomes are considered?	B1	B1	B1	B1	100%
6	What factors other than the intervention could affect the outcome?	N/A	C	C	C	66%
7	What are the characteristics of the population and study setting?	B1	C	C	C	66%
8	How many groups/sites in the study?	B1	B1	B1	B1	100%
	TOTAL SCORE	A:1 B1:4 B2:2 C:0 I:0 N/A:1	A:1 B1:3 B2:1 C:3 I:0 N/A:0	A:1 B1:3 B2:2 C:2 I:0 N/A:0	A:1 B1:3 B2:2 C:2 I:0 N/A:0	
			OVERALL PERCENTAGE AGREEMENT			87,25%

Table 4.25: Properties of study, outcome and discussion– case study – Article 12

AUTHOR(S)	Thistle, S.							
YEAR	2018							
TITLE	Treatment of Medial Tibial Stress Syndrome Using the MyoKinesthetic System: A Case Series.							
STUDY PROPERTIES								
Form of measurement	**Frequency of measurement**	**Duration of study**	**Number of participants**	**Assessors blinded**	**Control used**	**Randomisation of participants**	**Ranking**	**Total Percentage Agreement**
PROM. MYK System posture screen. LEFS. DPA Scale. PSFS. GRC. NDT. Well-Being Survey. NPRS.	Two posture screens.	6 weeks	6 participants	No	Group A: MYK (n=1) Group B: traditional treatment (n=1) and the control was Group C: no treatment (n=4).	Yes. An online number generator was used.	A:1 B1:3 B2:2 C:2 I:0 N/A:0	87,25%
LIMITATIONS	To the author's credit, a couple of limitations that were present in the study that could have affected the outcome were provided and discussed. As was seen in the previous studies in this section of the review, the sample size for this study was extremely small (n=6). There were two groups of one participant each, receiving treatment and a control group of n=4. Therefore, the sample size was too small to perform statistical analyses. Therefore, statistically analysing accurate effects of each treatment type is inhibited due to the small number of participants in experimental groups. Both participants in the experimental groups were 18 year old athletic females. Seeing that the intervention groups only included young females this decreases the generalisation of this study to the public. The outcomes could be different for older females or males. Non-homogenous groups are not ideal when assessing the effectiveness of an intervention (Kaiser *et al.* 2018). All participants were physically active and young. The two participants who were included in the experimental group complained of MTTS TII pain. The four individuals (two male and two female) who formed part of the control had no pain or prior history of MTSS TII. The MTSS TII participants were followed for six weeks while they received treatment. We have no medium term or long term outcomes of the interventions after treatment was suspended. However, it was noted that the patients were discharged at the end of the study but treatment was offered if they still experienced pain after the study. Whether this occurred is unclear. The two participants with MTSS TII received a different number of treatments. The first patient received six treatments that consisted of the MYK System. The second participant received seven treatments consisting of traditional treatment of cryotherapy massage, stretching							

	of the gastrocnemius/soleus complex and rolling of the plantar fascia. Both participants who received treatment, continued their sporting activities while undergoing treatment for MTSS TII. The control group comprised of four participants in the same team with no pain or prior history of MTSS TII and they received no intervention.Therefore, this study lacks a true control group. Participants in the control group went to two appointments and were then discharged from the study upon conclusion of their second (and final) posture screen. The control groups were included as a means of comparing posture screens and navicular drop measurements between participants with MTSS pain and those without. This suggests that this study was principally looking at the changes in posture in the MTSS TII patients in response to treatment as compared to their normal pain free counterparts. A final limitation noted was the coordination of treatment schedules. Scheduling treatment times between the principle investigator, the co-investigator and the participants was difficult and affected appointment frequency. This could have negatively affected the clinical success of the treatment. But conversely, it is possible that the use of multiple persons within the study would allow for blinding of the assessor (although not stated). It would also allow for the reduction in bias related to patient expectation, patient satisfaction, patient perception of practitioner confidence in the treatment plan, and patient perception of what the practitioner expected from the patient (Thornton *et al.* 2017).
OUTCOME	The person who was treated with the MYK system was cleared before six weeks due to significant decrease in pain and demonstrated vast improvement in her overall function. The other participant that received traditional treatment was discharged at the end of the six weeks and reported her pain rating to be similar to her initial appointment (no change). Therefore, she had no change in her perceived pain after the intervention and showed a lack of improvement. The context of these two outcomes related to the control groups provided no additional benefit to the study. There was no comment on the postural changes compared between the treatment participants and the control. This indicates that this then negates the previous suggestion made that the control was for purposes of evaluating postural changes in treatment.
DISCUSSIONS	This study compared the effectiveness of the MYK system treatment, traditional treatments, and no-treatment (control group). With only one participant receiving each intervention, the results must be viewed with caution given the limitations discussed above. The seemingly significant difference between the improvements with the MYK system as compared to the traditional interventions applied needs to be ratified and confirmed by research with larger sample sizes, appropriate statistical analysis as well as heterogeneous samples, equal numbers of treatment sessions, a control group with symptoms, long term follow up and consistency when scheduling treatment sessions. These parameters will all assist in the development of a clearer picture of the relative effectiveness of the two intervention types.
CONCLUSION	Given that the study falls prey to the same criticisms of a case study (Table 4.7; Table 4.11; Table 4.15), it is very difficult to accept the outcomes of the study due to the factors that potentially impact on the outcomes reached by the authors. This concurs with the reviewers who rated this specific study with an above average score: A = 1, B1 = 3, B2 = 2, C = 2, I = 0, N/A = 0 and an agreement percentage of 87,25%. Therefore, although it is suggested the MYK system treatment seems to be better than the traditional treatment, this needs to be accepted with caution and further testing in the form of a RCT designed study. It needs to be considered that this treatment may not be beneficial when this study is reproduced with a bigger sample size that has an increased homogenous group.

Table 4.26: Tabulated feedback data – case studies – Article 13

AUTHOR(S)	Tutté, M. L. andGalin, G.					
YEAR	2016					
TITLE	Shin Splints: Efficacy of Radial Extracorporeal Shock Wave Therapy in Ballet Dancers. A Series Of Cases					
CRITERIA		**Reviewer 1**	**Reviewer 2**	**Reviewer 3**	**Ranking**	**Percentage Agreement**
1	Study Identification	C	C	A	C	66%
2	How is the study type described?	B1	C	C	C	66%
3	What interventions are considered and how are they implemented?	B2	B2	B2	B2	100%
4	Is the intervention aimed at individuals or populations?	B1	C	B1	B1	66%
5	What outcomes are considered?	B1	B2	B1	B1	66%
6	What factors other than the intervention could affect the outcome?	N/A	N/A	I	N/A	66%
7	What are the characteristics of the population and study setting?	B1	B2	B2	B2	66%
8	How many groups/sites in the study?	B1	B1	B1	B1	100%
	TOTAL SCORE	A:0 B1:5 B2:1 C:1 I:0 N/A:1	A:0 B1:1 B2:3 C:3 I:0 N/A:1	A:1 B1:3 B2:2 C:1 I:1 N/A:0	A:0 B1:3 B2:2 C:2 I:0 N/A:1	
			OVERALL PERCENTAGE AGREEMENT			74,5%

Table 4.27: Properties of study, outcome and discussion– case study– Article 13

AUTHOR(S)	Tutté, M. L. and Galin, G.							
YEAR	2016							
TITLE	Shin Splints: Efficacy of Radial Extracorporeal Shock Wave Therapy in Ballet Dancers. A Series Of Cases							
STUDY PROPERTIES								
Form of measurement	**Frequency of measurement**	**Duration of study**	**Number of participants**	**Assessors blinded**	**Control used**	**Randomisation of participants**	**Ranking**	**Total Percentage Agreement**
VAS was used in training while they were jumping.	Not mentioned. They received 6 weekly schedules.	6 weeks.	4 ballet dancers.	No	No	No	A:0 B1:3 B2:2 C:2 I:0 N/A:1	74,5%
LIMITATIONS	The authors must be credited for publishing this study even though it has some limitations that are not unlike a small case series presentation (Table 4.7; Table 4.11; Table 4.15; 4.25) and include the following: - The participants consisted of four young ballet dancers diagnosed with MTSS and receiving Radial Extracorporeal Shock Wave Therapy (rESWT).Three were men and one female. This series of cases is not applicable to the generalisable MTSS TII patient. - There were no clear treatment guidelines. Two of them were treated with an EMS Swiss Dolorclast®Classic, and the remaining two were treated with LONGEST PowerShocker LGT-2500S. The number of clinical outcome measurements were not noted. - Individual VAS scores were not included for each participant. - Treatment consisted of six weekly sessions, with 3000p, 2,5b, 7 Hz per session protocol, focusing on the pain zone. In addition, the treatment programme included stretching, exercises and counselling on correct jumping technique. These factors as well as the actual intervention could have influenced the amount of pain the participants were experiencing and could have contributed to the decrease in VAS score. - It is also possible that the use of only subjective measures increased the likelihood that the study is subject to bias from patient expectation, patient satisfaction, and patient perception of practitioner confidence in the treatment plan, as well as patient perception of what the practitioner expected from the patient (Thornton *et al.* 2017). This calls into question the conclusions drawn by the authors.							

	- The lack of a control group also does not allow for the comparison of natural history in the reduction of symptoms, thus reducing the confidence that the reader has in the stated outcomes of the study.
OUTCOME	Although the participants continued their normal training and their performance schedules, there was a decrease of pain noted at two months from baseline with a mean decrease VAS score of 4.8 points. In addition, the authors indicate that impairment of exercise tolerance was decreased from 3 to 1 points. This is good as patients were able to continue with their normal training and performance schedules. Three of the participants were asymptomatic after six months and the other participant still had some discomfort during high-intensity rehearsals, but was still able to perform.
DISCUSSIONS	According to the author both the rESWT devices were effective for these patients. The interventions noted in this study showed that functional improvement was achieved and pain relief was optimal to allow the participants to comply with their performance schedules. This conclusion however assumes that stretching, exercises and counselling on correct jumping technique had no effect. This can however not be assumed as no literature was found to substantiate this position, but rather literature in general indicates that stretching, exercises and counselling on activity modification are indeed options for reducing the likelihood of MTSS TII (Winters *et al.* 2013b). Therefore, the outcomes need to be accepted with caution until such time that rESWT is shown to be beneficial and successful when treating patients with MTSS TII in larger NRCT or RCT studies. In addition, this outcome also needs to be recreated in population groups outside of the specialist sport of ballet. The future studies (NRCTs/RCTs) need to include a larger sample size, control groups, randomisation and clear guidelines of information.
CONCLUSION	This study had a poor study structure but a seemingly good clinical outcome based on the intervention (although it is acknowledged that this needs to be accepted with caution given the limitations discussed above). This can be seen in Table 4.26 where the reviewers scored this article as: A = 0, B1 = 3, B2 = 2, C = 2, I = 0, N/A = 1 and an agreement score of 74,5%.

4.4.1.2 Discussion

Table 4.28 shows the outcome as determined by reviewers:

Table 4.28: Outcome and methodological ranking of case studies/series

Study Type	Case Studies/Case Series					
Author(s)	Year:	Reported Outcome by the author:	Methodological Ranking:	Rigour as determined by reviewers:	Contextually evaluated clinical outcome:
Austin	1996	The authors found that **flexible orthotics, adjustive technique, ice massage at home, rehabilitation of foot inverters and everters and slowly returning to activity** can effectively manage patient with MTSS TII.	A:2 B1:4 B2:1 C:1 I:0 N/A:0	Good	The treatment programme suggests a good outcome.
Bonanno, Munteanu, Murley, Landorf and Menz	2018	This study states **foot orthoses** reduces the risk of injury by a third.	A:2 B1:3 B2:1 C:1 I:1 N/A:0	Moderate to good	The outcome was not structured to provide clinical outcomes it was a prediction study on the effects of orthotics.
De La Fuente, Henriquez, Andrade and Yañez	2019	In the participants it was found that **footwear and custom insoles** that distribute the pressure reduces the impact when running after rehabilitation.	A:1 B1:3 B2:2 C:1 I:0 N/A:1	Moderate	There were no clinical outcomes correlated to improved weight distribution measures of the foot
De Vries	1961	This study only showed that a distressed muscle can relax after one session of **static stretching.**	A:1 B1:2 B2:1 C:0 I:3 N/A:1	Moderate to poor	There is no support that stretching can assist MTSS TII patients
Fick, Albright and Murray	1992	The participant reported pain free running after his **rest, icing, anti-inflammatory drugs, switching activities, gradually return to running** approach.	A:0 B1:3 B2:2 C:3 I:0 N/A:0	Moderate	The treatment programme suggests a good outcome
Jovicić, Jovicić, Hrković and Lazović	2014	The author noted that after **physical therapy, iontophoresis of anaesthetic, low level laser therapy, ankle range of motion exercises, hamstrings and Achilles tendon stretching**, the signs and symptoms subsided and the patient recovered to his full functional capacity.	A:1 B1:5 B2:1 C:0 I:1 N/A:0	Moderate	The treatment programme suggests a good outcome
Knight	2010	**Acupuncture, manual therapy techniques, passive stretching, biomechanical assessment and muscle rehabilitation** was successful in treating a patient.	A:0 B1:3 B2:3 C:1 I:1 N/A:0	Moderate to poor	The treatment programme suggests a good outcome

Martinez, Lopez, Cox, Stankevitz, Larkins, Baker, and May	2020	Results of the **MYK system** indicated that 83.3% of participants had complete cessation of pain.	A:1 B1:5 B2:2 C:0 I:0 N/A:0	Moderate to good	The treatment programme suggests a good outcome in favour of MYK system of treatment
Pietrzak	2014	The participant showed a favourable outcome at the final intervention of **ice, myofascial release, ischaemic pressure, calf stretching, rest from activities initially and a gradual return to sport programme**.	A:1 B1:2 B2:3 C:2 I:0 N/A:0	Moderate to good	The treatment programme suggests a good outcome in favour
Sathe	2017	It is indicated that after **rest, ice massage, transcutaneous electronic nerve stimulation, whirlpool, ankle pumps, passive stretching to the calf muscles, toe taps, static cycling, and intrinsic muscle exercises** was followed, the patient returned to his specific sport.	A:0 B1:3 B2:3 C:1 I:0 N/A:1	Moderate	The treatment programme suggests a good outcome in favour
Saxena, Fullem and Gerdesmeyer	2017	Radial Soundwave Therapy (RSWT) was of benefit for these two participants.	A:0 B1:4 B2:2 C:2 I:0 N/A:0	Moderate	The treatment programme suggests a good outcome in favour
Thistle	2018	**MYK system** is an effective treatment for MTSS TII, as compared to traditional treatment.	A:1 B1:3 B2:2 C:2 I:0 N/A:0	Moderate to good	The treatment programme suggests a good outcome in favour
Tutté and Galin	2016	**Radial Extracorporeal Shock Wave Therapy** is sufficient in reducing MTSS TII related pain that occurs during activity.	A:0 B1:3 B2:2 C:2 I:0 N/A:1	Moderate	The treatment programme suggests a good outcome in favour

4.4.2 Non-Randomised Controlled Trials Introduction

The Newcastle-Ottawa Scale (Wells *et al*. 2003) was chosen as the scale to review to rate all non-randomised controlled trials. The scale is divided into three independent sections, namely selection, comparability and exposure. Each section has a particular number of criteria. Each criterion can only receive a single star. The comparability section is an exception as a maximum of two stars can be awarded. The maximum number of stars that can be awarded for each section is as follows: four stars for selection, two for comparability and three for exposure. Therefore, a maximum of nine stars can be awarded per study. To capture the data with more ease, when a star was awarded, it was recorded with a '1' and if no star was awarded it was recorded as '0'. The total stars awarded per reviewer is listed within the total score row. A mean score was then calculated for each criterion based on the majority ranking of the reviewers. The outcome was then listed within the total score row. The percentage agreement was calculated for each independent criterion, to ascertain the degree of agreement between reviewers. A 100% of percentage agreement shows that all the reviewers were in total agreement regarding that specific criterion. A percentage agreement of 33% shows that none of the reviewers were in agreement. The overall level of agreement between reviewers throughout review of a study is indicated by the total percentage agreement.

4.4.2.1 Examiner Agreement and Ranking of Articles: Non-Randomised Controlled Trials

Table 4.29: List of table numbers for non-randomised controlled trial feedback and analysis

Tabulated feedback data	Analysis of article	Author(s)	Year	Title
4.30	4.31	Griebert, Needle, McConnell, and Kaminski	2016	Lower-leg Kinesio tape reduces rate of loading in participants with medial tibial stress syndrome
4.32	4.33	Loudon and Dolphino	2010	Use of Foot Orthoses and Calf Stretching for Individuals With Medial Tibial Stress Syndrome
4.34	4.35	Meulenkamp, Sauter, Buitenhuis, Mert and van Der Wurff	2016	Short-term results of a rehabilitation programme for service members with lower leg pain and the evaluation of patient characteristics
4.36	4.37	Moen, Rayer, Schipper, Schmikli, Weir, Tol and Backx	2012	Shockwave treatment for medial tibial stress syndrome in athletes; A prospective controlled study
4.38	4.39	Naderi, Degens and Sakinepoor	2019	Arch-support foot-orthoses normalise dynamic in-shoe foot pressure distribution in medial tibial stress syndrome
4.40	4.41	Rompe, Cacchio, Furiaand Maffulli	2010	Low-energy extracorporeal shock wave therapy as a treatment for medial tibial stress syndrome
4.42	4.43	Schulze, Finze, Bader, and Lison	2014	Treatment of medial tibial stress syndrome according to the fascial distortion model: A prospective case control study
4.44	4.45	Smith, Winn and Parette	1986	Comparative study using four modalities in shin splint treatments
4.46	4.47	Van Lingen	1998	The effectiveness of ultrasound therapy as an adjunct to the treatment of medial tibial stress syndrome type 2 (shin splints).

Table 4.30: Tabulated feedback data– NRCT – Article 1

AUTHOR(S)	Griebert, M. C., Needle, A. R., McConnell, J. and Kaminski, T. W.					
YEAR	2016					
TITLE	Lower-leg Kinesio tape reduces rate of loading in participants with medial tibial stress syndrome.					
CRITERIA		**Reviewer 1**	**Reviewer 2**	**Reviewer 3**	**Ranking**	**Percentage Agreement**
SELECTION	1. Is the case definition adequate?	0	1	0	0	66%
	2. Representativeness of the cases	0	1	1	1	66%
	3. Selection of controls	1	0	0	0	66%
	4. Definition of controls	1	1	1	1	100%
COMPARABILITY	5. Comparability of cohorts on the basis of design or analysis	2	1	1	1	66%
EXPOSURE	6. Ascertainment of exposure	0	0	0	0	100%
	7. Same method of ascertainment for cases and controls	1	1	1	1	100%
	8. Non-response rate	0	0	0	0	100%
	TOTAL SCORE	5	5	4	4	
		OVERALL PERCENTAGE AGREEMENT				83%

Table 4.31: Properties of study, outcome and discussion– NRCT – Article 1

AUTHOR(S)	Griebert, M. C., Needle, A. R., McConnell, J. and Kaminski, T. W.							
YEA	2016							
TITLE	Lower-leg Kinesio tape reduces rate of loading in participants with medial tibial stress syndrome.							
STUDY PROPERTIES								
Form of measurement	Frequency of measurement	Duration of study	Number of participants	Assessors blinded	Control used	Randomisation of participants	Ranking out of 9	Total Percentage Agreement
Plantar pressure mat.	Three. Before application, after application and after 24 hours of continued use.	24 hours plus time to measure.	40. (20 healthy and 20 with MTTS TII.)	No	Yes	No. They were divided into healthy and MTSS TII patients.	4	83%
LIMITATIONS	To the authors credit, there were a few limitations that were mentioned and included: - The data in the study indicated a decrease in the rate of pronation during normal gait as a result of the Kinesio tape intervention. Therefore, it is unclear what effect the tape will have during functional movements such as running and jumping, which were not measured in this study design. - The concern that there was no formal control within the structure of the study to account for the amount of activity performed between testing sessions (i.e. did all participants have a similar degree of activity?) as the structure was a formalised pre-post structure where the patients were their own controls. All that is known is that the participants were active individuals, but it is not understood how the amount and type of activity increased/decreased as a result of the Kinesio tape and how activity was monitored prior to the 24 hour reading. - Not all participants participated in similar sporting activities, which implies that among the 40 participants there were subsets of different sporting activity and it is unclear whether the groups were representative of the sports included and similar in nature. This concern is equally applicable to the clinical parameters (e.g. associated with the MTSS TII) and demographic characteristics (e.g. limb dominance) between the groups, which are not reported between the groups in the study. Therefore, bias in terms of group characteristics cannot be excluded, seeing that one group was diagnosed with MTSS TII and one group was not. There is at least one noted significant difference between the groups in terms of the reported measures.							

	- Thirdly, this study did not include placebo treatment options, so the study is only able to talk to the effects of the intervention over time, and not on its efficacy and/or relative effectiveness. In addition to this, the outcomes were not clinical measure outcomes but rather measures of biomechanical change, which the literature has not yet clearly linked with the clinical progression of MTSS TII (Killeen *et al.* 2014). Therefore it is not possible to extrapolate the outcomes to a clinical scenario in practice for example, other than to state that the biomechanics around loading of the foot has changed. Future studies should include a randomised control clinical trial design, including clinical and biomechanical outcome measures to address this. - The study does not clearly define which of the authors were responsible for participant assessment (pressure mat readings), and who was responsible for applying the Kinesio tape, and whether they were the same or different individuals. The lack of clarity in this regard, limits the reviewer's ability to determine the possible presence of bias on the side of the assessor. Therefore, this provides difficulty when contextualising improvement of participants in this study. Assessors should preferably have been blinded as to group allocation, to reliably test if changes are due to the specific application of tape or just the perceived presence on the skin.
OUTCOME	The findings of the study demonstrated a decreased rate of medial plantar loading in patients with a history of, or current MTSS TII. This decreased rate is of benefit as it slows pronation and reduces injury forces predisposing the patient to MTSS TII. It is also reported that the Kinesio tape did not have any effect on healthy participants.
DISCUSSIONS	This study indicates that patients with MTSS TII may receive biomechanical support from Kinesio tape in normal daily activity (e.g. walking). This outcome however cannot be correlated with the clinical improvement or changes as these clinical outcomes were not recorded in this study. Therefore, along with the limitations noted in the table above, this particular study does not provide any evidence that Kinesio tape is able to assist patients with the clinical reduction in symptomatology. Therefore, future research should test the use of Kinesio tape with regard to its effect on the clinical outcomes of the MTSS TII syndrome. In addition, the Kinesio tape application should be considered in different sports, different occupations and in the general population. Further research should focus on the application of Kinesio tape for patients with MTSS TII and their recovery to pain free movement when walking as well as during more dynamic running and other sports specific activities.
CONCLUSION	The above study, although a good pre-post intervention design to measure the effects of Kinesio tape on patients with MTSS TII secondary to excessive pronation, does not provide any indication of the clinical impact of the Kinesio tape on the condition of MTSS TII. Therefore it is a relatively poor study in terms of an NRCT design in testing the relative effectiveness of the intervention. This is further compounded by a total score of 4/9 with an agreement score of 83% from the reviewers. Therefore, the study does not provide clinical evidence in support of the use of Kinesio tape in the amelioration of the clinical condition known as MTSS TII. This is principally due to the effect that the study set out to measure the effect of taping on pronation and the subjects chosen happen to be MTSS TII patients (either with a history, a current complaint and/or pain only on activity).

Table 4.32: Tabulated feedback data– NRCT – Article 2

AUTHOR(S)	Loudon, J. K. and Dolphino, M. R.					
YEAR	2010					
TITL	Use of Foot Orthoses and Calf Stretching for Individuals With Medial Tibial Stress Syndrome.					
CRITERIA		**Reviewer 1**	**Reviewer 2**	**Reviewer 3**	**Ranking**	**Percentage Agreement**
Selection	1. Is the case definition adequate?	1	1	0	1	66%
	2. Representativeness of the cases	0	1	0	0	66%
	3. Selection of controls	0	0	0	0	100%
	4. Definition of controls	0	0	0	0	100%
Comparability	5. Comparability of cohorts on the basis of design or analysis	0	0	1	0	66%
Exposure	6. Ascertainment of exposure	0	0	0	0	100%
	7. Same method of ascertainment for cases and controls	0	0	0	0	100%
	8. Non-response rate	0	0	0	0	100%
	TOTAL SCORE	1	2	1	1	
OVERALL PERCENTAGE AGREEMENT 87,25%						

Table 4.33: Properties of study, outcome and discussion– NRCT – Article 2

AUTHOR(S)	Loudon, J. K. and Dolphino, M. R.							
YEAR	2010							
TITLE	Use of Foot Orthoses and Calf Stretching for Individuals With Medial Tibial Stress Syndrome.							
STUDY PROPERTIES								
Form of measurement	**Frequency of measurement**	**Duration of study**	**Number of participants**	**Assessors blinded**	**Control used**	**Randomisation of participants**	**Ranking out of 9**	**Total Percentage Agreement**
Activity level NPRS GRC NDT	Baseline. Week 1. End of week 3.	Three weeks	23 participants consisting of 11 females and 12 males.	No	No. As only one group was used initially.	No. Only one group was used initially.	1	87,25%
LIMITATIONS	This pre-post experimental study only had one group that included all the participants. Thus, this study had a relatively small sample size. The one group was then divided into a successful or non-successful group based on the outcome of the NPRS scores. Non-parametric statistics were used to compare the outcomes of the two groups. These statistics although indicative (i.e. providing trends and better than case study evaluations) are not as good a basis for drawing strong conclusions compared to parametric statistics (Vickers 2005). It is unclear whether the groupings designated via the NPRS/GRC/NDT/level of activity/dorsiflexion range of motion were similar in terms of their demographic and clinical MTSS TII characteristics at the outset of the study as the authors only comment on age, duration of symptoms, BMI, navicular drop test and dorsiflexion range of motion.Although this comparison is good, it fails to include pain levels at the outset, activity impairment, involvement of dominance and a myriad of other factors that are known to predispose the participant to the development of MTSS TII. This lack of homogeneity between the groups therefore does not fairly isolate those factors that were or could be influenced by the orthotic use. For example, if the unsuccessful group had a greater predisposition to lower back pain with concomitant changes in the lower limb biomechanics, they may have adversely reacted to the orthotics based on the relationship between lower back pain and the dorsiflexion range of motion at the ankle joint (sagittal block) (Gilbert *et al.* 2006). To the authors' credit, they indicated that not all measures were included. However, this detracts significantly from the conclusions drawn in terms of this study. Also the separation of the patients by success or failure in attaining perceived outcomes that are important in MTSS TII, means that there will be significant differences between the groups that do not indicate the effectiveness of the treatment but rather indicate the degree to which the successful group is different from the unsuccessful group, which technically provides no information on the practical clinical relevance of the outcomes. However, what it may provide is to identify patients that may respond more favourably to certain interventions. Additionally, this study utilised only subjective feedback measures in terms of improvement, with the patients recording the orthotic use, exercises and levels of pain. This weakens the study in that these parameters are potentially influenced by patient perception, patient expectation and patient satisfaction with the treatment and its anticipated outcome (Talmage 2007). Additionally, previous experience with orthotic use may have influenced the outcome of the study. From the manner in which the article discusses the outcomes, there also seems to be a suggestion that women had a worse outcome with orthotics. However, the influence of integrating the programme into women's daily life may be more difficult than a male (Artazcoz *et al.* 2004) given the different daily demands on the genders. With no								

	reporting on the daily record completed by the patients, it is not clear how this impact would have been accounted for. The use of the subjective diary and objective feedback would have strengthened the study and decreased the implications of subjective biases. Patients who were included in this study were not screened for orthotic usage prior to the study. This could have had an effect on the outcomes as patients who wear orthotics could have received the wrong orthotic and conversely, patients who do not require orthotics would not have responded favourably as was seen by the two participants that could not tolerate the orthotics.
OUTCOME	In this study, off-the-shelf basic foot orthotic and a home gastrocnemius and soleus stretching programme was used. Orthotics were worn during waking hours for three weeks. The participants were shown how to correctly do their stretches and were instructed to repeat it twice daily. Pain level did not change after the three week intervention in two participants (it is reported that these patients could not tolerate the orthotics). The remaining participants had some improvement of pain level after three weeks. This resulted in 15 participants with a 50% improvement in NPRS score (65.2%) and eight without a 50% improvement in NPRS score, suggesting that approximately two thirds of the MTSS TII population was responsive to the intervention programme. No comment is possible on the individual modalities utilised in this programme, as the outcomes reflect the changes due to both interventions.
DISCUSSIONS	The purpose of this study was to determine the effectiveness of gastrocnemius and soleus stretching, and foot orthotics in diminishing the pain level in patients with MTSS TII.The results indicated that males respond more favourably to this intervention than females. The author also noted that runners with a shorter duration of symptoms have a better chance for symptom reduction. However, these outcomes do not imply that the treatments are clinically effective, but rather imply that these patients with these characteristics are more likely to benefit from this intervention. This is given by the manner in which the data was analysed. It could, however be argued that due to the high level of bias, this study is of poor quality in evaluating the direct effects of the interventions and cannot be used to effectively draw a conclusion on the use of gastrocnemius and soleus stretching and foot orthotics. Therefore, future studies are required to confirm the outcomes of this study as well as the direct impact of each intervention, through the completion of studies with larger sample sizes to allow generalisation to the greater population. Also then looking at a wider range of impairment and functional measure with a longer follow-up period.
CONCLUSION	It is noted that this study was a noble attempt to reach an improvement in the clinical outcomes for a certain group of subjects. However, the intrinsic limitations in this study, mainly the individuals' homogeneity and the lack of improvement as well as the manner in which the data was analysed, limits this study's ability to draw a reliable conclusion with regard to the gastrocnemius, soleus stretching and foot orthotics effectiveness. When the outcome and discussion of this study are compared, and the ranking given to this article by the reviewers (1/9) is considered, it is apparent that the reviewers agree that this study was of poor quality based on the flaws within this study. Therefore, it can be concluded that the study design does not permit the ability to state that there is evidence for use of gastrocnemius and soleus stretching, and foot orthotics, and there is poor evidence for MTSS TII treatment efficiency in patients.

Table 4.34: Tabulated feedback data– NRCT – Article 3

AUTHOR(S)	Meulekamp, M. Z., Sauter, W., Buitenhuis, M., Mert, A. and van Der Wurff, P.					
YEAR	2016					
TITLE	Short-term results of a rehabilitation programme for service members with lower leg pain and the evaluation of patient characteristics.					
CRITERIA		**Reviewer 1**	**Reviewer 2**	**Reviewer 3**	**Ranking**	**Percentage Agreement**
Selection	1. Is the case definition adequate?	0	1	0	0	66%
	2. Representativeness of the cases	1	1	1	1	100%
	3. Selection of controls	1	0	0	0	66%
	4. Definition of controls	1	0	0	1	66%
Comparability	5. Comparability of cohorts on the basis of design or analysis	0	0	0	0	100%
Exposure	6. Ascertainment of exposure	1	1	1	1	100%
	7. Same method of ascertainment for cases and controls	0	1	0	0	66%
	8. Non-response rate	0	0	0	0	100%
	TOTAL SCORE	4	4	2	3	
				OVERALL PERCENTAGE AGREEMENT		83%

Table 4.35: Properties of study, outcome and discussion– NRCT – Article 3

AUTHOR(S)	Meulekamp, M. Z., Sauter, W., Buitenhuis, M., Mert, A. and van Der Wurff, P.							
YEAR	2016							
TITLE	Short-term results of a rehabilitation programme for service members with lower leg pain and the evaluation of patient characteristics.							
STUDY PROPERTIES								
Form of measurement	**Frequency of measurement**	**Duration of study**	**Number of participants**	**Assessors blinded**	**Control used**	**Randomisation of participants**	**Rankingout of 9**	**Total Percentage Agreement**
PSFS **NPRS**	Week 1 and week 6.	6 weeks	116 service members.	No	No	No	3	83%
LIMITATIONS	Given that this is a study evaluating a rehabilitation programme, the outcomes do not allow for identification of specific intervention in the treatment of MTSS TII. In addition, there were a few limitations mentioned by the authors: • This retrospective observational study consisted of 116 service members that were divided into three groups. Group one was diagnosed with MTSS TII (n = 47), group two consisted of patients with CECS (n = 34), and group three consisted of patients who had operative intervention after CECS (n = 80). All three groups received the same rehabilitation programme. • Due to the retrospective character of this study, it was noted that some data were missing, even though the authors indicate that the data was sufficiently small so as not to affect the outcomes of the study and thus the intention to treat analysis was not used to impute the data. Therefore, although a seemingly small limitation, small impacts are important to consider in studies that only have subjective outcome measures. • This study was only able to represent outcomes of short-term rehabilitation. This has two impacts, which include the fact that a traditional rehabilitation programme usually takes six to eight weeks to affect muscular structures (Herring 2006) and up to three months to affect the ligamentous/tendinous and other fascial structures (Fraser 2008). Therefore, the question arises as to the actual impact at six weeks (as noted statistically as well as clinically). Secondly, the fact that the last measurement outcomes were taken in the sixth week, potentially indicates that the effect of the last rehabilitation intervention was measured as opposed to the effect of the programme in totality. The actual programme intervention effects are only measurable a period after the conclusion of the intervention (e.g. in the seventh week for this study). • The participants in this study were working in a wide range of military settings (army, navy, military police and air force). The physical activity between services may not be comparable. In addition the participants could have either had MTSS TII or CECS (the distribution is unclear as the inclusion was for lower limb pain, which is not specific to MTSS TII patients). There is also a note that patients could have had prior surgery and others not. This creates further subcategories further diluting the actual effect of the rehabilitation programme on MTSS TII specifically. These subcategories of young military specific personnel are therefore potentially not reflective of the entire MTSS TII population (generally) and thus the generalisability of the outcomes may only be limited to patients that would otherwise meet the inclusion criteria of this study.							

	The above limitations are further enhanced in that only subjective clinical measures of outcome were used. The use of only subjective measures indicates that the study may be affected negatively by bias's that stem from patient perception, patient expectation and patient satisfaction with the treatment and its anticipated outcome (Thornton *et al*. 2017). Secondary to this, the type of rehabilitative exercises is not well explained. Therefore, it would not be possible to recreate this type of study, which should be possible for validation of this outcome in different population groups, using prospective designs.
OUTCOME	The purpose of this study was to evaluate characteristics of service members with MTSS TII/CECS and the short-term outcomes of a rehabilitation programme. Within this context, this retrospective observational study of male and female service members with MTSS TII showed that the participants established no significant changes on the NPRS. However, in contrast, the PSFS showed a significant improvement in participants, indicating that there were changes in functional improvement even if the pain remained the same.
DISCUSSIONS	The results of this study showed that the short-term results of a rehabilitation programme for service members with MTSS TII are successful as found with the PSFS/improved functional abilities. In contrast, evaluation by the NPRS seems inconclusive. These results may be reflective of the demands on the physical fitness of the military personnel involved in this study, as it is unclear whether this rehabilitation programme was run concurrently with the normal physical requirements of the study participants. This, along with the timing of the study in terms of military operations, is important as the impact of external physical activity (i.e. a decrease in the normal military operations) may allow for functional ability to improve as frequency and intensity of the external requirements are decreased. However, if these activities were increased toward the end of the study, pain may have re-manifested with the sudden increase in external activity frequency and intensity. Given that the study was retrospective, it is not possible to determine this influence.Future studies controlling for external factors are therefore necessary. Due to the non-homogeneity of the three groups as noted above, it is recommended that future studies only assess one condition at a time and include a control group. The lack of clarity of the rehabilitation programme and its implementation also leads to questions regarding the degree of compliance with the programme. This would need to be more closely monitored in a future prospective study. Additionally, this makes it difficult for future studies to emulate the study and confirm or refute the outcomes obtained.
CONCLUSION	This study highlights that a short-term recovery may be possible for highly active individuals with MTSS TII, but based on the limitations noted in Table 4.35, it is impossible to conclude whether the intervention would be successful given a longer (and clinically more relevant) time frame or with a different population. Through the analysis of the article (Table 4.34) it is shown that the reviewers on average ranked the study as three out of nine, indicating that there were also significant methodological flaws in the study, quite aside from the limitations of the population and the timing of the research study within this population. This is indicates that the reviewers see a lack in the structure of this study even though the outcome of a rehabilitation programme looks promising. As a result, the study provides very little overall evidence towards the treatment of MTSS TII based on the poor rigour of the study as well as the questionable outcomes based on the overall impression created by the study.

Table 4.36: Tabulated feedback data– NRCT – Article 4

AUTHOR(S)	Moen, M. H., Rayer, S., Schipper, M., Schmikli, S., Weir, A., Tol, J. L. and Backx, F. J. G.					
YEAR	2012					
TITLE	Shockwave treatment for medial tibial stress syndrome in athletes; A prospective controlled study.					
CRITERIA		**Reviewer 1**	**Reviewer 2**	**Reviewer 3**	**Ranking**	**Percentage Agreement**
Selection	1. Is the case definition adequate?	0	1	1	1	66%
	2. Representativeness of the cases	0	1	0	0	66%
	3. Selection of controls	0	0	0	0	100%
	4. Definition of controls	1	0	1	1	66%
Comparability	5. Comparability of cohorts on the basis of design or analysis	1	1	1	1	100%
Exposure	6. Ascertainment of exposure	0	0	0	0	100%
	7. Same method of ascertainment for cases and controls	0	1	0	0	66%
	8. Non-response rate	0	0	0	0	100%
	TOTAL SCORE	2	4	3	3	
				OVERALL PERCENTAGE AGREEMENT		83%

Table 4.37: Properties of study, outcome and discussion – NRCT – Article 4

AUTHORS(S)	Moen, M. H., Rayer, S., Schipper, M., Schmikli, S., Weir, A., Tol, J. L. and Backx, F. J. G.							
YEAR	2012							
TITLE	Shockwave treatment for medial tibial stress syndrome in athletes; A prospective controlled study.							
STUDY PROPERTIES								
Form of measurement	**Frequency of measurement**	**Duration of study**	**Number of participants**	**Assessors blinded**	**Control used**	**Randomisation of participants**	**Rankingout of 9**	**Total Percentage Agreement**
VAS Likert scale for progression within a running programme	Baseline and after.	9 weeks	42	No	Yes. The treatment group (n=22) involved ESWT in combination with a graded running programme and the control group had a running programme only (n=20).	No	3	83%
LIMITATIONS	The authors should be congratulated on publishing this study, as research on this newer technology is important. Manual therapy practitioners will be looking to utilise such products based on product claims which require research validation. In addition, this study unlike many previous studies (Tutté and Galin 2016; Newman *et al*. 2017; Rompe *et al.* 2010; Zimmerman *et al.* 2019; Gomez Garcia *et al.* 2017) has a larger sample size, which is more likely to measure an intervention effect more accurately (Winters *et al.* 2016b) and this study was prospective in nature. The first and most significant limitation of the study is that the patients were recruited from two different venues (no randomisation), this resulted in there being significant differences in the gender distribution, age, days with symptoms as well as metres run on the treadmill with pain at the beginning of the study. This resulted in the combined therapy group having more males that were older, with a significantly greater duration of symptoms, but with an ability to run further on the treadmill without pain. This suggested that these patients had a more chronic, but lower grade/intensity of the condition than the other group, which tended to reflect a more acute and significantly activity-limiting condition. Given these differences it is acknowledged that the authors did statistically control for these							

	confounding variables. However, even with this control, it would have been clinically better to compare patients that were similar in terms of the pathogenesis of their condition as the response to interventions at different stages of the pathogenesis of a condition may be very different (Ewert and Sibthorp 2009) and may affect the outcomes to an extent that is greater than that controlled for by statistical means. This is particularly true as the outcome measures included time to recovery and progression in participation in a running programme. Then although the article critiques other studies for a lack of blinding and the mechanism, the manner of blinding in this study is not clear. It would seem that the assessors of the patients were blinded in that the data was recorded and captured after what the authors refer to as 'after blinded double data entry'. This blinding was however not seemingly extended to the patients (although separate venues were used to reduce patient contact between the groups) and they were not clearly separated from the person admitting patients onto the study. Also, no information was available as to whether the practitioners treating the patients were indeed different or the same at the two venues. All these factors influence the blinding of the patient, the practitioner/therapist and/or assessor and has the potential to affect the outcomes of the study (Boutron *et al.* 2006). The above implications of blinding and the effect on outcomes may further be enhanced by patient–practitioner interaction, given that the control group completed a graded running programme only and had no contact with a practitioner/therapist. This is in contrast to the intervention group who did have contact with a physical therapist. This contact may have unduly influenced these participants to expect better outcomes or be practitioner-influenced into reporting better outcomes as their potential for receiving feedback was greater throughout the study than the control group. This undue bias may have encouraged this group to improve to a greater extent than they would normally, either enlarging the clinical difference between the groups or diminishing the difference between the groups (dependent on the actual improvement in the other group) (Boutron *et al.* 2019). Having said this however, the authors need to be congratulated for ensuring that the patients were naïve to the intervention. This mechanism may have been able to attenuate the difference between the groups in terms of the actual therapy as neither group would have been able to have an expectation of outcome based on the lack of exposure to the ESWT. In terms of the statistical analysis of the data, it would seem that parametric statistics were completed, which allows for the drawing of more definitive conclusions than any of the prior studies analysed in this review. Nevertheless, the sample size is still relatively small and it is uncertain whether the group size was large enough (based on a power analysis) for determining actual differences based on the outcome measures utilised.
OUTCOME	The time it took for patients to recover fully was shorter in the ESWT group compared to the athletes only performing a graded running programme. On average the group receiving ESWT recovered 65% faster. This shows a significantly quicker recovery time compared to a graded running approach alone.
DISCUSSIONS	The aim of this study was to test the outcome of two treatment groups for MTSS TII. Treatment involved a graded running programme and the same programme with additional ESWT. As seen in the outcome, the group with the additional ESWT recovered quicker, This may have been based on the fact that this group was the group with the lower grade MTSS TII (less acute but more chronic presentation), which may have responded quicker in terms of pain reduction and therefore activity participation compared to the acute and more serious clinical presentation of the running programme only group. These effects may be due to the natural history in the ESTW and running programme group as opposed to the running programme group only. Additionally, the effects of gender participation in the different groups may also indicate that the concerns raised for the previous article (Loudon and Dolphino 2010: Table 4.33) are

	also relevant. This is particularly true in that pain perception as well as reporting is different between male and female patients (Chan *et al.* 2004). Finally, practitioner–patient interaction can also not be excluded as an influencing variable in terms of the subjective outcomes in this study. Based on the above limitations, future studies should consider a control group receiving a sham dose of ESWT or potentially creating a space for the running only group to see a physical therapist to remove the associated bias. One manner of achieving this is to structure either outcome measurements periodically throughout the study, use of sham ESWT or a combination of the two. A further limitation is that this relative effectiveness study of training programme with ESTW versus a training programme alone does not allow for the study to imply clinical efficacy of either treatment. All that can be stated is that the combined programme seems to be better than the stand alone intervention and that even this may actually be artificially produced based on the non-homogenous groups and bias of practitioner–patient interaction.
CONCLUSION	This study received a low ranking when it was ranked by the reviewers (3/9) (see Table 4.37). This indicates that there is a lack of methodological rigour in the study design. Thus it would, on the surface, seem that this poorly structured study, with significant limitations in terms of participant comparability (and condition homogeneity between the groups), showed a good outcome (only noted statistically as the minimally clinically important differences and their relationship to the outcomes were not reported). Thus, the study is typical of a study that provides limited evidence in support of the ESTW and training programme over just a training programme. This outcome implies that the study needs to be further validated with more controlled and rigorous studies, in order to improve the evidence in support of the combination therapy in the treatment of MTSS TII. Also, further efficacy studies are required to determine the effect of the ESWT as a stand-alone therapy. Both these future research goals will provide better information to practitioners in clinical practice.

Table 4.38: Tabulated feedback data– NRCT – Article 5

AUTHOR(S)	Naderi, A., Degens, H. and Sakinepoor, A.					
YEAR	2019					
TITLE	Arch-support foot-orthoses normalise dynamic in-shoe foot pressure distribution in medial tibial stress syndrome.					
CRITERIA		**Reviewer 1**	**Reviewer 2**	**Reviewer 3**	**Ranking**	**Percentage Agreement**
Selection	1. Is the case definition adequate?	1	1	1	1	100%
	2. Representativeness of the cases	1	1	1	1	100%
	3. Selection of controls	1	1	1	1	100%
	4. Definition of controls	0	1	1	1	66%
Comparability	5. Comparability of cohorts on the basis of design or analysis	2	1	1	1	66%
Exposure	6. Ascertainment of exposure	0	1	0	0	66%
	7. Same method of ascertainment for cases and controls	1	1	1	1	100%
	8. Non-response rate	0	0	0	0	100%
	TOTAL SCORE	6	7	6	6	
				OVERALL PERCENTAGE AGREEMENT		87,25%

Table 4.39: Properties of study, outcome and discussion– NRCT – Article 5

AUTHORS(S)	Naderi, A., Degens, H. and Sakinepoor, A.							
YEAR	2019							
TITLE	Arch-support foot-orthoses normalise dynamic in-shoe foot pressure distribution in medial tibial stress syndrome.							
STUDY PROPERTIES								
Form of measurement	**Frequency of measurement**	**Duration of study**	**Number of participants**	**Assessors blinded**	**Control used**	**Randomisation of participants**	**Rankingout of 9**	**Total Percentage Agreement**
Dynamic foot-pressure distribution during running	Twice. Pre and post application of an orthotic	Not mentioned.	100. 50 men with MTSS and 50 healthy men.	No	Yes. 50 anthropometrically-matched healthy runners.	No – stratified allocation was used to support the purpose of the study	6	87,25%
LIMITATIONS	According to the authors, the largest limitation of this study was that it did not evaluate muscle activity in participants, nor did it measure the three-dimensional movement of the lower limb during gait before and after the application of the orthotic. If this was assessed, it could have given a better understanding of the use of an orthotic in treating the biomechanical dysfunctions as an intrinsic risk factor of MTSS TII. Additionally, the study looked to determine if the orthotic was able to return the MTSS TII patient's load bearing back to normal as represented by the control group. This means that the effect of the orthotic on the actual clinical presentation of the MTSS TII was not measured and therefore cannot be commented on, irrespective of the rigour with which the study was designed. This further implies that the use of an orthotic in clinical practice cannot be supported other than to state that there is a change in the pronation of the MTSS TII patient's foot which may or may not be able to effect clinical change that has yet to be tested.							
OUTCOME	It was observed that the dynamic pattern of foot pressure is differently distributed between the control group and the men affected by MTSS TII. This is believed to be due to continued foot pronation. In this study it showed that the foot-pressure distribution pattern in the participants with MTSS TII was returned to normal with the use of foot orthoses.							
DISCUSSIONS	This pre-post intervention study measuring the effect of an orthosis on foot pressures and time on different parts of the foot showed that there is a change approximating the normal measures in the control subjects. What is not possible to determine is whether this has any effect on MTSS TII as causality of the MTSS TII with regards to the presenting pronation was notinvestigated in this study (i.e. was the pronation induced by other biomechanical lower limb changes resulting in MTSS TII, or was the pronation the sole reason for the development of the MTSS TII, or were extrinsic loading factors (activity frequency and intensity) the causes for the development of the MTSS TII in the patients within the group, and lastly whether the pronation is a result of							

	the MTSS TII?). This snap shot pre–post intervention would not be able to comment on these cause-effect relationships unless a future study was designed in a prospective manner with repeated measures taken in order to be able to determine the clinical impact of the short, medium and long term use of the orthotic. Future studies are needed to observe the preventative effects of arch-support foot orthoses in the long-term. Such studies should also consider measuring the three-dimensional movement of the lower limb during gait and evaluating muscle activity and clinical MTSS TII outcomes. A future study should focus on including men and women (or separate studies should be done to allow for larger sample sizes for each gender), as this would allow for more generalisation and representation of different perceptions of MTSS TII as genders report pain and dysfunction differently and for different reasons (Chan *et al.* 2004). Further to this, future studies should also include a range of athletic people and not just amateurs, as MTSS TII is commonly seen in athletes.
CONCLUSION	When this pre-post intervention study is compared to other NRCT studies, it is apparent that the structure of this particular study was stricter and more controlled. Notwithstanding this however, there is a core criterion that is lacking in this study, i.e. the clinical effect of the orthotic on MTSS TII. This is supported by the reviewers who had consensus and rated this article's parameters as a six out of nine with 87,25% agreement. Even though this study has good methodological rigour there was an absence of good clinical outcome. The outcome of this study indicated that there was a change in the foot distribution pattern in participants with MTSS TII. Within the context of this study it is inappropriate to state that orthotics are clinically effective in the treatment of MTSS TII. The level of evidence for this study with regard to clinical application is non-existent. Future studies should be conducted to interpret the possibility that orthotics have the ability to treat MTSS TII.

Table 4.40: Tabulated feedback data– NRCT – Article 6

AUTHOR(S)	Rompe, J. D., Cacchio, A., Furia, J. P. and Maffulli, N.					
YEAR	2010					
TITLE	Low-energy extracorporeal shock wave therapy as a treatment for medial tibial stress syndrome.					
CRITERIA		**Reviewer 1**	**Reviewer 2**	**Reviewer 3**	**Ranking**	**Percentage Agreement**
Selection	1. Is the case definition adequate?	1	1	1	1	100%
	2. Representativeness of the cases	1	1	1	1	100%
	3. Selection of controls	1	1	1	1	100%
	4. Definition of controls	0	1	0	0	66%
Comparability	5. Comparability of cohorts on the basis of design or analysis	1	1	1	1	100%
Exposure	6. Ascertainment of exposure	1	1	1	1	100%
	7. Same method of ascertainment for cases and controls	1	1	1	1	100%
	8. Non-response rate	0	0	0	0	100%
	TOTAL SCORE	6	7	6	6	
				OVERALL PERCENTAGE AGREEMENT		95,75%

Table 4.41: Properties of study, outcome and discussion– NRCT – Article 6

AUTHORS(S)	Rompe, J. D., Cacchio, A., Furia, J. P. and Maffulli, N.							
YEAR	2010							
TITLE	Low-energy extracorporeal shock wave therapy as a treatment for medial tibial stress syndrome.							
STUDY PROPERTIES								
Form of measurement	**Frequency of measurement**	**Duration of study**	**Number of participants**	**Assessors blinded**	**Control used**	**Randomisation of participants**	**Rankingout of 9**	**Total Percentage Agreement**
Numeric rating scale. 6-point Likert scale.	Baseline. 1 month, 4 months and 15 months	15 months	94. Two groups consisting of 47 participants each.	No	Yes (n=47).	No	6	95,75%
LIMITATIONS	All the participants were runners participating in a variety of sporting activities/occupations. Given this diversity and the fact that the groups were homogenous in their composition, does allow for better testing of the intervention because the variables related to the patients were indeed similar. A total of 125 MTTS TII participants were eligible for this study. It was explained to them that they could choose between a home training programme and the same programme with low energy radial shockwave therapy. 47 participants chose a training programme in combination with a low energy radial shockwave therapy and 78 declined treatment with low energy radial shockwave therapy. The decision was based on informed consent principles and therefore it was anticipated that the patient chose their allocated group based on these principles. However, the fact that the shockwave treatment had to be self-funded may have skewed patient perception of the interventions available and the possible association between cost–benefit ratio cannot be excluded from the outcomes attained (Büttner *et al*. 2020). This bias may have influenced the outcome of the study and it would be preferable that future studies consider funding to allow access for all patients to all interventions thereby allowing full randomisation and negation of patient perception and decision making around cost-benefit ratios affecting the study outcomes. The authors then decided to only use 47 participants from the 78 that decided on the home training programme alone. To reduce intentional bias, an independent person conducted the retrospective selection process by actively case matching the controls by age and gender. This, although important, would not have negated the perceptual influences of the subjective outcome measures that were completed by the patients. Patients were discouraged against using any co-interventions in the first four months. Pain medication was allowed if needed (paracetamol), although this does not seem to have been recorded and reported on within the article, other than to state that treatment failure seemed to							

	be linked to the request for medication use. It is unclear whether patients actually took medication throughout the study or not because a medication diary was not provided which would allow the reader to understand the influence of medication on the outcomes. It was also noted that the patients were specifically patients with recalcitrant MTSS TII, who had been unresponsive to three previous conservative non-surgical intervention approaches. This means that outcomes of this study are limited to patients with MTSS TII that is unresponsive to other conventional interventions.
OUTCOME	This study showed that after 15 months, 85% of participants in the treatment group and 46% in the control group could return to running at their pre-injury state.This showed that the success rate for the treatment group was double at th 15th month interval compared to the control group.
DISCUSSIONS	This study provides evidence that repetitive low-energy radial shockwave therapy is effective for up to 15 months after injury for patients with recalcitrant MTSS TII. However, given the unusual distribution of patients by virtue of them deciding on their intervention group, based on a cost-benefit ratio and the effect of this on subjective clinical outcomes, the results of the study need to be accepted with caution. Future prospective studies should be done to further confirm these statements. Therefore, this study provides some evidence in support of this treatment and thus contributes to the evidence in support of low-energy radial shockwave therapy in clinical practice.
CONCLUSION	When the outcomes are compared to the review in Table 4.40, it can be seen that the majority rating was given as a six out of nine by the reviewers. This ranking is indicative of the few methodological flaws, but does not account for the influence of limitations discussed under limitations in this table on the previous page. Thus, caution needs to be applied when commenting on the ability of repetitive low-energy radial shockwave therapy to contribute to evidence for or against this type of intervention and its effectivity for MTSS TII. Therefore, we are unable to draw a conclusion on the use of this intervention in clinical practice.

Table 4.42: Tabulated feedback data– NRCT – Article 7

AUTHOR(S)	Schulze, C., Finze, S., Bader, R. and Lison, A.					
YEAR	2014					
TITLE	Treatment of medial tibial stress syndrome according to the fascial distortion model: A prospective case control study					
CRITERIA		**Reviewer 1**	**Reviewer 2**	**Reviewer 3**	**Ranking**	**Percentage Agreement**
Selection	1. Is the case definition adequate?	0	1	0	0	66%
	2. Representativeness of the cases	0	0	0	0	100%
	3. Selection of controls	0	0	0	0	100%
	4. Definition of controls	0	0	0	0	100%
Comparability	5. Comparability of cohorts on the basis of design or analysis	0	0	1	0	66%
Exposure	6. Ascertainment of exposure	0	0	0	0	100%
	7. Same method of ascertainment for cases and controls	0	0	0	0	100%
	8. Non-response rate	0	0	0	0	100%
	TOTAL SCORE	0	1	1	0	
				OVERALL PERCENTAGE AGREEMENT		91,5%

Table 4.43: Properties of study, outcome and discussion– NRCT – Article 7

AUTHORS(S)	Schulze, C., Finze, S., Bader, R. and Lison, A.							
YEAR	2014							
TITL	Treatment of medial tibial stress syndrome according to the fascial distortion model: A prospective case control study							
STUDY PROPERTIES:								
Form of measurement	**Frequency of measurement**	**Duration of study**	**Number of participants**	**Assessors blinded**	**Control used**	**Randomisation of participants**	**Rankingout of 9**	**Total Percentage Agreement**
VAS.	Not mentioned. Seemingly different for each participant.	Therapy was continued until full exercise tolerance or painlessness was reached. Terminated study after 3 weeks.	32. 30 males and 2 females. One group.	No.	No.	No.	0	91,5%
LIMITATIONS	This study was a pre-post experimental pilot study. Based on this, the study had some inherent flaws. The sample size was small, affecting the statistics utilised. The degree to which the outcomes can be categorically accepted or are questioned due to the effects of clinical outliers (Yeomans and Yeomans 2000) and with the use of only subjective outcome measures, the effect of expectation, perception and satisfaction need to be adequately addressed (Talmage 2007). The above could have been counteracted with the use of blinded assessors (which was not done), the use of objective clinical outcomes measures applied, along with blinded assessors and the use of a clinical trial structure which followed the participants in two comparable groups (control and intervention) over the period of allocated time to document change. The lack of the above structures means that the study by Schulze *et al.* (2014) does suffer from the various biases associated with the structure and procedure chosen for the study. To the authors' credit, it was noted and acknowledged that the following limitations are others that need to be considered: there was no medium or long term follow up recorded, the results are limited due to the small sample size, the lack of control group and a short follow-up period. Therefore, the authors mentioned that the outcomes attained in this study require further testing to determine the effect of the treatment on MTSS TII as well as whether this effect is applicable across different population groups.							
OUTCOM	During therapy, exercise induced pain on the VAS decreased from five points to one. After the first treatment, the level of pain that was felt was significantly reduced compared to follow up treatments. Only 13% of patients reported no symptoms after the initial treatment and 50% of patients reported that they were free of symptoms after three weeks.							

DISCUSSIONS	Based on the outcome of this study, it seems that one treatment utilising the fascial distortion model (Schulze *et al.* 2014) is sufficient to decrease pain and improve exercise. This is, however in contrast to the fact that literature suggests at least three months of intervention before physiological change can be seen in the fascial tissues (Fraser 2008) leading to a formal and more concrete resolution of clinical symptoms and signs. It is therefore possible that the immediate effect of the treatment seen in this study may be transient and result in the same level of MTSS TII recurrence as seen in those patients that have chronic MTSS TII (Meulekamp *et al*. 2016). This agrees with the comment made by the authors that outcomes may be transient. uture studies should look into extending the intervention period until patients are asymptomatic and/or consider structured studies with longer term follow up measurement points in order to establish the possibility of re-occurrence of the MTSS TII, such that the impact of the treatment focusses not only on the immediate resolution of pain, but also considers the biomechanical outcomes of the condition and the effects of the treatment on these biomechanical changes in order to reduce re-occurrence. Additionally, this study did not incorporate a control group. It would be necessary to include a control group in future studies to show that the fascial distortion model can be demonstrated as better or worse than a control intervention (relative effectiveness) or a control/sham intervention (efficacy). Further comparative studies will also allow long-term observations.
CONCLUSION	Based on the result of this table and its content, it is understood why the reviewers rated this NRCT very low (zero out of nine) on the NOS. This scale is utilised to determine set criteria that permit for the rigour of the study to be interpreted. Due to the significant limitations discussed above, it is not surprising that the rating given by the reviewers for this article is low. This low rating would recommend that even though the clinical outcome of this study was positive, there is no evidence/very limited evidence in support of the use of the fascial distortion model in practice and that more rigorous studies are required.

Table 4.44: Tabulated feedback data– NRCT – Article 8

AUTHOR(S)	Smith, W., Winn, F. and Parette, R.					
YEAR	1986					
TITLE	Comparative study using four modalities in shin splint treatments.					
CRITERIA		**Reviewer 1**	**Reviewer 2**	**Reviewer 3**	**Ranking**	**Percentage Agreement**
Selection	1. Is the case definition adequate?	1	1	1	1	100%
	2. Representativeness of the cases	1	0	0	0	66%
	3. Selection of controls	1	1	1	1	100%
	4. Definition of controls	0	1	1	1	66%
Comparability	5. Comparability of cohorts on the basis of design or analysis	1	2	1	1	66%
Exposure	6. Ascertainment of exposure	0	1	1	1	66%
	7. Same method of ascertainment for cases and controls	1	1	1	1	100%
	8. Non-response rate	1	0	0	0	66%
	TOTAL SCORE	6	7	6	6	
				OVERALL PERCENTAGE AGREEMENT		78,75%

Table 4.45: Properties of study, outcome and discussion– NRCT – Article 8

AUTHORS(S)	Smith, W., Winn, F. and Parette, R.							
YEAR	1986							
TITLE	Comparative study using four modalities in shin splint treatments.							
STUDY PROPERTIES								
Form of measurement	**Frequency of measurement**	**Duration of study**	**Number of participants**	**Assessors blinded**	**Control used**	**Randomisation of participants**	**Rankingout of 9**	**Total Percentage Agreement**
Perceived pain. Range of motions. Number of treatments.	Daily.	Different for each group.	50. 5 groups of 10. - Iontophoresis - Cryotherapy massage - Ultrasound - Phonophoretic treatment - Control group	No	Yes. Received no intervention.	Yes	6	78,75%
LIMITATIONS	Given the fact that in the period in which the authors published this study, there were limited guidelines in terms of the manner in which the study was to be presented, they must be commended for presenting this study. This is one of the larger studies reviewed as part of this systematic review. Given the revised publication guidelines in terms of NRCTs (Stang 2010), one of the limitations of this study is the fact that the large patient numbers are divided into five groups of 10 patients each. This implies the use of non-parametric statistics, which weakens the ability of the study to draw definitive conclusions, based principally on the fact that the a priori analysis/power analysis would probably demand a greater sample size to more adequately and effectively measure the clinical differences between the interventions. As has been fairly consistent with the articles reviewed in this systematic review, the sample populations are also limited to a younger age group of between 18-25 years of age. With the small sample the small age range suggests that the clinical presentation of the MTSS TII was fairly homogenous between the groups. However, with the lack of baseline data to compare the groups in terms of the clinical outcome measures, this is an assumption. Given that various therapists were used to administer treatment and the fact that there is no articulated protocol or training in terms of the research protocol, it is unclear as to whether these practitioners were following a similar approach to each of the patients, whether they were responsible for the application of a single modality each or whether there was a mechanism of blinding in the research process. These							

	various possibilities leave the trial open for criticism in terms of the introduction of bias in the form of the therapist–patient interaction and its effect on the subjective reporting measures as well as the number of treatments required by each of the participants in the study.
OUTCOME	This study had five groups and compared the effects of ice massage, ultrasound, iontophoresis, and phonophoresis in young individuals with MTSS TII. All the treatments reduced perceived pain compared to the control group. It was seen in the results that none of the modalities were superior to another treatment (relative effectiveness). However, compared to the control group, any intervention was superior to no intervention (efficacy). Range of motion was improved with all interventions except when ultrasound alone was compared to the control group.
DISCUSSIONS	The purpose of this study was to see which modality is superior to another. Based on the outcome it was seen that applying any intervention has the possibility of reducing perceived pain, this can occur through two mechanisms, viz. either affecting the pathogenesis of MTSS TII and/or through the application of Melzack and Wall's (1976) gait control theory where mechanical stimulation of the skin can also reduce pain. This is another reason why measures of pain may not be good measures of the clinical improvement of MTSS TII. The only intervention that appeared less effective was the ultrasound. Ultrasound was as effective to reduce pain but did not increase the individual's active range of motion. This does however also raise another problematic area in that the outcome measurements do not necessarily match the mechanism of action of the intervention. For example, it is inappropriate to state that ultrasound is less clinically effective when compared to the other interventions as the ultrasound does not have a function in increasing range of motion. Its application is to reduce inflammation and allow for micro massage to disperse the oedema associated with the inflammatory process (James *et al.* 2007). Thus stating it is less clinically effective when compared to the other outcomes, e.g. ice massage, which has the possibility to affect the pain, inflammation, swelling and movement, is unfair. These comparisons are based on mechanism of action and not efficacy. Therefore, the choice of outcome measures needs to fairly compare the clinical interventions (Ewert and Sibthorp 2009). Given the limitations and the lack of reporting of some crucial information (as discussed above) regarding the manner in which the study was applied, future studies should focus on repeating this study, with larger sample sizes per group in order to detect changes that may not have been evident to Smith *et al.* (1986). Additionally, the structure for each of the intervention groups in terms of intervention administration and measurement taking needs to be consistent and accompanied by staggered follow up measurement readings at periodic intervals after the treatment has been stopped.
CONCLUSION	Although the above study contained limitations, it is a very good design with the inclusion of different groups of intervention and a control group. This is shown by the reviewers giving it a total score of six out of nine. As mentioned before, this study would provide a better indication of the clinical impact of these interventions on the condition of MTSS TII if a priori analysis/power analysis is used and if they considered outcomes that would equally measure the effects of the individual treatments and/or only compare interventions that would affect the outcome measure(s) in similar ways. This study provides limited clinical evidence in support of the use of iontophoresis, cryotherapy massage, ultrasound and phonophoretic treatment in the clinical condition known as MTSS TII. Therefore, it is a relatively good study structure in terms of an NRCT design. This is shown by the reviewers giving it a total score of six out of nine. This study does provide clinical evidence in support of the use of iontophoresis, cryotherapy massage, ultrasound and phonophoretic treatment in the clinical condition known as MTSS TII.

Table 4.46: Tabulated feedback data– NRCT – Article 9

AUTHOR(S)	Van Lingen, L. H.					
YEAR	1998					
TITLE	The effectiveness of ultrasound therapy as an adjunct to the treatment of medial tibial stress syndrome type 2 (shin splints).					
CRITERIA		**Reviewer 1**	**Reviewer 2**	**Reviewer 3**	**Ranking**	**Percentage Agreement**
Selection	1. Is the case definition adequate?	0	0	0	0	100%
	2. Representativeness of the cases	0	0	0	0	100%
	3. Selection of controls	1	1	1	1	100%
	4. Definition of controls	1	1	0	1	66%
Comparability	5. Comparability of cohorts on the basis of design or analysis	0	1	1	1	66%
Exposure	6. Ascertainment of exposure	0	0	0	0	100%
	7. Same method of ascertainment for cases and controls	1	0	1	1	66%
	8. Non-response rate	0	1	0	0	66%
	TOTAL SCORE	3	4	3	4	
				OVERALL PERCENTAGE AGREEMENT		83%

Table 4.47: Properties of study, outcome and discussion– NRCT – Article 9

AUTHORS(S)	Van Lingen, L. H.							
YEAR	1998							
TITLE	The effectiveness of ultrasound therapy as an adjunct to the treatment of medial tibial stress syndrome type 2 (shin splints)							
STUDY PROPERTIES								
Form of measurement	**Frequency of measurement**	**Duration of study**	**Number of participants**	**Assessors blinded**	**Control used**	**Randomisation of participants**	**Rankingout of 9**	**Total Percentage Agreement**
NPRS. PDI. McGill Short Form Pain Questionnaire.	Initial treatment, final treatment and one month after final treatment.	10 treatments.	30 patients. Two groups of 15 patients each.	No.	Yes. (n=15).	Yes.	4	83%
LIMITATIONS	To the authors credit, the following limitations were noted: - The small sample size (n=15 per group), which resulted in the use of non-parametric statistics, making the statistical and clinical conclusions weaker. - The control group had a statistically significant increased number of sedentary patients and this type of patient has the potential to respond differently to treatment. The placebo group also had more athletes who participated in running. There was no comparison of MTSS TII symptoms at baseline. An advantage of the study, is that the study's participants ranged from 19-52 years old and were male and female and thus are reflective of the general population and not as restrictive as those limited to athletes (Griebert *et al.* 2016; Knight 2010; Saxena *et al.* 2017) or those limited to military personnel (Bonanno *et al.* 2018; Meulenkamp *et al.* 2016). Furthermore, there is some concern as to whether the outcome measure is measuring the effect of the intervention(s). Ultrasound is not a principle modality for pain reduction or improving ADLs but rather to limit inflammation and associated swelling (Kitchen and Bazin 2007). This indicates an issue when assessing the conclusion that was drawn on the clinical effect of ultrasound and if this is a true reflection of the modality in the treatment of MTSS TII. This study included ultrasound and an education programme versus an education programme only. Based on the fact that it was not a singular treatment, the only conclusion that can be made is based on the effectiveness of ultrasound in conjunction with an education programme.							

OUTCOME	All outcomes indicated that whilst there was active treatment, the MTSS TII patients improved, but that when the treatment was stopped the improvement trajectory levelled off indicating that active intervention was required in order to stimulate and maintain recovery.
DISCUSSIONS	The outcomes seem to concur with the assertions made in discussion of the publication by Smith *et al.* (1986) where the clinical effect can either be related to the gate control theory (Melzack and Wall 1976) or an actual improvement in the MTSS TII. From the results obtained in this study it would suggest that the reduction in pain and changes in the disability index and the McGill pain questionnaire may actually be related to the gate control theory as opposed to actual clinical effect on the MTSS TII. However, this assumption needs to be validated with future research, which sets out to look at the longer term effects of all interventions utilised for the treatment of MTSS TII in clinical practice. Therefore, given that the outcomes suggest that ultrasound and an education programme is no better than an education programme alone in reducing pain and changing range of motion associated with ADLs, this research would not support the use of ultrasound in the treatment of MTSS TII. However, future research with larger sample sizes and more appropriate outcome measures are required to confirm or refute this assertion.
CONCLUSION	Based on the various limitations noted in this Table 4.47 it cannot be concluded if ultrasound is a clinically relevant intervention for patients with this condition, as there is a mismatch between the intervention and the measures of clinical improvement. The above is true even though the reviewers indicated that the study was ranked as four out of nine with an 83% total agreement. This indicates that even though this study had moderate methodological rigour, there is still inconclusiveness of the results and the clinical use of ultrasound in clinical practice.

4.4.2.2 Discussion

Table 4.48: Outcome and methodological ranking of non-randomised controlled trials

Outcome as determined by reviewers:

Study Type:	Non-randomised Controlled Trials				
Author(s)	Year:	Reported Outcome	Methodological Ranking: 0-3 poor 4-5 moderate 6-9 good	Outcome as determined by reviewers	Clinical outcome
Griebert, Needle, McConnell, and Kaminski	2016	**KT tape** decreases the rate of medial plantar loading in patients with a history or current MTSS TII and has no effect in healthy patients.	4/9	Moderate	There were no clinical outcomes correlated to improved weight distribution measures of the foot
Loudon and Dolphino	2010	Off-the-shelf basic **foot orthotic** versus a **home gastrocnemius and soleus stretching programme** showed no significant changes.	1/9	Poor	Inconclusive for the treatment programmes
Meulenkamp, Sauter, Buitenhuis, Mert and van Der Wurff	2016	A **rehabilitation programme** was not effective for MTSS TII based on a NPRS score.	3/9	Poor	Inconclusive for the treatment programmes
Moen, Rayer, Schipper,Schmikli, Weir, Tol and Backx	2012	**ESWT** patients recovered fully in less time compared to a graded running programme.	3/9	Poor	Inconclusive for the treatment programmes
Naderi, Degens and Sakinepoor	2019	**Foot orthoses** returned the foot-pressure distribution pattern to normal with regard to MTSS TII patients.	6/9	Good	There were no clinical outcomes correlated to improved weight distribution measures of the foot
Rompe, Cacchio, Furiaand Maffulli	2010	**Low energy radial shockwave therapy** is more effective in patients with MTSS TII than a home training programme.	6/9	Good	Inconclusive for shock wave therapy
Schulze, Finze, Bader, and Lison	2014	The **fascial distortion model** was beneficial in treatment of MTSS TII after one visit.	0/9	Poor	No evidence in favour of theFDM
Smith, Winn and Parette	1986	The effects of **ice massage, ultrasound, iontophoresis and phonophoresis** separately in patients with MTSS TII each shows reduced perceived pain compared to the control group.	6/9	Good	Biased evidence in favour of cryotherapy massage, iontophoresis and phonophoresis. Biased not in favour of ultrasound.
Van Lingen	1998	Results showed no benefit with using **ultrasound therapy** compared to rest.	4/9	Moderate	Inconclusive for ultrasound as this was a relative effectiveness study (both groups had an education programme included)

4.4.3 Randomised Controlled Trials Introduction

Reports documenting the methodological rigour of RCTs need to address the trials design, conduct, analysis and generalisability (Campbell *et al*. 2004). When this information is extracted, it allows the reader to make an informed judgement about the external and internal validity. In order for RCT's to provide benefit for health care professionals, the published reports need to be of the highest possible standard (Begg *et al.* 1996). Therefore, a statement called CONSORT was developed to be used internationally in order to improve the reporting of RCTs (Schulz *et al.* 2010). CONSORT stands for Consolidated Standards of Reporting Trials and consists of a 25-item checklist and a flow diagram (Begg *et al.* 1996).

In this systematic review, the PEDro scale (www.pedro.org.au 1999) was used for reviewing all RCTs. This scale is made up of 11 criteria to rate, of which a total of one score can be allocated to each criterion. Therefore, the maximum ranking that any RCT can receive is 11. If one point was allotted to the study being reviewed a 'Y' was awarded. When no point was awarded it was noted as an 'N'.

4.4.3.1 Examiner Agreement and Ranking of Articles: Randomised Controlled Trials

Table 4.49: List of table numbers for randomised controlled trial feedback and analysis

Tabulated feedback data	Analysis of article	Author(s)	Yea	Title
4.50	4.51	Andrish, Bergfeld,and Walheim	1974	A prospective study on the management of shin splints.
4.52	4.53	Gomez Garcia,Ramon Rona, Gomez Tinoco, Benet Rodriguez, Chaustre Ruiz, Cardenas Letrado, Lopez-Illescas Ruiz and Alarcon Garcia	2017	Shockwave treatment for medial tibial stress syndrome in military cadets.
4.54	4.55	Johnston,Flynn, Bean, Breton, Scherer, Dreitzler and Thomas	2006	A Randomised Controlled Trial of a Leg Orthosis versus Traditional Treatment for Soldiers with Shin Splints - A Pilot Study.
4.56	4.57	Moen,Bongers, Bakker, Weir, Zimmermann, van der Werve and Backx	2010	The additional value of a pneumatic leg brace in the treatment of recruits with medial tibial stress syndrome; a randomised study.
4.58	4.59	Moen,Holtslag, Bakker, Barten, Weir, Tol and Backx	2012	The treatment of medial tibial stress syndrome in athletes; a randomised clinical trial.
4.60	4.61	Newman, Waddington and Adams	2017	Shockwave treatment for medial tibial stress syndrome: A randomised double blind sham-controlled pilot trial.
4.62	4.63	Payne	2007	The relative effectiveness of three treatment protocols in the treatment of medial tibial stress syndrome type II.
4.64	4.65	Robertson	2003	The relative effectiveness of periosteal pecking combined with therapeutic ultrasound compared to therapeutic ultrasound in the treatment of medial tibial stress syndrome type II.

Table 4.50: Tabulated feedback data– RCT- Article 1

AUTHOR(S)	Andrish, J. T., Bergfeld, J. A. and Walheim, J.					
YEAR	1974					
TITL	A prospective study on the management of shin splints					
CRITERION		**Reviewer 1**	**Reviewer 2**	**Reviewer 3**	**Ranking**	**Percentage Agreement**
1	Eligibility criteria were specified	N	N	Y	N	66%
2	Subjects were randomly allocated to groups (in a crossover study, subjects were randomly allocated an order in which treatments were received)	Y	Y	Y	Y	100%
3	Allocation was concealed	N	N	N	N	100%
4	The groups were similar at baseline regarding the most important prognostic indicators	Y	Y	N	Y	66%
5	There was blinding of all subjects	N	N	N	N	100%
6	There was blinding of all therapists who administered the therapy	N	N	N	N	100%
7	There was blinding of all assessors who measured at least one key outcome	N	N	N	N	100%
8	Measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups	Y	Y	N	Y	66%
9	All subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome was analysed by 'intention to treat'	Y	Y	Y	Y	100%
10	The results of between-group statistical comparisons are reported for at least one key outcome	Y	Y	N	Y	66%
11	The study provides both point measures and measures of variability for at least one key outcome	N	N	N	N	100%
	TOTAL SCORE:	5	5	3	5	
		OVERALL PERCENTAGE AGREEMENT				87,6%

Table 4.51: Properties of study, outcome and discussion– RCT – Article 1

AUTHORS(S)	Andrish, J. T., Bergfeld, J. A. and Walheim, J.							
YEAR	1974							
TITLE	A prospective study on the management of shin splints							
STUDY PROPERTIES								
Form of measurement	**Frequency of measurement**	**Duration of study**	**Number of participants**	**Assessors blinded**	**Control used**	**Randomisation of participants**	**Ranking**	**Total Percentage Agreement**
Absence of pain and tenderness. Number of days of running lost.	Every 3 days until recovered.	Summertime training over two years.	Started with 2777 men. MTSS TII = 97 men	No.	Yes.	Yes.	5	87,6%
LIMITATIONS	Given that at the time of this publication, there were no guidelines for the reporting of RCTs, there were no limitations mentioned by the authors for this study. This study consisted of two phases. Phase one focused on giving prophylactic interventions to groups 2-5. A total of 2777 first year shipmen were allocated in five groups. All groups were given a physical education programme, with Group 1 being the control (n=1453 men), Group 2 used heel pads when running and ran with tennis shoes (n=344), Group 3 were instructed to do heel cord/Achilles tendon stretching (n=300), Group 4 wore heel pads and did heel cord stretching (n=463) and Group 5 had a graded running programme for two weeks before they started doing the physical education programme (n=217). All groups had multiple checks to ensure that these measures were effectively carried out. All men were briefed on MTSS TII and were urged to seek medical care if they had any leg pain. All men were then clinically assessed to determine who with leg pain had developed MTSS TII. The men who developed MTSS TII were reportedly from: group 1 = 43, group 2 = 15, group 3 = 12, group 4 = 14 and group 5 = 13. Phase two included these 97 cases of MTSS TII. They were allocated into five treatment groups. All groups were not allowed to run unless pain free and had to ice three times a day during the group allocated treatments, which were as follows: Group 1 was the control (n=19), Group 2 took aspirin four times daily for one week (n=25), Group 3 took phenylbutazone four times daily for one week (n=19), Group 4							

	continued to do heel cord stretching exercises (n=16) and Group 5 had to use an immobilising cast for one week (n=18). Each patient was then seen in the clinic twice a week until full recovery (absence of pain and tenderness). Full activity was resumed after recovery. For phase three, each participant was then randomly assigned to wear or not wear a heel pad for future running. Given that 51 men were assigned a heel pad and 46 were not, was related to the fact that 21% of the shipmen using the heel pad had recurrent MTSS TII and 11% who did not use it had recurrent MTSS TII. As can be seen above, most groups had less than 20 participants. This small sample had implications for data analysis in that only non-parametric statistics could be utilised, implying that only trends could be discussed and categorical conclusions were not possible. The given structure of the second part of the study would only allow for testing the relative effectiveness of the different programmes (e.g. rest, ice and aspirin, versus rest, ice and no additional treatment (control)). Therefore, it cannot comment on the efficacy of an individual treatment or the relative effectiveness of a single intervention. In addition, the period of wash out between phase one and phase two was not commented on and it is unclear as to the effect of the interventions of phase one, and how these were antagonistic or agonistic in terms of the interventions that the participants received in phase two. (Currently, it is also not possible to determine the relationship between different interventions for MTSS TII and whether they are antagonistic and agonistic as there is limited research available on the efficacy and relative effectiveness of the different interventions). Unlike many of the previous studies (Knight 2010; Pietrzak 2014; Saxena *et al.* 2017) where the patients were able to continue with activity, this study required participants to rest during the course of the study. Therefore, the effectiveness of the programmes in this study need to be interpreted in this context and may not be comparable to the NRCTs previously described in this systematic review. This is compounded by the fact that shipmen are military personnel (i.e. navy) and it is possible that their level of participation in activity is higher than the general public and therefore they are more likely to develop MTSS TII. Thus the effects of rest during the study may also present as a hidden intervention. A further limitation of the study is the use of only subjective measures of pain reporting and numbers of days lost due to inability to participate due to pain. These outcomes are affected by patient perception, patient expectation, patient satisfaction as well as previous exposure to the type of intervention allocated to the group in which they were placed (Thornton *et al.* 2017). All these factors detract from the use of subjective measures as an 'only/or' principle outcome in a study as it is reliant on patients completing the questionnaires without background noise interfering with the responses that they provide. The number of days lost due to pain are also subjective as participation in an activity

	also relates to emotional and reactive perceptions in terms of the like or dislike of the activity, the like or dislike of the person/people overseeing and participating in the activity as well as the weather conditions that may facilitate or detract from participation. In a situation where shipmen may be forced to participate in such activities, the participation in the research may have provided a reason for them to excuse themselves from the activity and therefore the loss in the number of days may not actually be reflective of the true clinical picture of the patient.
OUTCOME	The purpose of this study was to establish incidence and morbidity of MTSS TII (phase one) and to evaluate different types of intervention (phase two). The authors noted that of the 97 shipmen that developed MTSS TII, no means of prophylaxis (phase one) was superior to any other. In fact, it is almost suggested that the prophylaxis within the context of normal military training is not protective against MTSS TII. It was noted that in phase two the longer period of symptoms prior to treatment, had an effect on the time lost from running (i.e. patients who had suffered for one to four days lost eight days of running compared to patients who had symptoms for more than 14 days before entering the study and lost 11 days of running). Finally, 22 shipmen who delayed seeking medical intervention for more than 10 days did not recover until they stopped running. It was noted that there was no significant difference between intervention groups. The analysis of the type of intervention does not provide a clear significance.
DISCUSSIONS	Within the limitations of a small sample size, the requirement to have rest from all activity during phase two, the application of the intervention for one week (short-term results) and the use of only subjective measures has direct impact on accepting the conclusions drawn in the study. The inconclusive outcomes therefore have to be accepted with caution.
CONCLUSION	Based on the structure and outcomes of this study, the use of rest in conjunction with one of the following: aspirin, phenylbutazone, heel cord stretching exercises or an immobilising cast cannot be accepted due to the degree of bias introduced by the limitations. This is concurred by the reviewers who ranked this study as a five out of eleven. In conclusion, seeing that this study is outdated and that newer research has been done on the effect of other treatments and the duration of these treatments, this particular study has no clinical relevance.

Table 5.52: Tabulated feedback data– RCT- Article 2

AUTHOR(S)	Gomez Garcia, S., Ramon Rona, S., Gomez Tinoco, M. C., Benet Rodriguez, M., Chaustre Ruiz, D. M., Cardenas Letrado, F. P., Lopez-Illescas Ruiz, A. and Alarcon Garcia, J. M.					
YEAR	2017					
TITLE	Shockwave treatment for medial tibial stress syndrome in military cadets: A single-blind randomised controlled trial					
CRITERION		**Reviewer1**	**Reviewer 2**	**Reviewer 3**	**Ranking**	**Percentage Agreement**
1	Eligibility criteria were specified	Y	N	Y	Y	66%
2	Subjects were randomly allocated to groups (in a crossover study, subjects were randomly allocated an order in which treatments were received)	Y	Y	Y	Y	100%
3	Allocation was concealed	Y	Y	Y	Y	100%
4	The groups were similar at baseline regarding the most important prognostic indicators	Y	Y	Y	Y	100%
5	There was blinding of all subjects	Y	Y	Y	Y	100%
6	There was blinding of all therapists who administered the therapy	N	Y	N	N	66%
7	There was blinding of all assessors who measured at least one key outcome	N	Y	Y	Y	66%
8	Measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups	Y	Y	Y	Y	100%
9	All subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome was analysed by 'intention to treat'	Y	N	Y	Y	66%
10	The results of between-group statistical comparisons are reported for at least one key outcome	Y	Y	Y	Y	100%
11	The study provides both point measures and measures of variability for at least one key outcome	Y	Y	Y	Y	100%
	TOTAL SCORE	9	9	10	10	
			OVERALL PERCENTAGE AGREEMENT			87,6%

Table 4.53: Properties of study, outcome and discussion– RCT – Article 2

AUTHORS(S)	Gomez Garcia, S., Ramon Rona, S., Gomez Tinoco, M. C., Benet Rodriguez, M., Chaustre Ruiz, D. M., Cardenas Letrado, F. P., Lopez-Illescas Ruiz, A. and Alarcon Garcia, J. M							
YEAR	2017							
TITLE	Shockwave treatment for medial tibial stress syndrome in military cadets: A single-blind randomised controlled trial							
STUDY PROPERTIES								
Form of measurement	**Frequency of measurement**	**Duration of study**	**Number of participants**	**Assessors blinded**	**Control used**	**Randomisation of participants**	**Ranking**	**Total Percentage Agreement**
VAS. Running test. Roles and Maudsley scale (RM).	Baseline and at a follow-up 4 weeks later.	4 weeks	42 military cadets. Treatment (n=23) and control (n=19).	Yes	Yes. (n=19)	Yes	10	87,6%
LIMITATIONS	This was a single-blinded randomised controlled study involving 42 military cadets (33 men and 9 women) with MTSS TII. Group 1 received a single session of ESWT and a training programme and group 2 received the same training programme without the ESWT. The exercise programme consisted of muscle stretching (calf stretch), muscle strengthening exercises (lower limb exercises with Thera band and some without) and joint mobility exercises (active range of motion of the ankle). Therefore, this study was a relative effectiveness study and not a study on treatment efficacy of any one modality. One of the limitations is the small sample size. Based on the fact that one of the groups had less than 20 participants, only non-parametric statistics could be utilised, thereby only allowing trends to be commented on as opposed to having the ability to conclude categorical outcomes. Random allocation was performed by a physiotherapist using Epidat 4.0 through a computer-generated list. As mentioned in the article, allocation was concealed form the recruiter and the study participants, which decreases bias of allocation and its impact on the outcomes. This is further improved in terms of the sample homogeneity (participants were military cadets), but conversely, inclusion of only military cadets makes the outcomes less generalisable to the general population. Only subjective measurement tools report outcomes. This is similar to the measurement tools used in Andrish *et al.* (1974). As mentioned before, these type of outcomes are affected by patient perception, patient expectation, patient satisfaction as well as previous exposure to the type of intervention allocated to the group in which they were placed (Thornton *et al.* 2017). This is important as prior exposure to the ESWT with good results as well as the exposure to ESWT with poor results may be as a result of good previous exposure or expectation							

	to be in the ESWT group and then not receiving it respectively. Therefore patient expectation, exposure, perception and satisfaction related to a novel modality as compared to the group that got the 'same old' intervention may reflect the patient views in the subjective clinical measures as opposed to actual clinical outcomes.
OUTCOME	The ESWT group had a 69.6% decrease in pain at the four week follow up measurement. The control group's pain decreased by 51%. The VAS score at the end of running for the ESWT group decreased from six to two.But the control group's VAS score after running decreased from seven to four. A single ESWT session in patients with MTSS TII based on pain at rest was decreased by 83% in four weeks. Moreover, participants in the intervention group were able to run 17 minutes 33 seconds at the four week follow up compared to 4 minutes 48 seconds in the exercise-only group.
DISCUSSIONS	Based on the outcomes in this study showing that the ESWT group had a significantly greater improvement than the exercise-only group at the four week follow-up after baseline measurements were done, this shows that a single round of ESWT treatment when combined with a certain exercise programme, increased the functional and clinical recovery in military personal who had MTSS TII. Given the interventions, future research studies should look at the effects/efficacy of the different elements of the treatment protocol and the efficacy of ESWT and then structure studies to understand whether these interventions are agonistic or antagonistic in their clinical actions. The ESWT programme also needs to be considered in terms of the cost–benefit ratio compared to that of a treatment programme that may be less expensive but may yield the same results when pitted against placebo or the training programme individually when patient subjectivity is better controlled for. Although assessors where blinded, the application of only subjective outcomes limits the positive impact that objective measures could have brought to the study to enable a clearer understanding of actual measured clinical change that is not reliant on patient subjectivity.
CONCLUSION	In the review done on this study, it is seen that the reviewers agreed to a 87,6% level and this indicates that this study had significant methodological rigour in terms of the criteria outlined in the PEDro scale (1999) (reviewers ranked this article with a total score of ten out eleven, indicating a very good level of methodological rigour as outlined in Table 4.54). It is, however, apparent that based on the limitations mentioned above, the outcomes of the study need to be accepted with caution although the rigour of the study is very good.

Table 4.54: Tabulated feedback data– RCT- Article 3

AUTHOR(S)	Johnston, E., Flynn, T., Bean, M., Breton, M., Scherer, M., Dreitzler, G. and Thomas, D.					
YEAR	2006					
TITLE	A Randomised Controlled Trial of a Leg Orthosis versus Traditional Treatment for Soldiers with Shin Splints - A Pilot Study					
CRITERION		**Reviewer1**	**Reviewer 2**	**Reviewer 3**	**Ranking**	**Percentage Agreement**
1	Eligibility criteria were specified	Y	Y	Y	Y	100%
2	Subjects were randomly allocated to groups (in a crossover study, subjects were randomly allocated an order in which treatments were received)	Y	Y	Y	Y	100%
3	Allocation was concealed	N	N	Y	Y	66%
4	The groups were similar at baseline regarding the most important prognostic indicators	Y	Y	Y	Y	100%
5	There was blinding of all subjects	N	N	N	N	100%
6	There was blinding of all therapists who administered the therapy	N	N	N	N	100%
7	There was blinding of all assessors who measured at least one key outcome	N	N	N	N	100%
8	Measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups	N	Y	N	N	66%
9	All subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome was analysed by 'intention to treat'	N	Y	Y	Y	66%
10	The results of between-group statistical comparisons are reported for at least one key outcome	Y	Y	Y	Y	100%
11	The study provides both point measures and measures of variability for at least one key outcome	Y	Y	Y	Y	100%
	TOTAL SCORE	5	7	8	7	
			OVERALL PERCENTAGE AGREEMENT			90,7%

Table 4.55: Properties of study, outcome and discussion– RCT – Article 3

AUTHORS(S)	Johnston, E., Flynn, T., Bean, M., Breton, M., Scherer, M., Dreitzler, G. and Thomas, D							
YEAR	2006							
TITLE	A Randomised Controlled Trial of a Leg Orthosis versus Traditional Treatment for Soldiers with Shin Splints - A Pilot Study							
STUDY PROPERTIES								
Form of measurement	**Frequency of measurement**	**Duration of study**	**Number of participants**	**Assessors blinded**	**Control used**	**Randomisation of participants**	**Ranking**	**Total Percentage Agreement**
VAS before and after activity. Global rating of change (GRC).	Biweekly	6 weeks	25 active duty soldiers were initially drafted. Two groups.	No	Yes. (n=13)	Yes	7	90,7%
LIMITATIONS	This pilot study was the first study done to assess the Shin Saver Orthosis for MTSS TII. Twenty-five soldiers were randomly assigned to either orthosis group (n=12) or traditional treatment group (control). Traditional treatment consisted of an activity modification and ice massage biweekly. This study presented with a couple of limitations which include: - The sample size was too small to utilise the stronger parametric statistics, therefore this study should be repeated with a larger sample size to determine whether the actual effects are refuted or confirmed. This sample size was further compounded by the very high dropout rate. Of the 25 original patients, only 13 participants completed all elements of the study (seven participants from Shin Saver Orthosis group and six participants from the control group were fully recorded at the end of six weeks). This was due to the wrong diagnosis being made (six participants had tibial stress fractures), failure to return to scheduled follow-up treatments or permanently changing base. - Although the groups seem relatively homogenous given the information provided in Table 1 (Johnston *et al.* 2006), the table is not reflective of all the patients data and MTSS TII data that should have been included. Therefore, it is unclear to the reader as to the comparability of the groups. - Researchers collected data for several months but were unable to reach enough participants. This in and of itself is a problem as climatic changes would also not have allowed for the comparison of activity between patients within and between groups based purely on the types of activity and required training as well as field work in the various seasons. - Further confounding factors noted that some participants admitted they did not use the device when prescribed due to discomfort, caused mainly by rashes and excessive perspiration (possibly the summer patients in Texas). Other participants mentioned that due to strict training tests they continued to train and partake in said tests even if severe pain was experienced.							

OUTCOME	In terms of the conclusions and outcomes noted by the authors, VAS scores compared before and after activity for both groups showed no significant improvement. Two participants reported mild relief with the use of the Shin Saver Orthosis, while five patients reported no relief or increased pain with it.
DISCUSSIONS	In terms of the study, it would seem that a large number of patients dropped out due to brace discomfort and seemingly limited functional application of the brace. It can also not be excluded that the changes in the loading of the lower extremity did not predispose the patients to developing the subsequent stress fractures (noted as incorrect diagnoses) in the study, based on the fact that inclusion required a scan that would have excluded these at the outset of the study. This suggests that the brace may in about 24% of the patients actually cause harm (induce fractures) in addition to the loss of other patients (not stated in terms of number) based on brace discomfort. Therefore, conservatively 25% of the population perceived no benefit from the brace intervention. Given that there was a sample size of patients well below what an a priori analysis would potentially have recommended in order to detect a possible statistical and possibly MCID, the outcomes of this study are actually inconclusive and undetermined. This concurs with the conclusion drawn by the authors of the study.
CONCLUSION	The reviewers scored this article as a total score of seven (see Table 4.65), This shows that the authors of this study achieved a moderate to good rigour in the execution and methodology of this specific study. However, within the context of this, the limitations for the small sample size and the discomfort of the brace leading to inadequate use, must be kept in mind. This leads to the conclusion that the Shin Saver Orthosis provides little evidence for the effective treatment of MTSS TII in clinical practice.

Table 4.56: Tabulated feedback data– RCT- Article 4

AUTHOR(S)	Moen, M. H., Bongers, T., Bakker, E. W., Weir, A., Zimmermann, W. O., van der Werve, M. and Backx, F. J.					
YEAR	2010					
TITLE:	The additional value of a pneumatic leg brace in the treatment of recruits with medial tibial stress syndrome; a randomised study					
CRITERION		**Reviewer1**	**Reviewer 2**	**Reviewer 3**	**Ranking**	**Percentage Agreement**
1	Eligibility criteria were specified	Y	Y	Y	Y	100%
2	Subjects were randomly allocated to groups (in a crossover study, subjects were randomly allocated an order in which treatments were received)	Y	Y	Y	Y	100%
3	Allocation was concealed	Y	Y	Y	Y	100%
4	The groups were similar at baseline regarding the most important prognostic indicators	Y	Y	Y	Y	100%
5	There was blinding of all subjects	Y	Y	Y	Y	100%
6	There was blinding of all therapists who administered the therapy	N	Y	N	N	66%
7	There was blinding of all assessors who measured at least one key outcome	Y	Y	N	Y	66%
8	Measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups	Y	Y	Y	Y	100%
9	All subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome was analysed by 'intention to treat'	Y	Y	Y	Y	100%
10	The results of between-group statistical comparisons are reported for at least one key outcome	Y	Y	Y	Y	100%
11	The study provides both point measures and measures of variability for at least one key outcome	Y	Y	N	Y	66%
	TOTAL SCORE	10	11	8	10	
			OVERALL PERCENTAGE AGREEMENT			90,7%

Table 4.57: Properties of study, outcome and discussion– RCT – Article 4

AUTHORS(S)	Moen, M. H., Bongers, T., Bakker, E. W., Weir, A., Zimmermann, W. O., van der Werve, M. and Backx, F. J.							
YEAR	2010							
TITLE	The additional value of a pneumatic leg brace in the treatment of recruits with medial tibial stress syndrome; a randomised study							
STUDY PROPERTIES								
Form of measurement	**Frequency of measurement**	**Duration of study**	**Number of participants**	**Assessors blinded**	**Control used**	**Randomisation of participants**	**Ranking**	**Total Percentage Agreement**
Days to completing the running programme. Sports Activity Rating Scale (SARS) score.	Every 2 weeks. Follow-up after 6 months.	It was patient specific. The average was 58 days (2 months) for both groups.	15 recruits	Yes	Yes. Control group (n=7) had a rehabilitation programme without brace.	Yes. 2 groups. Intervention group = 8. Control = 7.	10	90.7
LIMITATIONS	This study consisted of 15 military men between the ages of 17 and 22. This does not allow for generalisation to the population – due to the specific age and physical training/activity levels. Given this narrow range of patients, it is possible that there was increased homogeneity between the groups tested. However, given the high degree of patient specificity the outcomes may not be applicable to patients that do not meet the inclusion criteria for this study. The only limitation that was mentioned by the authors of this study was the use of only a subjective progression tool throughout the study (i.e. patients' leg pain). Therefore, some patients never progressed further through the rehabilitation phases after noting that they still had the same level of pain in their legs. It was noted by the authors that there is no valid scoring system that can be used for MTSS TII or that could be used to decide on rehabilitation progress. This complicated the six phases of the running programme (the rehabilitation programme consisted of leg exercises and a graded running programme). Additionally, it was noted that participants were only supervised up until phase two. The last four phases the patient had to complete at home. Although compliance was reported by the authors, no overt reporting mechanism seems to have been used. This may have decreased the patients' compliance and reporting thereof within the programme and could have led to bias. This is particularly important when 86% of participants complained of discomfort when wearing the brace (small wounds and chaffing were seen around the malleoli), and compliance may have been compromised. The study involved a small number of participants and lacked an a priori/power calculation.Thus, the study sample size only allowed the use of non-parametric statistics and the discussion of only trends such that no categorical conclusions could be drawn.							

	Given that the study included a rehabilitation programme and an additional brace, it is not possible to determine whether the brace alone would assist patients with MTSS TII. Therefore this is a relative effectiveness study determining whether the rehabilitation programme versus the rehabilitation programme plus the brace was better at achieving specific outcomes. This means that the actual contribution of the brace to the outcomes is unknown and would require an efficacy study.
OUTCOME	There was no significant difference noted on the amount of days it took to complete the running programme or in the SARS score between the groups. At the six months follow-up, none of the participants noted that they had MTSS TII symptoms.
DISCUSSIONS	In this single blinded randomised study testing the benefit of a pneumatic leg brace vs an ordinary rehabilitation programme, it was shown that there is no larger benefit to the rehabilitation training and brace versus the rehabilitation training alone. Given that there are also some significant flaws in the methodological design of the study as discussed under the limitations and seeing that the brace is not comfortable to wear, there is no ability to consider the combination of rehabilitation training with a brace as the outcomes seem to be the same for the rehabilitation training alone. It would also be of benefit to consider the development of a scoring system that could be used in research studies that includes rehabilitation and the need for progression in the rehabilitation in order to allow for better standardisation of the process between the various participants in order to a achieve either a uniform or consistent outcome by allowing measurement of time through the programme and/or clinical outcomes at time points that are similar for patients in the study.
CONCLUSION	A factor that contributes to the reviewers' high ranking of the article, is that this study is a well-structured study which fulfils the criteria set out for RCT studies. Although this study achieved a good ranking (reviewers ranked this study a ten), the inconclusive clinical outcomes of this study add no value in a clinical context (in terms of effectiveness and intervention) in support of either intervention.

Table 4.58: Tabulated feedback data– RCT- Article 5

AUTHOR(S)	Moen, M. H., Holtslag, L., Bakker, E., Barten, C., Weir, A., Tol, J. L. and Backx, F.					
YEAR	2012					
TITLE	The treatment of medial tibial stress syndrome in athletes; a randomised clinical trial.					
CRITERION		**Reviewer1**	**Reviewer 2**	**Reviewer 3**	**Ranking**	**Percentage Agreement**
1	Eligibility criteria were specified	Y	Y	Y	Y	100%
2	Subjects were randomly allocated to groups (in a crossover study, subjects were randomly allocated an order in which treatments were received)	Y	Y	Y	Y	100%
3	Allocation was concealed	N	Y	N	N	66%
4	The groups were similar at baseline regarding the most important prognostic indicators	Y	Y	Y	Y	100%
5	There was blinding of all subjects	N	Y	Y	Y	66%
6	There was blinding of all therapists who administered the therapy	N	Y	Y	Y	66%
7	There was blinding of all assessors who measured at least one key outcome	Y	Y	Y	Y	100%
8	Measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups	N	Y	N	N	66%
9	All subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome was analysed by 'intention to treat'	Y	Y	N	Y	66%
10	The results of between-group statistical comparisons are reported for at least one key outcome	Y	Y	Y	Y	100%
11	The study provides both point measures and measures of variability for at least one key outcome	Y	Y	N	Y	66%
	TOTAL SCORE	7	11	9	9	
			OVERALL PERCENTAGE AGREEMENT			81,5%

Table 4.59: Properties of study, outcome and discussion– RCT – Article 5

AUTHORS(S)	Moen, M. H., Holtslag, L., Bakker, E., Barten, C., Weir, A., Tol, J. L. and Backx, F.							
YEAR	2012							
TITLE	The treatment of medial tibial stress syndrome in athletes; a randomised clinical trial.							
STUDY PROPERTIES								
Form of measurement	**Frequency of measurement**	**Duration of study**	**Number of participants**	**Assessors blinded**	**Control used**	**Randomisation of participants**	**Ranking**	**Total Percentage Agreement**
Completion of running schedule (progression based on VAS). Likert Scale	Weeks 2, 4, 6, 8, 10, 12, 16, 22,28, 34, 42, 50	Patient specific. But up to 50 weeks.	74 initially (with 14 dropouts). Three groups.	No	Yes	Yes	9	81,5%
LIMITATIONS	In this randomised study, 74 participants were included into three intervention groups (each less than 20 participants). All groups participated in a graded running programme. Group two did additional strengthening and stretching exercises for the calf, while group three wore a sports compression stocking. There are two limitations to this structure, the first being related to the fact that there are three groups, each with less than 20 participants, results in the use of non-parametric statistics, which means that only trends in terms of outcomes can be discussed. This weakens the study outcomes and further suggests that the likelihood of attaining statistical significance is small (also given that the authors report discrepancies in the baseline data for use in the a priori/power analysis (Johnston *et al.* 2006)). Secondly, the interventions can only be tested for relative effectiveness as each of the groups have a training programme (constituted of several parts) in addition to the exercises or compression stocking (in the intervention groups). This curtails the ability of the study to be able to comment on any one intervention modality. The above limitations are further enhanced by the 19% dropout rate (we applaud the authors for reporting this). In addition, the authors must be thanked for analysing the effect of these dropouts and indicating that they had no statistical effect on the outcomes. However, on a subjective level, when 19% of the population leave, citing that there is a lack of progress in the improvement of the clinical condition, this suggests that none of the groups provided benefit for a sizable portion of the population under study. This therefore needs to foreground to the conclusions that are drawn in this study. The athletes, assessors and investigators were not blinded in this study. This lack of blinding means that the outcomes are potentially affected by patient perception, patient expectation, patient satisfaction as well as previous exposure to the type of intervention allocated to							

	the group in which they were placed (Thornton *et al.* 2017). In addition, the enthusiasm of the assessors and investigators in terms of the intervention that the patient was receiving may also have influenced the study. These factors may also have in part contributed to the departure of the patients that left the study.
OUTCOME	The mean time to reach phase six (continuous running for 18 minutes at an intensity of two, meaning running while being able to speak or intensity three, where talking is difficult while jogging) of the running programme for group 1 was 105,2 days. Group 2 took 117,6 days and for group 3 it was 102,1 days. Satisfaction was measured for group 1 at 6.5, group 2 was 5.9 and 6.8 for group 3. The outcomes measured in this study were time to complete running programme and general satisfaction with interventions. These were not significantly different between the groups.
DISCUSSIONS	This study was the first randomised MTSS TII treatment in athletes outside the military. The majority of other studies included a wide variety of military or navy personnel (Johnston *et al*. 2006; Moen *et al.* 2010; Meulenkamp *et al.* 2016; Bonanno *et al.* 2018). In addition, it also included a wider age range (most previous studies ranged from 15 to about 30 years of age at each extreme) with patients aged between 16-51 years old. This has benefits for the extrapolation of data to the general population, but it also requires that the study be approached in a slightly different manner, in that it would have been essential to stratify the patients within each of the groups to ensure that there was an equal representation of age, gender and chronicity of the MTSS TII in both groups. With randomisation, although good in well-defined narrow studies, it may have resulted in unequal groups in terms of the patient demographics and condition profile at the outset. It would seem that the conclusion drawn by the authors suggests that there were no differences between the different groups. Thus, based on the high dropout rate and the inability of the study to draw any firm conclusions, quite aside from the limitations noted above, this study does not provide a basis that supports or negates the use of any of the intervention combinations. Additionally, the lack of a natural history or control group further does not allow for determining whether any of the intervention combinations are actually better than placebo. Thus, practitioners should be cautioned when considering utilising this study to provide informed consent to patients.
CONCLUSION	Although the study was highly ranked by the reviewers (they scored it as a nine out of eleven) in terms of the methodological rigour, it is significant thatin this study there was a 19% drop out rate due to lack of progress. Taking this into account, caution needs to be applied when looking to apply any of the treatment interventions as they are not different from one another and because there is no control group to indicate that any one or more of the programmes are better than placebo. Therefore, this study has limited benefit for the use in clinical practice for patients with MTSS TII.

Table 4.60: Tabulated feedback data for group 1 – RCT- Article 6

AUTHOR(S)	Newman, P., Waddington, G. and Adams, R.					
YEAR	2017					
TITLE	Shockwave treatment for medial tibial stress syndrome: A randomised double blind sham-controlled pilot trial.					
CRITERION		**Reviewer1**	**Reviewer 2**	**Reviewer 3**	**Ranking**	**Percentage Agreement**
1	Eligibility criteria were specified	Y	N	Y	Y	66%
2	Subjects were randomly allocated to groups (in a crossover study, subjects were randomly allocated an order in which treatments were received)	Y	Y	Y	Y	100%
3	Allocation was concealed	Y	Y	Y	Y	100%
4	The groups were similar at baseline regarding the most important prognostic indicators	Y	Y	Y	Y	100%
5	There was blinding of all subjects	Y	Y	Y	Y	100%
6	There was blinding of all therapists who administered the therapy	N	Y	Y	Y	66%
7	There was blinding of all assessors who measured at least one key outcome	Y	Y	Y	Y	100%
8	Measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups	Y	Y	Y	Y	100%
9	All subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome was analysed by 'intention to treat'	Y	N	Y	Y	66%
10	The results of between-group statistical comparisons are reported for at least one key outcome	Y	Y	Y	Y	100%
11	The study provides both point measures and measures of variability for at least one key outcome	Y	Y	Y	Y	100%
	TOTAL SCORE	10	9	11	11	
			OVERALL PERCENTAGE AGREEMENT			90,7%

Table 4.61: Properties of study, outcome and discussion– RCT – Article 6

AUTHORS(S)	Newman, P., Waddington, G. and Adams, R.							
YEAR	2017							
TITLE	Shockwave treatment for medial tibial stress syndrome: A randomised double blind sham-controlled pilot trial.							
STUDY PROPERTIES								
Form of measurement	**Frequency of measurement**	**Duration of study**	**Number of participants**	**Assessors blinded**	**Control used**	**Randomisation of participants**	**Ranking**	**Total Percentage Agreement**
NRS. Global rating of Change Scale.	Baseline and week 10.	10 weeks.	28 participants	Yes	Yes	Yes	11	90,7%
LIMITATIONS	Not dissimilar to the previous study (Moen *et al.* 2012) this study was also underpowered thus disabling the ability to generate a statistically significant difference between the groups and categorically state conclusions. To their credit the authors do analyse the baseline demographic and MTSS TII condition data to ensure that the groups before and after dropout were still similar. This assists in negating the extraneous effects of groupings that are significantly different in their presentation and potential healing time, which then reflect negatively and unfairly on the interventions. To their credit the authors went to appropriate and considered lengths to ensure blinding. It is clear that the patients were unaware of the intervention received. The allocation was concealed so researcher bias was excluded in terms of allocating patients to a group and the analysis was blinded in terms of the outcomes generation. However, what was unclear is that the person administering the treatment would have known which treatment group the patient was in, thus there is still a potential for therapist influence and autosuggestion, which does not technically allow the study to be double blinded in terms of the intervention. To compound the above, the study included a sham-controlled group, which received shockwave therapy but at the lowest setting. This is not a complete control as even a low dose of shockwave could have produced clinical results. Therefore, this sham technically speaking disqualifies this study as an efficacy study and turns it into a relative effectiveness study (Vickers 2005). A true placebo controlled trial would be required to validate that the lowest settings on the shockwave does not actually produce a clinical result in order for the outcomes of this study to be seen in a different light, i.e. one of testing efficacy. Alternatively, the shockwave intervention without the unit activated would have been a better control.							

OUTCOME	At the week 10 mark it was noted that the control group had 1.1/10 (NRS) less pain that the intervention group. This was not statistically significant. No significant difference was noted between the respective groups for pain pressure threshold on the muscle or pain during running (pain limited distance run or in the change in self-perception).
DISCUSSIONS	Based on the pilot study there was no difference between standard dose shockwave treatment and sham shockwave (low setting intervention) treatment in athletes with MTSS TII. This however, needs to be accepted with caution as it is unclear as to whether the sham intervention actually has the ability to produce a clinically beneficial effect. Particularly as the patients reported a decrease in 'bone pain' for this group that was significant. Therefore, the outcomes of this current study actually suggest that both groups with their respective shockwave therapy settings actually had a clinically beneficial effect, but what is not possible to tell, is if this effect size is sufficiently large enough to allow both intervention types to be better than placebo, as the efficacy of the two intervention dosages have not been pitted against a true control (natural history) and a true placebo. Therefore, in effect the study does not at the present time, provide any information on whether shockwave therapy is indeed beneficial for treating MTSS TII in patients.
CONCLUSION	This study met all the requirements for a strong RCT, which was indicated by the reviewers who ranked this study as eleven out of eleven. The lack of statistically significant outcomes between the sham dose and intervention dose, as stated in the discussion above, is that it does not allow confident conclusions. As mentioned before, future studies would have to be done in order to determine the outcome of shockwave and to increase the benefit for patients.

Table 4.62: Tabulated feedback data– RCT- Article 7

AUTHOR(S)	Payne, L.					
YEAR	2007					
TITLE	The relative effectiveness of three treatment protocols in the treatment of medial tibial stress syndrome type II					
CRITERION		**Reviewer1**	**Reviewer 2**	**Reviewer 3**	**Ranking**	**Percentage Agreement**
1	Eligibility criteria were specified	Y	Y	Y	Y	100%
2	Subjects were randomly allocated to groups (in a crossover study, subjects were randomly allocated an order in which treatments were received)	Y	Y	Y	Y	100%
3	Allocation was concealed	N	Y	Y	Y	66%
4	The groups were similar at baseline regarding the most important prognostic indicators	Y	Y	Y	Y	66%
5	There was blinding of all subjects	N	Y	Y	Y	66%
6	There was blinding of all therapists who administered the therapy	N	Y	N	N	66%
7	There was blinding of all assessors who measured at least one key outcome	N	Y	N	N	66%
8	Measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups	Y	Y	Y	Y	100%
9	All subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome was analysed by 'intention to treat'	Y	Y	Y	Y	100%
10	The results of between-group statistical comparisons are reported for at least one key outcome	Y	Y	Y	Y	100%
11	The study provides both point measures and measures of variability for at least one key outcome	Y	Y	Y	Y	100%
	TOTAL SCORE	7	11	9	9	
			OVERALL PERCENTAGE AGREEMENT			75,5%

Table 4.63: Properties of study, outcome and discussion– RCT – Article 7

AUTHORS(S)	Payne, L							
YEAR	2007							
TITLE	The relative effectiveness of three treatment protocols in the treatment of medial tibial stress syndrome type II							
STUDY PROPERTIES								
Form of measurement	**Frequency of measurement**	**Duration of study**	**Number of participants**	**Assessors blinded**	**Control used**	**Randomisation of participants**	**Ranking**	**Total Percentage Agreement**
Numerical Pain Rating Scale. McGill Short Form Questionnaire. Pain Disability Index.	First, third and fifth consultation.	4 treatments	45 (15 per group).	No.	No.	Yes. Into three groups: 1 – TENS, 2 – Needling and 3- Electro-needling	9	75,5%
LIMITATIONS	To the authors credit, there were a couple of limitations and these included an acknowledgement that the sample size was too small (no power analysis was completed) to draw definitive conclusions. Although randomisation was used in terms of the allocation of patients to the three intervention groups, it is noted that the groups were not homogenous at the baseline with regards to the NRS (a significant difference was noted p = 0.008). This has a dampening effect on the conclusions drawn as all the outcome measures are directly or indirectly measures of pain or related to pain description. This is related principally to the effects of the 'ceiling effect' and 'floor effect', which are the effects of the limitations of improvements based on what the scale or measurement tool allows. For example, if the NRS is rated from 0-10, then the group that started on 7/10 has a greater degree of improvement theoretically possible as compared to a group that started with a 5/10 pain rating. This is known as the floor effect. This effect would therefore potentially result in the 7/10 group showing a significant improvement when compared to the 5/10 group, but the significance is artificial or a created artefact based on the measurement tool limitations and the differences between the groups at the start. The ceiling effect is the same principle applied in the reverse format, where an increase in the value on the questionnaire or measurement tool indicated improvement, so the lower the initial starting score the greater the ability to improve and show significance when compared to a group that started with a score closer to the optimal score. Lack of assessor blinding is an important component of this study, as it calls into question the ability of the assessor to be neutral and in no way influence the outcomes of the study, whether this be overt or implied in the interaction of the assessor with the patients. The outcomes of the study are limited to the short-term effects of the tested interventions based on the measurement interval not exceeding four visits. This does not allow us to accurately see the medium and long-term effects of TENS, needling and electro-needling. Additionally, this study may also fall prey to the same problems as those studies that looked at the relative effectiveness of interventions without relevant							

	efficacy studies having been carried out. For example, this study could well conclude that there was no difference between the three interventions, but then as readers we would not be able to convert that into clinical practice as the significant changes in pain or clinical resolution in all three groups have no reference to whether any of the three treatments are actually better than placebo alone. There should be standardised electrical parameters throughout the study. Because these settings vary due to acute or chronic pain. Therefore, the different parameters were different in patients.
OUTCOME	All three groups improved with the intervention that they received. However, no intervention was better alone when compared to the other. According to objective measurements of pain, the treatment effect was not statistically significant, but there was a trend towards the electro-needling group showing a faster decrease in pain than the other two groups.
DISCUSSIONS	With the principle limitations including: - small sample size - non-homogenous groups at the outset with particular reference to pain reporting - lack of a control group/placebo group or natural history group - lack of blinding of the assessor This study has limited ability to support any one outcome measure tested in this relative effectiveness study, without the underlying efficacy studies for each of the noted interventions being completed. The efficacy studies are required to enable contextualisation of the results in a bed of literature that either negates the collective treatments utilised (if the results of the efficacy studies show that they are no better than placebo) or confirms that these outcomes are actually better than placebo (allowing for the extrapolation of this information into clinical practice). Additionally future studies should also, like the ESWT/shockwave, have studies completed that outline differences in the frequency, intensity and duration of the electro-modality application in order to determine whether any of these inputs can result in the alteration of the clinical outcomes.
CONCLUSION	Based on the well-structured study and the clear and rigorous processes, this study allowed for the reviewers to rank the study very highly. Notwithstanding this, various factors as mentioned above (small sample size, non-homogenous groups, lack of control group, lack of blinding) affects the external validity and significantly limits the perception of drawing a definitive conclusion about TENS, needling and electro-needling in the context of MTSS TII treatment. This problem is further reinforced when comparing the three treatment protocols and attempting to show which protocol conveys the best outcome in the short-term. Therefore, this study provides limited evidence in terms of support for any one intervention.

Table 4.64: Tabulated feedback data– RCT- Article 8

AUTHOR(S)	Robertson, M. E.					
YEAR	2003					
TITLE	The relative effectiveness of periosteal pecking combined with therapeutic ultrasound compared to therapeutic ultrasound in the treatment of medial tibial stress syndrome type II.					
CRITERION		**Reviewer1**	**Reviewer 2**	**Reviewer 3**	**Ranking**	**Percentage Agreement**
1	Eligibility criteria were specified	Y	N	Y	Y	66%
2	Subjects were randomly allocated to groups (in a crossover study, subjects were randomly allocated an order in which treatments were received)	Y	Y	Y	Y	100%
3	Allocation was concealed	Y	Y	N	Y	66%
4	The groups were similar at baseline regarding the most important prognostic indicators	Y	Y	Y	Y	100%
5	There was blinding of all subjects	N	Y	N	N	66%
6	There was blinding of all therapists who administered the therapy	N	Y	N	N	66%
7	There was blinding of all assessors who measured at least one key outcome	N	Y	N	N	66%
8	Measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups	Y	Y	Y	Y	100%
9	All subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome was analysed by 'intention to treat'	Y	Y	Y	Y	100%
10	The results of between-group statistical comparisons are reported for at least one key outcome	Y	Y	Y	Y	100%
11	The study provides both point measures and measures of variability for at least one key outcome	Y	Y	Y	Y	100%
	TOTAL SCORE	8	10	7	8	
			OVERALL PERCENTAGE AGREEMENT			84,5%

Table 4.65: Properties of study, outcome and discussion– RCT – Article 8

AUTHORS(S)	Robertson, M. E.							
YEAR	2003							
TITLE	The relative effectiveness of periosteal pecking combined with therapeutic ultrasound compared to therapeutic ultrasound in the treatment of medial tibial stress syndrome type II.							
STUDY PROPERTIES								
Form of measurement	**Frequency of measurement**	**Duration of study**	**Number of participants**	**Assessors blinded**	**Control used**	**Randomisation of participants**	**Ranking**	**Total Percentage Agreement**
Short-form McGill Pain Questionnaire. Numerical Pain Rating Scale. Pain Disability Scale Pressure pain threshold using an algometer.	4 treatments	2 weeks	44 participants	No.	Yes. Group 1 = periosteal pecking and ultrasound. Group 2 = only ultrasound.	Yes. Two equal groups of 22 patients.	8	84,5%
LIMITATIONS	To the author's credit, the following limitations were mentioned and included: -This study had a limited number of participants. Based on this small sample size, the results may have been skewed or represented incorrectly. In order to utilise the stronger parametric statistics a larger sample size could be included in future studies. This would decrease the opportunity of incorrectly agreeing with the null hypothesis (Vickers 2005). -Duration of the study was limited to two weeks and there were no long-term follow-ups noted. Therefore, this study is only able to represent outcomes of short-term effectiveness of periosteal pecking combined with therapeutic ultrasound compared to therapeutic ultrasound. This does not allow health care professionals to see the full extent of improvement. This would need to be considered when looking at clinical effectiveness of the treatments. Based on this study, treatment was only for two weeks. Some patients may need longer to fully recover. The assessor was not blinded in this study. This could lead to a change in the outcome and could also have an effect on observer bias. To reduce the bias and the possible effect on outcome, future research should include a double-blinded structure to the study. The patients were not blinded either which could lead to bias in this study (Boutron *et al*. 2019). Seeing that subjective measurement forms were used, this weakens the outcome of the study based on the fact that participants could have reported something different to how they were feeling in order to help the researcher or because they felt that they needed to. Further subjective measurements lead to bias as someone can report something based on how they are feeling. If someone is having a bad day and is feeling frustrated, they may report that they are feeling worse and that they are not responding.							
OUTCOME	When objective measures were utilised, both groups had similar outcomes. Both groups showed favourable outcomes from the first to final treatment. The combined group was highly significant and therapeutic ultrasound only was significant. When an inter-group analysis was done at the final treatment the combined intervention showed a significant difference.							

	When subjective measures were utilised, both Group 1 (periosteal pecking and ultrasound) and Group 2 (ultrasound) performed similarly. Both groups improved significantly from the initial treatment to the final treatment.
DISCUSSIONS	This study was to investigate the effectiveness of periosteal pecking combined with therapeutic ultrasound compared to only therapeutic ultrasound in the treatment of MTSS TII. As can be seen above when objective measures are taken into account, the combination of periosteal pecking and ultrasound are highly significant. Although the subjective measurements were inconclusive, as mentioned under limitations, this could be due to bias. Based on the use of ultrasound in conjunction with periosteal pecking, this review cannot confidently report on either intervention separately. This leads to confusion as to whether periosteal pecking or the combination of periosteal pecking with ultrasound led to this outcome. Future studies should consider testing only periosteal pecking vs periosteal pecking and ultrasound if they want to confirm which one is effective in recovery. The author in this study highlighted a need to assess foot biomechanics in future studies when working with athletes suffering from MTSS II. This could be due to the change in foot biomechanics that could lead to this condition.As mentioned in Bonanno *et al.* (2018) pronation or supination can have an effect in these studies. Similarly, in De la Fuente *et al.* (2019) where the correction of pronation could have led to a positive outcome. Future studies should consider blinding the observer and increasing the follow-up time to see the long term effects in order to strengthen the results and increase the benefit of these results in clinical practice.
CONCLUSION	There were some flaws in the manner in which the conceptual outcomes of the study were tested, thereby limiting the ability of the study to draw conclusions on the clinical interventions. Therefore, even though the study was ranked as eight out of eleven for internal validity, the external validity compromised the ability of the researcher to draw conclusions.

4.4.3.2 Discussion

Table 4.66: Outcome and methodological ranking of randomised controlled trials

Outcome as determined by reviewers:

Study Type:	**Randomised Controlled Trials**				
Author(s)	Year	Reported Outcome	Methodological Ranking	Outcome as determined by reviewers	Clinical outcome
Andrish, Bergfeld and Walheim	1974	**Heel pads, cord stretching, heel pads and heel cord stretching and a graded running programme** were assessed and none showed superiority.	5	Moderate to poor	No difference between intervention programmes
Gomez Garcia, Ramon Rona, Gomez Tinoco, Benet Rodriguez, Chaustre Ruiz, Cardenas Letrado, Lopez-Illescas Ruiz and Alarcon Garcia	2017	**Extracorporeal Shock Wave Therapy and a training programme** is more successful compared to the same training programme in MTSS TII.	10	Good	No difference between intervention programmes
Johnston, Flynn, Bean, Breton, Scherer, Dreitzler and Thomas	2006	No conclusion can be drawn to the effectiveness of **Shin Saver orthosis.**	7	Moderate	No outcome
Moen, Bongers, Bakker, Weir, Zimmermann, van der Werve and Backx	2010	There is no benefit of a **pneumatic leg brace** vs an ordinary rehabilitation programme in patients with MTSS TII.	10	Good	No difference between intervention programmes
Moen, Holtslag, Bakker, Barten, Weir, Tol and Backx	2012	The authors found that **graded running programme, same programme and additional strengthening and stretching exercises for the calf or sports compression stocking** had no significant effect.	9	Good	No difference between intervention programmes
Newman, Waddington and Adams	2017	There was no difference between **standard dose shockwave treatment and sham shockwave treatment** in athletes with MTSS TII.	11	Excellent	No difference between intervention programmes
Payne	2007	Patients enhanced regardless of the type of intervention being: **TENS, needling and electro-needling.**	9	Good	No difference between intervention programmes
Robertson	2003	Both **periosteal pecking combined with therapeutic ultrasound and only therapeutic ultrasound** showed favourable outcomes.	8	Good	No difference between intervention programmes

4.5 CONCLUSION

In this chapter the findings of the internal validity of the study by means of the reviewer rating of each article within this review is offered. It has also provided an outline of the external validity factors of each article in terms of its properties, structure, limitations and outcomes. This permits the reader to understand the relationship of the internal and external validity of the studies and how this impacts on the outcomes of the article and thus the evidence that is available based on the outcomes of the various studies.

To meet the requirements of this study, the following chapter (Chapter Five) introduces a discussion around each of the interventions outlined in the articles in order to be able to establish the level of evidence that is available for each of the specific interventions that have been communicated for use in MTTS TII.

CHAPTER FIVE DISCUSSION OF RESULTS

5.1 INTRODUCTION

After reviewing the different study types that were presented in Chapter Four, this chapter contextualises the level of evidence for each specific intervention used when trying to treat MTSS TII.

The various interventions acknowledged within the articles that were included and reviewed are shown in Section 5.2 (A review of interventions for MTSS TII). The interventions that were identified are presented in tables in Section 5.4 (Ranking of evidence for each intervention). These tables are divided, one for single interventions and a separate table for multi-modal interventions. These tables were drawn up to summate the level of evidence, as determined by Dagenais and Haldeman (2011) for each single intervention or multiple interventions. These tables will be used to determine the level of evidence and the level of support (adequate or inadequate) for the use of this specific intervention or combination of interventions in the management of MTSS TII. These tables will also indicate if there is a lack of evidence and directions for future investigations.

5.2 A REVIEW OF INTERVENTIONS FOR MTSS TII

After the 30 articles that met the inclusion criteria were reviewed, the following interventions were acknowledged as having been tested for possible use in the management and treatment of MTSS TII:

Single Interventions:

- Cryotherapy massage
- Electro-needling
- Extracorporeal Shock Wave Therapy
- Fascial distortion model
- Foot orthoses
- Iontophoresis
- KT tape
- MYK System

- Needling
- Phonophoresis
- Stretching
- TENS
- Ultrasound therapy

Multi-Modal Interventions:

- Graded Running Programme with other interventions
- Rehabilitation with other interventions
- Strengthening exercises with other interventions
- Nonstandard intervention programmes

5.3 DISCUSSION OF THE CRITERIA FOR RANKING EVIDENCE

There are three possible grading systems that are utilised to rank evidence:

- AGREE (Dagenais and Haldeman 2011).
- GRADE (Brozek *et al.* 2009).
- Grading suggested by Foley *et al.* (2003).

Of the above systems, Foley *et al.* (2003) along with Dagenais and Haldeman (2011) uses a grading of evidence that is more understandable to health care providers and is far less complex compared to the Cochrane GRADE system (Brozek *et al.* 2009). The GRADE system focuses on providing a uniform method when creating healthcare guidelines, which leads to a higher level of complexity, but is less pragmatic than the AGREE system. In addition, Foley *et al.* (2003) and Dagenais and Haldeman (2011) include a category which includes a descriptor to indicate whether the evidence offered, agrees or conflicts within the clinical category that the evidence is ranked for which accounts for disparity between articles that may show opposing results. The addition of this information allows for the reader to better contextualise the information presented.

Therefore, based on the AGREE (Dagenais and Haldeman 2011) and Foley *et al.* (2003) systems, the different levels are best described as follows:

Strong Evidence: The findings of studies within one specific area were reinforced by the results of two or more RCTs of at least ‘fair/moderate’ quality.

Moderate Evidence: The findings were reinforced by at least one RCT of 'fair/moderate' quality.

Limited Evidence: The findings were reinforced by one non-experimental study (NRCT, CS and cohort study).

Consensus of Evidence: If there is a lack of evidence, agreement was achieved by experts on a suitable intervention. Consensus opinion is seen as the lowest form of evidence. Therefore, it is debatably not considered to be evidence. On the other hand it could also indicate that the data between different studies agree that the results for a specific intervention is consistent (i.e. the outcomes are consistently strong evidence in favour of or against a specific intervention for a certain condition). The latter was used in this chapter.

Conflicting Evidence: If an incongruity is found between at least two RCTs findings. If there is a minority of conflicting cases, the conclusion is decided on the majority results, unless the incongruity study has a superior quality.

No Evidence: The available study or studies were of low/poor quality and therefore, provided no clear evidence that would support the treatment regimen.

Thus, the tables (5.2-5.7) below will use the above system to grade the level of evidence as found in this study.

5.4 RANKING OF EVIDENCE FOR EACH OF THE INTERVENTIONS

The interventions are listed and are discussed based on Table 5.1.

Table 5.1: List of intervention and corresponding table number

Table number	Intervention
Table 5.2	Single intervention with evidence
Table 5.3	Single intervention with no evidence
Table 5.4	Graded Running Programme with other interventions
Table 5.5	Rehabilitation with other interventions
Table 5.6	Strengthening exercises with other interventions
Table 5.7	Nonstandard treatment programmes

5.4.1 Single Interventions with Evidence

Table 5.2: Single interventions with evidence

Author(s)/Year	Study Type	Ranking of Individual Study	Clinical outcomes obtained	Level of Evidence of Intervention					
				Strong	Moderate	Limited	Consensus	Conflicting	No evidence
Smith *et al.* (1986)	NRCT	Good	Internal validity good, external validity is poor, no efficacy testing only relative effectiveness, thus evidence for **cryotherapy massage** is inconclusive. Trend to improved clinical outcomes was noted in the results.			X	Same study		
Smith *et al.* (1986)	NRCT	Good	Internal validity good, external validity is poor, no efficacy testing only relative effectiveness, thus evidence for **iontophoresis** is inconclusive.Trend to improved clinical outcomes was noted in the results.			X			
Smith *et al.* (1986)	NRCT	Good	Internal validity good, external validity is poor, no efficacy testing only relative effectiveness, thus evidence for **phonophoresis**. is inconclusive. Trend to improved clinical outcomes was noted in the results.			X			
Smith *et al.* (1986)	NRCT	Good	Internal validity good, external validity is poor, no efficacy testing only relative effectiveness, thus evidence for **ultrasound** is inconclusive**.** Trend to improved clinical outcomes was noted in the results.			X			
Robertson (2003)	RCT	Good	Internal validity good, external validity is poor, no efficacy testing only relative effectiveness, thus evidence for **ultrasound** is inconclusive**.** Groups showed similar improvement.			X			
Payne (2007)	RCT	Good	Internal validity good, external validity is poor, no efficacy testing only relative effectiveness, thus evidence for **TENS**is inconclusive. Trend to improved clinical outcomes was noted in the results.		X		Same study		
Payne (2007)	RCT	Good	Internal validity good, external validity is poor, no efficacy testing only relative effectiveness, thus evidence for **Needling**is inconclusive. Trend to improved clinical outcomes was noted in the results.		X				
Payne (2007)	RCT	Good	Internal validity good, external validity is poor, no efficacy testing only relative effectiveness, thus evidence for **Electro-Needling** is inconclusive**.** Trend to improved clinical outcomes was noted in the results.		X				
Newman *et al.* (2017)	RCT	Excellent	Internal validity good, external validity is poor, an attempt at efficacy testing (control an incomplete sham intervention), thus evidence for **Extracorporeal Shock Wave Therapy** is inconclusive. No difference was noted between the groups clinically.			X	Only one study		
Schulze *et al.* (2014)	NRCT	Poor	Internal validity poor, external validity is poor, an attempt at efficacy testing (without a control), no evidence in favour of the **Fascial Distortion Model.** Trend to improved clinical outcomes was noted in the results.			X	Only one study		X
Martinez *et al.* (2020)	CS	Moderate to good	Internal validity good, external validity is average, no efficacy testing, thus evidence for **MYK system** is limited. Trend to improved clinical outcomes was noted in the results.			X		X	
Thistle (2018)	CS	Moderate to good	Internal validity good, external validity is poor, no efficacy testing, no relative effectiveness, no comparison to natural history (asymptomatic controls) thus evidence for **MYK system** inconclusive. Trend to improved clinical outcomes was noted in the results.						X

The study by Smith *et al.* (1986) showed that the interventions utilised by this study showed limited evidence. This was based on the fact that the internal validity was good but the

external validity was poor. However, even in this context, the trend is positive based on the actual clinical outcomes attained in the study. It is therefore possible that all of the interventions tested are comparable to ultrasound and therefore equal to placebo (therefore not to be utilised in clinical practice as there is no therapeutic benefit) or better than placebo (therefore not to be utilised in clinical practice as there is no therapeutic benefit). When these outcomes are contextualised in the results obtained by Gam and Johannsen (1995), the outcome seems to suggest that these therapies in their comparison to ultrasound are all no better than placebo as they found no research evidence for the use of ultrasound.

Therefore, future studies should focus on including a control group thereby increasing measurement of the efficacy of the ultrasound and the other treatments reviewed by Smith *et al.* (1986). The above assertion is supported in that Robertson's (2003) study showed that they found a clinical trend that was not positive, which concurs with the systematic review outcomes (Gam and Johannsen 1995).

This indicates that more studies are needed to show the appropriateness or inappropriateness of ultrasound in clinical practice. This means that practitioners in the field should not be utilising these interventions in clinical practice for the treatment of MTSS TII.

The study by Payne (2003) was a RCT with good internal validity achieving a ranking of good from the reviewers. Although the external validity was poor, these interventions ranked as a moderate level of evidence and were associated with a trend towards good clinical outcomes.

Given the supportive clinical outcomes of the study done by Liu *et al.* (2015) on the effectiveness of dry needling, it could be seen as a gold standard intervention. This in addition to the outcomes by Payne (2003), indicate that needling is better than placebo implying that all interventions utilised in the Payne (2003) study would be as effective as needling and better than placebo. Therefore, further efficacy studies on the interventions utilised (electro-dry needling and TENS) should be considered to validate that this assumption drawn from the literature is indeed a valid one.

Given the outcomes of this review, the use of needling, TENS and electro-dry needling may be clinically useful in assisting patients with the resolution of their MTSS TII, but the evidence available for this statement is limited and requires further research.

Newman *et al.* (2017) as well as Schulze *et al.* (2014) showcase the most recent research. It is noted that Newman *et al.* (2017) achieved no difference between the intervention groups in terms of the clinical outcomes. This may be based on the fact that this study, although structured as an efficacy study, utilised an 'active' sham control that may also have had a clinical effect. Therefore, in this context and given that the study, although well-

structured also had external validity concerns, it provides very limited evidence to support the use of extracorporeal shock wave therapy. This is compounded in that this study is the only study of its kind for MTSS TII and future research should attempt to include a proper sham control in order to effectively test the efficacy of Extracorporeal Shock Wave Therapy.

The opposite is true of the fascial distortion model study by Schulze *et al.* (2014). This study attained poor internal and external validity. Thus, even though the trend in the clinical outcomes suggested a clinical effect of the FD Model, this study is limited to providing very little to no evidence to inform clinical practice guidelines.

Given that both the extracorporeal shock wave therapy and the FD Model are relatively new clinical approaches to MTSS TII and similar trials/research are not available, future studies are recommended to further strengthen the evidence for use or avoidance of these interventions in clinical practice.

Although Martinez *et al.* (2020) and Thistle (2018) represent two studies that tested the efficacy and relative effectiveness of the MYK system and indicated that the trends supported good clinical outcomes for patients, only one provided appropriate levels of evidence through methodological rigour that could be used to show that this method of treatment may be utilised in clinical practice for the treatment of MTSS TII.

The study by Thistle (2018) included asymptomatic controls and as such compromised the external and internal validity of the study in addition to limiting the clinical outcomes conclusions that could be drawn. Therefore, this study provides little evidence to support MYK system use in clinical practice. However, due to the positive trend that was noticed, future research is recommended to validate the outcomes of the study by Thistle (2018). The review of the case study done by Martinez *et al.* (2020), showed a good internal validity and an average external validity. Therefore, the level of evidence for the MYK system is limited in supporting a positive clinical outcome for patients who are treated with this system. Future studies should focus on utilising an RCT design in order to get the best level of evidence.

5.4.2 Single Interventions with No Evidence

Table 5.3: Single interventions no evidence

AUTHOR(S)/YEAR	STUDY TYPE	RANKINGOF INDIVIDUAL STUDY	CLINICAL OUTCOMES OBTAINED	LEVEL OF EVIDENCE OF INTERVENTION					
				Strong	Moderate	Limited	Consensus	Conflicting	No evidence
De Vries (1961)	CS	Moderate to poor	**No clinical outcomes** measured for **stretching** only EMG activity measured.				Only one study		X
Bonanno *et al.* (2018)	CS	Moderate to Good	The outcome was not structured to provide clinical outcomes it was a prediction study on the effects of **footorthoses.**				X		X
Johnston *et al.* (2006)	RCT	Moderate	Internal validity good, external validity is poor due to drop out/inclusion criteria specificity, no evidence in favour of the **foot orthoses.**						X
Naderi *et al.* (2019)	NRCT	Good	**No clinical outcomes** measured for **foot orthoses**.						X
Griebert *et al.* (2016)	NRCT	Moderate	There were **no clinical outcomes** correlated to improved weight distribution measures of the foot with the use of **KT tape**.				Only one study		X

The studies in Table 5.3 indicated no evidence in the use of the interventions mentioned in this Table. This resulted from the fact that these studies only measured biomechanical outcomes or outcomes related to a specific type of intervention (i.e. change in pressures related to foot weight bearing/pressure or EMG reactions within a combination of muscles involved in MTSS TII). Since there are no data available for the correlation of these measures to the clinical outcomes or clinical changes of pain, activities of daily living or other practical and clinically available measures, the changes in these non-clinical measures and their impact on the patient's condition cannot be extrapolated (Winters *et al.* 2013a; Winkelmann *et al.* 2016; Yamaski 2019). This is further complicated in that there is debate around which biomechanical measures are associated with MTSS TII and whether these are caused by, or result from the presenting condition (Hyde and Gengenbach 2007; Winkelmann *et al.* 2016; Yamaski 2019; Martinez *et al.* 2020).

Practitioners are therefore advised not to use foot orthoses, static stretching and KT tape as stand-alone interventions as they have no clinical evidence to support their use in the clinical improvement of patients although there is a variable effect of these interventions on associated biomechanical structure of the foot complex in patients with MTSS TII. However, it is possible that these studies could be reproduced in order to test clinical outcome measures and/or studies could be done to define the relationship between the clinical outcome measures and the biomechanical measures enabling better interpretation of the

outcomes achieved in the above studies. This would then allow for the interpretation of the information either for or against the use of these interventions in clinical practice. Thus currently, caution needs to be applied when using these types of interventions in practice and patients cannot be provided with an expectation that these interventions are necessarily going to result in a positive clinical outcome.

5.4.3 Graded Running Programme with Other Interventions

Table 5.4: Graded running programme with other interventions

AUTHOR (S)/YEAR	STUDY TYPE	RANKING OF INDIVIDUAL STUDY	CLINICAL OUTCOMES OBTAINED	LEVEL OF EVIDENCE OF INTERVENTION					
				Strong	Moderate	Limited	Consensus	Conflicting	No evidence
Fick *et al.* (1992)	CS	Moderate	Internal validity average, external validity is poor, no efficacy testing only relative effectiveness, thus evidence for graded running is inconclusive. No difference between groups – non-clinical outcomes – running and satisfaction.						
Moen *et al.* (2012)	RCT	Good	Internal validity good, external validity is poor, efficacy testing only relative effectiveness, thus evidence for graded running is inconclusive. Outcome was the same for both groups. Trend towards improvement.			X		X	
Moen *et al.* (2012)	NRCT	Poor	Internal validity poor, external validity is poor, efficacy testing only relative effectiveness, thus evidence for graded is inconclusive. ESWT and graded running was better than graded running alone.						
Pietrzak *et al.* (2014)	CS	Moderate to good	Internal validity moderate to good, external validity is poor, no efficacy testing only relative effectiveness, thus evidence for graded running is inconclusive. It was suggested that there was a good clinical outcome.						

In this context, a graded running programme is a programme that allows people to return to their previous running activity through a series of phases. The participants were only able to move on to the next phase of the programme once the current/prior phase was completed.

For the above Table 5.4, all studies that included a graded running programme were placed together, as this was the commonality within the treatment programme that was received by the participants in these studies. Given that each of these studies provided an overview of the possible pragmatic outcomes of a clinical training programme, they are very limited in providing evidence in support of any one possible intervention for the treatment of MTSS TII. In addition to the graded running programme, each study also utilised another intervention in conjunction with a graded running programme.

With the variance in the internal validity, generally poor external validity and the structure of the studies being such that there was generally a graded running programme versus a graded running programme and another intervention, this did not provided a solid basis allowing the evaluation of the programmes utilised. This may also have been responsible for the variance in the clinical outcomes from no difference between the groups versus graded running programme with ESWT being better than its counterpart tothe case study where good clinical outcomes were reported.

Thus, based on the conflicting levels of rigour, based on the internal and external validity of the studies and the varying (conflicting) outcomes, the evidence in support of a graded running programme combined with or without another intervention is very limited.

Therefore, the application of a graded running programme in clinical practice needs to be addressed with caution whether it is applied in isolation or in conjunction with another intervention. Patients need to be cautioned and expectations of clinical success should not be encouraged. Therefore, it is incumbent on researchers to provide evidence in more rigorously structured studies in order to comment on two aspects of these types of interventions:

1. Is a graded running programme better than placebo?
2. Is a graded running programme enhanced by the addition of other interventions?

These answers would allow for more effective clinical application of these interventions in clinical practice

5.4.4 Rehabilitation with Other Interventions

Table 5.5: Rehabilitation with other interventions

AUTHOR(S)/YEAR	STUDY TYPE	RANKING OF INDIVIDUAL STUDY	CLINICAL OUTCOMES OBTAINED	LEVEL OF EVIDENCE OF INTERVENTION					
				Strong	Moderate	Limited	Consensus	Conflicting	No evidence
Meulenkamp *et al.* (2016)	NRCT	Poor	Internal validity good, external validity is poor, an attempt at efficacy testing (control an incomplete sham intervention), thus evidence for **Rehabilitation programme.**Outcome was the same for both groups. Trend towards improvement.						
Austin (1996)	CS	Good	Internal validity good, external validity is poor, no efficacy testing (no control) or relative effectiveness, thus evidence for rehabilitation is inconclusive. It was suggested that there was a good clinical outcome.						
Knight (2010)	CS	Moderate to poor	Internal validity was average, external validity was poor, no efficacy testing (no control) or relative effectiveness, thus evidence for rehabilitation is inconclusive. It was suggested that there was a good clinical outcome.			X	X		
Moen *et al.* (2010)	RCT	Good	Internal validity good, external validity was poor, no efficacy testing, only relative effectiveness, thus evidence for rehabilitation is inconclusive.Outcome was the same for both groups.						
Sathe (2017)	CS	Moderate	Internal validity moderate, external validity was poor, no efficacy testing or relative effectiveness, thus evidence for rehabilitation is inconclusive.It was suggested that there was a good clinical outcome.						
De La Fuente *et al.* (2019)	CS	Moderate	There were **no clinical outcomes** correlated to improved weight distribution measures of the foot with a rehabilitation.						X

In this context, rehabilitation within each of the above studies included a programme that focused on promoting recovery, maximising functional capacity, fitness and performance.

In the above Table 5.5, the level of evidence for the use of a rehabilitation programme was established from five studies that provided clinical evidence in terms of the outcomes measured in the studies. One article provided only biomechanical/pressure change distribution outcomes and therefore could not be included in providing clinical outcomes as there is no correlation between biomechanical measures and the clinical picture of MTSS

TII (Hyde and Gengenbach 2007; Winkelmann *et al.* 2016; Yamaski 2019; Martinez *et al.* 2020).

From the five studies that provided clinical outcomes, three were case studies, one was a RCT and one a NRCT. Given the hierarchical relationship between these study types, the three case studies provide very limited evidence in support of the use of rehabilitation in the treatment of MTSS TII, even though they showed good clinical outcomes for the patients involved in these case studies. By contrast the NRCT and RCT have the ability to provide for moderate levels of evidence (Dagenais and Haldeman 2011; Foley *et al.* 2003). However, the Moen *et al* (2010) study found no difference between their two groups (rehabilitation with a brace and without). Thus, this is a good RCT but there is some external validity issues. Therefore, this study does not provide evidence in favour of or against these interventions as there is no control group. Furthermore, there is no proxy markers for bracing or rehabilitation as being better than placebo in MTSS TII. Hence it is impossible to determine whether the clinical outcomes are actually better than placebo in this study.This assertion is also true of the Meulenkamp *et al.* (2016) study and thus neither publication allows for determination of the level of evidence that their studies contribute to this systematic review.

The use of rehabilitation, with or without an additional intervention in the management and treatment of MTSS TII can at best be given a level of limited evidence with consensus that there seems to be clinical improvement (accepted cautiously in that it is not possible to determine whether this is indeed more than just placebo). Therefore, future studies need to be conducted to test the efficacy of rehabilitation programmes.

Therefore, the application of a rehabilitation programme for purposes of treating MTSS TII in clinical practice needs to be addressed with caution whether it is applied in isolation or in conjunction with another intervention. Patients need to be cautioned and expectations of clinical success should not be encouraged. Therefore, it is incumbent on researchers to provide evidence in more rigorously structured studies in order to comment on three aspects of these types of interventions:

1. Is a rehabilitation programme better than placebo?
2. Is a rehabilitation programme enhanced by the addition of other interventions?
3. Given the lack of clarity and sometimes the omission of the composition of the rehabilitation programmes, it is also essential that future research detail the programmes such that they can also be tested against each other in order to determine which would be more effective for which subgroups of MTSS TII patients. This could aid in the development of clinical prediction rules as subgroup responses

to treatment could be linked to specific clinical presentations. This last suggestion is founded on the basis that it would seem from both the graded running programme outcomes (Table 5.4) and the rehabilitation programme outcomes (Table 5.5) that there is a tendency for these programmes to yield better clinical outcomes in case studies or smaller trials where the patients have a greater tendency to have their individual intrinsic or extrinsic factors predisposing them to MTSS TII addressed in their treatment programmes. Given that these lower level studies tend to be more pragmatic, perhaps the lack of outcomes (or similarity of outcomes between groups) in the higher level studies are negated in larger groups where those who do not benefit negate the outcomes of those who do benefit from the applied clinical programme interventions. Alternatively, the higher level studies need to more rigorously apply inclusion/exclusion criteria that include intrinsic and/or extrinsic predisposing factors to more appropriately test the interventions in MTSS TII specific subgroups of patients.

These answers would allow for more effective clinical application of these interventions in clinical practice.

5.4.5 Strengthening Exercises with Other Interventions

Table 5.6: Strengthening exercises with other interventions

AUTHOR(S) /YEAR	STUDY TYPE	RANKING OF INDIVIDUAL STUDY	CLINICAL OUTCOMES OBTAINED	LEVEL OF EVIDENCE OF INTERVENTION					
				Strong	Moderate	Limited	Consensus	Conflicting	No evidence
Gomez Garcia *et al.* (2017)	RCT	Good	Internal validity good, external validity was poor, no efficacy testing as well as relative effectiveness was included and thus evidence for strengthening is inconclusive. Both groups showed a good clinical outcome.						
Jovicić *et al.* (2014)	CS	Moderate	Internal validity moderate, external validity was poor, no efficacy testing only relative effectiveness, thus evidence for strengthening is inconclusive.It was suggested that there was a good clinical outcome.						
Rompe *et al.* (2010)	NRCT	Good	Internal validity good, external validity was poor, no efficacy testing and relative effectiveness was included and thus evidence for strengthening is inconclusive. ESWT and strengthening exercises had a better outcome than strengthening exercises alone. Both showed a trend towards improvement.						
Saxena *et al.* (2017)	CS	Moderate	Internal validity moderate, external validity was very poor, no efficacy testing only relativeeffectiveness, thus evidence for strengthening is inconclusive.It was suggested that there was a good clinical outcome when combined with radial soundwave therapy.		X			X	
Tutte and Galin (2016)	CS	Moderate	Internal validity moderate, external validity was very poor, no efficacy testing only relativeeffectiveness, thus evidence for strengthening is inconclusive. There was a good clinical outcome when combined with rESWT.						
Van Lingen (1998)	NRCT	Moderate	Internal validity moderate, external validity was very poor, efficacy testing and relative effectiveness, thus evidence for strengthening is inconclusive. Clinical outcome was the same for both groups.						

In this group of studies, there are three case studies, two NRCTs and one RCT from which to draw a conclusion about the level of evidence available. Given that the case studies provide little more than pragmatic evidence, their collective contribution to the level of evidence from a strengthening programme vantage point in clinical practice is limited.

In terms of the methodological rigour, the first NRCT (Van Lingen 1998) was good but the external validity did cause concern about the outcomes, providing limited evidence regarding the use of strengthening exercises in MTSS TII. This is not unlike the NRCT by Rompe *et al.* (2010), where there were similar concerns. However the clinical outcomes

showed improvement in favour of the strength programme with ESWT. Therefore, when the two NRCTs are considered together it would seem that muscle strengthening plays a limited role in the clinical resolution of MTSS TII, but the assumption could only be conclusively made if there was evidence to show that the strengthening programme was indeed itself better than placebo in the context of MTSS TII treatment. Unfortunately, the only RCT available (Gomez Garcia *et al.* 2017) was not an efficacy study but rather one that evaluated interventions that were in many ways similar to Rompe *et al.* (2010). Thus in terms of the collective evidence available for the use of a strengthening programme in clinical practice for patients with MTSS TII, it is at best limited and somewhat conflicting as the results are not consistent and seem to favour treatment groups that include additional modalities.

Therefore, the application of a strength training programme for purposes of treating MTSS TII in clinical practice needs to be addressed with caution. It seems that the isolated application of the programme may have very limited value and that when combined with another intervention seems to yield better results (this may however be directly attributable to the additional intervention).

Given this outcome, patients need to be cautioned and expectations of clinical success should not be encouraged in clinical practice. Researchers therefore need to provide evidence in more rigorously structured studies in order to comment on three aspects of these types of interventions:

1. Is a strength training programme better than placebo?
2. Is a strength training programme enhanced by the addition of other interventions?
3. Given the inconsistent application of a strength training programme across the studies, it becomes impossible to draw a conclusive idea as to what type of programme will benefit patients with a particular MTSS TII presentation. This speaks to the same discussion around the graded running programme outcomes (Table 5.4) and the rehabilitation programme outcomes (Table 5.5) where these programmes are more likely to yield better clinical outcomes in case studies or smaller trials where the patients have a greater tendency to have their individual intrinsic or extrinsic factors predisposing them to MTSS TII addressed in their treatment programmes. Thus, the effect of a strength training programme should be better contextualised in improved studies that outline the homogeneity of patients in terms of the intrinsic and extrinsic risk factors for MTSS TII.

These answers would allow for more effective clinical application of these interventions in clinical practice.

5.4.6 Nonstandard Treatment Programmes

Table 5.7: Nonstandard treatment programmes

AUTHOR(S)/YEAR:	STUDY TYPE:	RANKING OF INDIVIDUAL STUDY:	CLINICAL OUTCOMES OBTAINED	LEVEL OF EVIDENCE OF INTERVENTION					
				Strong	Moderate	Limited	Consensus	Conflicting	No evidence
Loudon and Dolphino (2010)	NRCT	Poor	Internal validity poor, external validity was poor, no efficacy testing only relative effectiveness, thus evidence for **orthotic and stretching**is inconclusive.Trend to improved clinical outcomes was noted in the results.			X	Only one study		
Robertson (2003)	RCT	Good	Internal validity good, external validity was poor, efficacy testing and relative effectiveness was included, thus evidence for **ultrasound and periosteal pecking** is inconclusive. Groups showed similar improvement.		X		Only one study		
Andrish *et al.* (1974)	RCT	Moderate to poor	Internal validity moderate to poor, external validity was poor, efficacy testing and relative effectiveness was included, thus evidence for**rest/immobilisation cast** is inconclusive. No difference was noted between the groups clinically.			X	Only one study		
Andrish *et al.* (1974)	RCT	Moderate to poor	Internal validity moderate to poor, external validity was poor, efficacy testing and relative effectiveness was included, thus evidence for **rest/phenylbutazone** is inconclusive. No difference was noted between the groups clinically.			X	Only one study		
Andrish *et al.* (1974)	RCT	Moderate to poor	Internal validity moderate to poor, external validity was poor, efficacy testing and relative effectiveness was included, thus evidence for **rest/stretching of heel cord** is inconclusive.No difference was noted between the groups clinically.			X	Only one study		
Andrish *et al.* (1974)	RCT	Moderate to poor	Internal validity moderate to poor, external validity was poor, efficacy testing and relative effectiveness was included, thus evidence for **rest/aspirin** is inconclusive.No difference was noted between the groups clinically.			X	Only one study		

When looking at the non-standard treatments or those that did not fit any of the preceding analysis categorie, the study by Andrish *et al.* (1974) showed that the interventions utilised had limited evidence to support their use in clinical practice. This was based on the fact that the internal validity was moderate to poor and the external validity was poor. However, even in this context, the trend is positive based on the actual clinical outcomes attained in the study. It is therefore possible that all of the interventions tested are comparable to each other and therefore equal to placebo (therefore not to be utilised in clinical practice as there is no therapeutic benefit) or better than placebo (therefore not to be utilised in clinical practice as there is no therapeutic benefit). It is currently impossible to determine which of these options are applicable in this analysis, because none of the interventions are noted

gold standard interventions for MTSS TII or have been shown to be better than placebo. Thus, to err on the side of caution, it is recommended that these interventions are utilised with caution in clinical practice and that patients are not provided with the expectation that these interventions will indeed result in clinical improvement.

In terms of evidence, it is seen that the study by Loudon and Dolphino (2010), provides little support for use in clinical practice as the NRCT was poorly executed and plagued by external validity concerns. In addition, due to the lack of efficacy testing of the intervention only relative effectiveness can be commented on. In this case the trend was towards clinical improvement but the same problem plagues the contextualisation of this improvement as that which plagued Andrish *et al.* (1974), which was the fact that there is no manner of determining whether the reported clinical improvement is actually the same as or better than a placebo response.

Therefore, future studies should focus on including a control group thereby measuring the efficacy of the interventions utilised in the Andrish *et al*. (1974) and Loudon and Dolphino (2010) studies.

By contrast the study by Robertson was a well performed RCT, and although it had external validity concerns, the use of ultrasound as a sham/placebo intervention as supported by Gam and Johannsen (1995), allowed for the extrapolation that periosteal pecking was not better than ultrasound and therefore no better than placebo. Thus its use in clinical practice is not supported. Further research is required to support this outcome or refute the claims that periosteal pecking should not be used in clinical practice.

5.5 CONCLUSION OF CHAPTER FIVE

Table 5.8: Summary of evidence for interventions/intervention combinations in terms of clinical outcomes

Interventions that provided clinical outcomes and contribute to the development of clinical practice recommendations	Level of Evidence of Intervention					
	Strong	Moderate	Limited	Consensus	Conflicting	No evidence
Cryotherapy massage			X	Only one study		
Iontophoresis			X	Only one study		
Phonophoresis.			X	Only one study		
Ultrasound			X	Only one study		
TENS		X		Only one study		
Needling		X		Only one study		
Electro-Needling		X		Only one study		
Extracorporeal Shock Wave Therapy			X	Only one study		
Fascial Distortion Model			X	Only one study		X
MYK system			X		X	X
Graded Running Programme with other interventions			X		X	
Rehabilitation with other interventions			X	X		X
Strengthening exercises with other interventions		X			X	
Nonstandard treatment programmes		X	X			

Given the review of the treatment options available and the evidence provided by the presence of single or multiple articles, Table 5.8 indicates that only the use of TENS, needling, electro-dry needling and strengthening programmes with additional interventions provided moderate evidence for positive clinical outcomes and therefore for use of these modalities in clinical practice.

The non-standard treatment options (Andrish *et al.* 1974, Loudon and Dolphino 2010 and Robertson 2003), provided limited to moderate evidence against the use of the published interventions (orthotic and stretching, ultrasound and periosteal pecking, rest/immobilisation cast, rest/phenylbutazone, rest/stretching of heel cord, rest/aspirin) in these studies, indicating that these practices should be excluded from clinical practice protocols until

further research has been completed, addressing the short comings of these studies and providing further evidence in support of or against the use of these interventions in clinical practice.

With regard to the remaining combination intervention options, there was limited information available for each with positive support for rehabilitation programmes and conflicting support for graded training programmes. This would thus show relatively better support for rehabilitation programmes as opposed to graded training programmes. Therefore, this should be a consideration in clinical practice, although applied in the context that with the limited evidence available, may not achieve complete resolution of MTSS TII that presents in clinical practice.

For the individual therapies, the options of cryotherapy, iontophoresis, phonophoresis, ultrasound, extracorporeal shockwave therapy and the fascial distortion model, the evidence suggests that they all provided limited evidence (internal validity, external validity, comparable clinical outcomes) which is limited by a lack of efficacy testing of the interventions and the inability of allowing contextualisation of the findings of the various studies (De La Fuente *et al.* 2019, De Vries 1961, Naderi *et al.* 2019, Griebert *et al.* 2016). Similar problems plague the MYK system studies (Martinez *et al.* 2020, Thistle 2018). However, there were two studies in this domain which had conflicting results which compromised the ability to draw effective conclusions with regards to this intervention.

CHAPTER SIX CONCLUSION AND RECOMMENDATIONS

6.1 INTRODUCTION

This chapter concludes this dissertation and presents recommendations for future studies.

6.2 CONCLUSION

The aim of this study was to determine the current evidence for the conservative treatment of MTSS. Through conducting a systematic search, 30 articles were chosen based on the inclusion and exclusion criteria. Appointed reviewers then assisted in reviewing these articles using appropriate measurement tools. In Chapter Four, the studies were ranked based on internal validity (reviewer assessment) and external validity evaluation of the studies. Both validities were assessed in the context of their impact on the clinical outcomes.

Based on the outcomes of the above evaluation, it was determined whether the studies provided evidence in support or not in support of the intervention for use in clinical practice. This was presented in Chapter Five and contextualised utilising the criteria outlined by Foley *et al.* (2003) and Dagenais and Haldeman (2011).

Thus in the context of the above, this systematic review concluded that the use of TENS, needling, electro-dry needling and strengthening programmes with additional interventions are moderately supported for use in the treatment of MTSS TII in clinical practice. There was evidence in support of rehabilitation programmes and conflicting evidence/no support for graded training programmes. The non-standard treatment options in the studies provided limited to moderate evidence against the use of the published interventions (orthotic and stretching, ultrasound and periosteal pecking, rest/immobilisation cast, rest/phenylbutazone, rest/stretching of heel cord, rest/aspirin), indicating that these practices should be excluded from clinical practice protocols until further research has been completed. Evidence for individual therapies (cryotherapy, iontophoresis, phonophoresis, ultrasound, extracorporeal shockwave therapy and the fascial distortion model), was limited whereas there was no to limited evidence in support of the MYK system of intervention (Martinez *et al.* 2020, Thistle 2018).

6.3 RECOMMENDATIONS

6.3.1 Recommendations to Improve This Systematic Review

In future research, it would be beneficial to familiarise the reviewers with the appropriate measurement tools. It could be considered to run a mock review before the start of the article review process to ensure that the reviewers understand the scales and therefore decrease reviewer variance. This would decrease the possibility for bias in the review process.

Some of the reviewers mentioned that it was difficult to understand and interpret the individual scales, particularly the Liddle scale (Liddle *et al.* 1996). Special effort was taken to supply the reviewers with adequate explanations and information of the scales (see Appendix J). Due to the fact that the Liddle scale had six options that needed to be selected for each criterion, the reviewers reported some difficulty interpreting the scale. These scales need to be improved to facilitate the evaluation process of ranking the structure of case studies/ series, non-randomised clinical trials and observational studies.

The budget funds could be increased to permit the inclusion of non-English articles. This would lead to an increase in the number of articles that would be included. This will limit the risk of language bias in future systematic reviews. However, the drawback of translation, if these articles are counted in, may result in translation bias. Therefore, the process of translation and the possible inclusion of bias needs to be considered (Scollen and Scollen 1995) and the values of language versus translation bias need to be addressed in terms of the outcomes of a future systematic review.

6.3.2 Recommendations for Future Studies

Future studies are recommended to utilise the prescribed outlines (e.g. the CONSORT) for the development of study protocols in order to ensure that the requirements of methodological rigour are improved within the context of the various study types. These considerations include, but may not be limited to, the number of participants per specific study, sample homogeneity, sample recruitment, allocation and randomisation as well as matching protocol outcome measures to the mechanism or proposed mechanism of the intervention(s).

Studies should assess and consider patient inclusion based on their intrinsic biomechanical factors linked to MTSS TII to increase the homogeneity between the groups' participants. In instances where this information is not available in terms of the causality relationship between the intrinsic biomechanical factor and the MTSS TII pathogenesis, this area requires further study prior to the information informing clinical trials.

Efficacy studies should be conducted on singular interventions with a true or proven control. If this is not possible then studies should assess relative effectiveness whilst including one intervention that can act as a gold standard (or has been efficacy tested and shown to be better than placebo) in order for the reader to draw effective clinical conclusions from the study.

All future studies should provide more information regarding the specific treatment programmes if the study is testing programmes for the treatment of MTSS TII. This includes specification (including but not limited to) rest periods, type of activities ceased or included in the study, progression points and decision in training programmes and any other co-interventions (e.g. the ability to access pain medication).

A wealth of case studies and case series were found but only a limited number of randomised control numbers. In order to increase the evidence regarding the relative effectiveness of interventions and their efficacy in the conservative treatment of MTSS TII, these studies should be used as a basis for future randomised control trials.

To improve studies with regards to skewing on the basis of patient bias, future studies should incorporate subjective as well as objective reporting mechanisms of the clinical outcomes. Additionally, researchers should receive recommendation to use the most suitable and validated measurement tool to measure patient progression dependably. This latter statement however may for the foreseeable future be limited until such time as the pathogenesis of the condition is better understood and the reporting mechanisms can be linked to specific pathogenic processes and thus measure improvement as well as allow for appropriate assessment of baseline similarity of the participants in terms of the MTSS TII presentation.

A future systematic review should focus on identifying the diagnostic methods used in diagnosing MTSS and the reliability, sensitivity, specificity and validity of these diagnostic tools as this would lead to the development of appropriate outcome measures noted in the previous paragraph.

6.3.3 Recommendations for Practitioners

There is currently no intervention that has strong evidence.

There is moderate evidence for the use of:

- TENS.
- Needling.
- Electro-needling.

- Strengthening exercises with other interventions.

No therapy in isolation has been tested to show individual efficacy in terms of the treatment of MTSS TII, with the limitations in all other interventions either being characterised by conflicting outcomes where more than one study was available. In those studies where there was only a single intervention or groups that were treated with a single intervention, the information provided limited information as the outcomes could not be contextually evaluated due to the lack of efficacy testing of interventions in MTSS TII.

It is therefore important that patients presenting to practitioners with MTSS TII are appraised of the fact that there is limited evidence for many common interventions that are utilised in clinical practice and that even these may not work in individual case studies. These interventions are highly dependent on the unique mix of intrinsic or extrinsic factors that predisposed the patient to the MTSS TII to start with. Therefore, expectations of clinical outcomes need to be tempered with caution and re-evaluation of the patient at periodic intervals is necessary in order to ensure that there is progression. This assertion is based on the fact that the case studies overall showed better outcomes where the possibility exists that patient-specific interventions are more likely to be effective when the pathogenesis of the condition, assessment of the condition and therefore the measurement of clinical outcomes in these studies is improved.

REFERENCES

Aboyans, V., Criqui, M. H., Abraham, P., Allison, M. A., Creager, M. A., Diehm, C., Fowkes, F. G. R., Hiatt, W. R., Jönsson, B. and Lacroix, P. 2012. Measurement and interpretation of the ankle-brachial index: a scientific statement from the American Heart Association. *Circulation*, 126(24): 2890-2909.

Alfayez, S. M., Ahmed, M. L. and Alomar, A. Z. 2017. A review article of medial tibial stress syndrome. *Journal of Musculoskeletal Surgery and Research*, 1(1): 2.

American Academy of Orthopaedic Surgeons. 1995-2018. *Shin splints*. Available: https://orthoinfo.aaos.org/en/diseases--conditions/shin-splints (Accessed 17 August 2018).

Andrews, J. C., Schünemann, H. J., and Oxman, A. D. 2013. GRADE guidelines: 15. Going from evidence to recommendation—determinants of a recommendation's direction and strength. *J Clin Epidemiol*., 66: 726–35.

Andrish, J. T., Bergfeld, J. A. and Walheim, J. 1974. A prospective study on the management of shin splints. Journal of Bone and Joint Surgery - Series A, 56 (8): 1697-1700.

Ardern, C. L., Dupont, G., and Impellizzeri. F, M. 2017. Unravelling confusion in sports medicine and sports science practice: a systematic approach to using the best of research and practice-based evidence to make a quality decision. *Br J Sports Med*, 53(1):50-56.

Arslan, E., Alemdaroglu, U., Koklu, Y., Hazir, T., Muniroglu, S. and Karakoc, B. 2017. Effects of passive and active rest on physiological responses and time motion characteristics in different small sided soccer games. *Journal of human kinetics*, 60(1): 123-132.

Artazcoz, L. A., Borrell, C., Benach, J., Cortès, I. and Rohlfs, I. 2004. Women, family demands and health: the importance of employment status and socio-economic position. *Social science & medicine*, 59(2): 263-274.

Aune, A. A., Bishop, C., Turner, A. N., Papadopoulos, K., Budd, S., Richardson, M. and Maloney, S. J. 2019. Acute and chronic effects of foam rolling vs eccentric exercise on ROM and force output of the plantar flexors. *Journal of sports sciences*, 37(2): 138-145.

Austin, W. M. 1996. Shin splints with underlying posterior tibial tendinitis: A case report. Journal of Sports Chiropractic and Rehabilitation, 10 (4): 163-168.

Babarinde, O., Ismail, H. and Schellack, N. 2017. An overview of the management of muscle pain and injuries. *South African Family Practice*, 59(5): 11-19.

Babbie, E. R. and Mouton J. 2001. *The Practice of Social Research*. South African Edition. Cape Town. Oxford University Press Southern Africa.

Bates, P. 1985. Shin splints - a literature review. *British journal of sports medicine*, 19(3): 132-137.

Beck, B. R. 2016. *Exercise-Induced Leg Pain*. Available: https://www.acsm.org/docs/default-source/files-for-resource.library/basics_exercise-induced-leg-pain.pdf?sfvrsn=8c62186b_2(Accessed 5 February 2020).

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

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

Begg, C., Cho, M., Eastwood, S., Horton, R., Moher, D., Olkin, I., Pitkin, R., Rennie, D., Schulz, K. F. and Simel, D. 1996. Improving the quality of reporting of randomized controlled trials: the CONSORT statement. *Jama*, 276(8): 637-639.

Birbili, M. 2000. Translating from one language to another. Social research update, 31 (1): 1-7.

Boland, A., Cherry, G. and Dickson, R. 2013. *Doing a Systematic Review*. London: Sage. Available: https://www.sagepub.com/sites/default/files/upm-binaries/58630_Boland__Doing_a_Systematic_Review.pdf, pp.1-17.

Bonanno, D. R., Munteanu, S. E., Murley, G. S., Landorf, K. B. and Menz, H. B. 2018. Risk factors for lower limb injuries during initial naval training: A prospective study. Journal of the Royal Army Medical Corps, 164 (5): 347-351.

Bonanno, D. R., Murley, G. S., Munteanu, S. E., Landorf, K. B. and Menz, H. B. 2015. Foot orthoses for the prevention of lower limb overuse injuries in naval recruits: Study protocol for a randomised controlled trial. Journal of Foot and Ankle Research, 8 (1)

Borenstein, M., Hedges, L. V., Higgins, J. P. and Rothstein, H. R. 2011. *Introduction to meta-analysis*. Hoboken, NJ: John Wiley & Sons.

Boutron, I., Estellat, C., Guittet, L., Dechartres, A., Sackett, D. L., Hróbjartsson, A. and Ravaud, P. 2006. Methods of blinding in reports of randomized controlled trials assessing pharmacologic treatments: a systematic review. *PLoS Med*, 3(10): e425.

Boutron, I., Page, M. J., Higgins, J. P., Altman, D. G., Lundh, A., Hróbjartsson, A. and Group, C. B. M. 2019. Considering bias and conflicts of interest among the included studies. In: Higgins, J. and Green, S. (eds).*Cochrane Handbook for Systematic Reviews of Interventions.*Hoboken, NJ: John Wiley & Sons,177-204.

Bovenschen, H. J., Booij, M. T. and Van Der Vleuten, C. J. 2013. Graduated compression stockings for runners: friend, foe, or fake? *Journal of Athletic Training*, 48(2): 226-232.

Brantingham, J.W., Bonnefin, D., Perle, S.M., Cassa, T.K., Globe, G., Pribicevic, M., Hicks, M. and Korporaal, C., 2012. Manipulative therapy for lower extremity conditions: update of a literature review. Journal of manipulative and physiological therapeutics, 35(2), pp.127-166.

Brody, K. 2015. Analysis of Patient Outcomes Using the MyoKinesthetic™ System in a Treatment-Based Classification System for Low Back Pain: A Dissertation of Clinical Practice Improvement. PhD thesis, University of Idaho.

Brozek, J. L., Akl, E. A., Alonso-Coello, P., Lang, D., Jaeschke, R., Williams, J. W., Phillips, B., Lelgemann, M., Lethaby, A., Bousquet, J., Guyatt, G. H., Schünemann, H. J. and Group, G. W. 2009. Grading quality of evidence and strength of recommendations in clinical practice guidelines. Part 1 of 3. An overview of the GRADE approach and grading quality of evidence about interventions. *Allergy*, 64(5): 669-677.

Büttner, F., Winters, M., Delahunt, E., Elbers, R., Lura, C. B., Khan, K. M., Weir, A. and Ardern, C. L. 2020. Identifying the 'incredible'! Part 2: Spot the difference-a rigorous risk of bias assessment can alter the main findings of a systematic review. *British journal of sports medicine*, 54(13): 801-808.

Campbell, M. K., Elbourne, D. R. and Altman, D. G. 2004. CONSORT statement: extension to cluster randomised trials. *Bmj*, 328(7441): 702-708.

Cano, V. 2002. *The Importance of Literature Reviews*. Available: http://www.hospiweb.scotcit.ac.uk/lectures/lit_rev.html (Accessed 11 March 2020).

Carr, K. and Sevetson, E. 2008. How can you help athletes prevent and treat shin splints? *J Fam Pract*, 57(6):406-8

Cashin, A. G. and McAuley, J. H. 2020. Clinimetrics: Physiotherapy Evidence Database (PEDro) Scale. *Journal of Physiotherapy*, 66(1): 59.

Chan, A. W., Krieza-Jeric, K., Schmid, I. and Altman, D. G. 2004. Outcome reporting bias in randomized trials funded by the Canadian institutes of Health Research. *Canadian Medical Association Journal*, 171: 735-740.

Choi, D., Cole, K. J., Goodpaster, B. H., Fink, W. J. and Costill, D. L. 1994. Effect of passive and active recovery on the resynthesis of muscle glycogen. *Medicine and science in sports and exercise*, 26(8): 992-996.

Clarke, M. 2007. The Cochrane collaboration and systematic reviews. *British Journal of Surgery*, 94(4): 391-2.

Cooper, N. J., Jones, D. R., Sutton, A. J. 2005. The use of systematic reviews when designing studies. *Clin Trials*, 2: 260–4.

Couture, C. J. and Karlson, K. A. 2002. Tibial stress injuries: decisive diagnosis and treatment of 'shin splints'. *The Physician and Sports Medicine*, 30(6): 29-36.

Craig, D. I. 2008. Medial Tibial Stress Syndrome: Evidence-Based Prevention. *Journal of Athletic Training*, 43(3): 316–318.

Dagenais, S. and Haldeman, S. 2011. *Evidence-Based Management of Low Back Pain-E-Book*. New York: Elsevier Health Sciences.

Dalley, A. F., Agur, A. M. and Moore, K. 1999. *Clinically oriented anatomy*. New York: Lippincott Williams & Wilkins.

Damsted, C., Glad, S., Nielsen, R. O., Sørensen, H. and Malisoux, L. 2018. Is there evidence for an association between changes in training load and running-related injuries? A systematic review. *International journal of sports physical therapy*, 13(6): 931.

Deeks, J. J., Dinnes, J., D'Amico, R., Sowden, A. J., Sakarovitvh, C., Song, F., Petticrew, M., Altman. 2003. DG: Evaluating non-randomised intervention studies. *Health technology Assessment*, 7(27):iii-73.

De la Fuente, C., Henriquez, H., Andrade, D. C. and Yañez, A. 2019. Running footwear with custom insoles for pressure distribution are appropriate to diminish impacts after shin splints. Asian Journal of Sports Medicine, 10 (3)

De Vries, H. A. 1961. Electromyographic observations of the effects of static stretching upon muscular distress. Research Quarterly of the American Association for Health, Physical Education and Recreation, 32 (4): 468-479.

Detmer DE. 1986. Chronic shin splints. Classification and management of medial tibial stress syndrome. *Sports Med*, 3(6):436-46.

Dhai, A. and McQuoid-Mason, D. J. 2010. *Bioethics, human rights and health law: Principles and practice*. Cape Town: Juta and Company Ltd.

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

Elattar, O., Smith, T., Ferguson, A., Farber, D. and Wapner, K. 2018. Uses of Braces and Orthotics for Conservative Management of Foot and Ankle Disorders. *Foot & Ankle Orthopaedics*, 3(3): 2473011418780700.

Ewert, A. and Sibthorp, J. 2009. Creating outcomes through experiential education: The challenge of confounding variables. *Journal of Experiential Education*, 31(3): 376-389.

Farivar, S., Malekshahabi, T. and Shiari, R. 2014. Biological effects of low level laser therapy. *Journal of lasers in medical sciences*, 5(2): 58.

Fick, D. S., Albright, J. P. and Murray, B. P. 1992. Relieving Painful 'Shin Splints'. Phys Sportsmed, 20 (12): 105-113.

Foley, N. C., Teasell, R. W., Bhogal, S. K. and Speechley, M. R. 2003. An evidence-based review of stroke rehabilitation. *Topics in stroke Rehabilitation*, 10(1): 29-58.

Fraser, D. F. 2008. A prospective clinical trial to determine the relative effectiveness of cross friction massage versus Graston instrument assisted soft tissue mobilisation in treating patellar tendinopathy. PhD thesis, Durban University of Technology.

Frost, H. M. 2001. From Wolff's law to the Utah paradigm: insights about bone physiology and its clinical applications. *The Anatomical Record: An Official Publication of the American Association of Anatomists*, 262(4): 398-419.

Garcia, J. M. 2017. Shockwave treatment for medial tibial stress syndrome in military cadets: A single-blind randomized controlled trial. Int J Surg, 46: 102-109.

Galbraith, R. and Lavallee, M. 2009. Medial tibial stress syndrome: conservative treatment options. *Current Reviews in Musculoskeletal Medicine*, 2(3): 127-133.

Gam, A. N. and Johannsen, F. 1995. Ultrasound therapy in musculoskeletal disorders: a meta-analysis. *Pain*, 63(1): 85-91.

George, J. W., Tunstall, A. C., Tepe, R. E. and Skaggs, C. D. 2006. The effects of active release technique on hamstring flexibility: a pilot study. *Journal of manipulative and physiological therapeutics*, 29(3): 224-227.

Gerow, G., Matthews, B., Jahn, W. and Gerow, R. 1993. Compartment syndrome and shin splints of the lower leg. *Journal of manipulative and physiological therapeutics*, 16(4): 245-252.

Giorgi, A. 2016. *Peripheral Vascular Disease. Healthline*. Available: https://www.healthline.com/health/peripheral-vascular-disease (Accessed on 15 April 2020).

Gomez Garcia, S., Ramon Rona, S., Gomez Tinoco, M. C., Benet Rodriguez, M., Chaustre Ruiz, D. M., Cardenas Letrado, F. P., Lopez-Illescas Ruiz, A. and Alarcon

Gopalakrishnan, S. and Ganeshkumar, P. 2013. Systematic Reviews and Meta-analysis: Understanding the Best Evidence in Primary Healthcare. *Journal of family medicine and primary care*, 2(1): 9–14. Available: https://doi.org/10.4103/2249-4863.109934

Gordon, L. L. 2019. The Relationship Between Work-life Balance, Stress, and Injury in Construction Trade Workers. PhD thesis, Durban University of Technology.

Green, S. 2005. Systematic reviews and meta-analysis. *Singapore Medical Journal*, 46(6): 270-274.

Green, S. and Higgins, J. P. T. 2008. *Cochrane handbook for systematic reviews of interventions version 5.0.1.* Available:http://www.cochrane-handbook.org

Green, S. and Higgins, J. P. T. 2011. Glossary. *Cochrane Handbook for Systematic Reviews of Interventions 4.2.5.* [updated May 2005]. Available: https://training.cochrane.org/handbook/current

Griebert, M. C., Needle, A. R., McConnell, J. and Kaminski, T. W. 2016. Lower-leg Kinesio tape reduces rate of loading in participants with medial tibial stress syndrome. Physical Therapy in Sport, 18: 62-67.

Gyer, G., Michael, J., Inklebarger, J. and Tedla, J. S. 2019. Spinal manipulation therapy: Is it all about the brain? A current review of the neurophysiological effects of manipulation. *Journal of Integrative Medicine*, 17(5): 328-337.

Hall, J. E. 2010. *Guyton and Hall textbook of medical physiology e-Book*. New York: Elsevier Health Sciences.

Harris, K. J. 2013. The state of current knowledge regarding evidence-based conservative management of iliotibial band syndrome: A systematic review. M.Tech., Chiropractic, Durban University of Technology.

Haslett, C., Chilvers, E., Hunter, J. and Boon, N. 1999. *Davidson's Principles and Practice of Medicine*. 18th ed. London: Churchill Livingstone.

Hemingway P. and Brereton N, 2009. *What is a systematic review?* Available: http://www.whatisseries.co.uk/whatis/pdfs/What_is_syst_rev.pdf (Accessed 11 March 2020).

Herring, K. M. 2006. A plyometric training model used to augment rehabilitation from tibial fasciitis. *Current sports medicine reports*, 5(3): 147-154.

Hewlett, S., Wit, M., Richards, P. 2006. Patients and professionals as research partners: Challenges, practicalities, and benefits. *Arthritis Care Res*., 55: 676–80.

Holen, K., Engebretsen, L., Grøntvedt, T., Rossvoll, I., Hammer, S. and Stoltz, V. 1995. Surgical treatment of medial tibial stress syndrome (shin splint) by fasciotomy of the superficial posterior compartment of the leg. *Scandinavian journal of medicine & science in sports*, 5(1): 40-43.

Hou, W., Lin, C., Wei, Y., Hsieh, K., Lu, K., Chiu, S., and Ni, J. 2010. Applicability of the Newcastle-Ottawa Scale (NOS) for rating quality of cohort studies: using studies regarding the predictors of returning to work after traumatic limb injuries for example. In: Bero, L., Montgomery, P., Robinson, K., Pigott, T., and Krause, K. *Bringing Evidence-Based Decision-Making to New Heights. Abstracts of the 2010 Joint Colloquium of The Cochrane and Campbell Collaborations*, 18-22 October. Keystone, USA: John Wiley & Sons.

Huang, C.-Y., Hsieh, T.-H., Lu, S.-C. and Su, F.-C. 2011. Effect of the Kinesio tape to muscle activity and vertical jump performance in healthy inactive people. *Biomedical engineering online*, 10(1): 70.

Hubbard, T. J. and Denegar, C. R. 2004. Does cryotherapy improve outcomes with soft tissue injury? *Journal of athletic training*, 39(3): 278.

Hyde, T. E. and Gengenbach, M. S. 2007. *Conservative management of sports injuries*. Burlington, Massachusetts: Jones & Bartlett Learning.

Ioannidis, J. P. and Lau, J. 1999. Pooling research results: benefits and limitations of meta-analysis. *The Joint Commission journal on quality improvement*, 25(9): 462-469.

James, S., Ali,K., Pocock, C., Robertson, C., Walter, J. and Bell, J. 2007). Ultrasound guided dry needling and autologous blood injection for patellar tendinosis. *Br J Sports Med*., 41(8):5 18-522.

Johnston, E., Flynn, T., Bean, M., Breton, M., Scherer, M., Dreitzler, G. and Thomas, D. 2006. A Randomized Controlled Trial of a Leg Orthosis versus Traditional Treatment for Soldiers with Shin Splints - A Pilot Study. Military Medicine, 171 (1): 40-44.

Jovicić, M., Jovicić, V., Hrković, M. and Lazović, M. 2014. Medial tibial stress syndrome: case report. Medicinski pregled, 67 (7-8): 247-251.

Kaiser, U., Kopkow, C., Deckert, S., Neustadt, K., Jacobi, L., Cameron, P., De Angelis, V., Apfelbacher, C., Arnold, B. and Birch, J. 2018. Developing a core outcome domain set to assessing effectiveness of interdisciplinary multimodal pain therapy: the VAPAIN consensus statement on core outcome domains. *Pain*, 159(4): 673-683.

Kendall, J. M. 2003. Designing a research project: randomised controlled trials and their principles. *Emergency Medicine Journal*, 20: 164-168.

Kiel, J. and Kaiser, K. 2019. *Stress reaction and fractures*. Treasure Island, Fl: StatPearls Publishing.

Killeen, S., Sourallous, P., Hunter, I. A., Hartley, J. E. and Grady, H. L. 2014. Registration rates, adequacy of registration, and a comparison of registered and published primary outcomes in randomized controlled trials published in surgery journals. *Annals of surgery*, 259(1): 193-196.

Kitchen, S. and Bazin, S., 2007. *Electrotherapy*. 10th ed. Edinburgh: Churchill Livingstone.

Knapik, J. J., Graham, B., Cobbs, J., Thompson, D., Steelman, R. and Jones, B. H. 2013. A prospective investigation of injury incidence and injury risk factors among Army recruits in military police training. *BMC musculoskeletal disorders*, 14(1): 32.

Knight, R. R. 2010. Integration of manual therapy, rehabilitation and acupuncture in the treatment of a 17-year-old male professional football player with chronic medial tibial stress syndrome. Journal of the Acupuncture Association of Chartered Physiotherapists: 81-87.

Korkola, M. and Amendola, A. 2001. Exercise-induced leg pain. Sifting through a broad differential. *Phys Sports Med June*, 29; 13. Available: http://www.physsportsmed.com/cover.html (Accessed 29 August 2018).

Lam, G., Fontaine, R., Ross, F. L. and Chiu, E. S. 2017. Hyperbaric oxygen therapy: exploring the clinical evidence. *Advances in skin & wound care*, 30(4): 181-190.

Lang, S. and Kleijnen, J. 2010. Quality assessment tools for observational studies: lack of consensus. *International Journal of Evidence-Based Healthcare: December 2010*, 8(4): 247.

Larsen, K., Weidich, F. and Leboeuf-Yde, C. 2002. Can custom-made biomechanic shoe orthoses prevent problems in the back and lower extremities? A randomized, controlled intervention trial of 146 military conscripts. Journal of Manipulative and Physiological Therapeutics, 25 (5): 326-331.

Lefebvre, C., Manheimer, E. and Glanville, J. 2001. *Cochrane Handbook for Systematic Reviews of Interventions Version 5.1.0*. Available: https://consumers.cochrane.org/what-systematic-review(Accessed 17 August 2018).

Liberati, A., Altman, D. G., Mulrow, J. T., Gotzsche, P. C. and Icannidis, J. P. A. 2009. The PRISMA Statement for Reporting Systematic Reviews and Meta-Analyses of Studies That Evaluate Health Care Interventions: Explanation and Elaboration. *PLoS Med*, 6(7).

Liddle, J., Williamson, M. and Irwig, I. 1996. *Method for Evaluating Research and Guideline Evidence*.Sydney: NSW Health Department.

Lindsay, D., Dearness, J., Richardson, C., Chapman, A. and Cuskelly, G. 1990. A survey of electromodality usage in private physiotherapy practices. *Australian Journal of Physiotherapy*, 36(4): 249-256.

Liu, L., Huang, Q.-M., Liu, Q.-G., Ye, G., Bo, C.-Z., Chen, M.-J. and Li, P. 2015. Effectiveness of dry needling for myofascial trigger points associated with neck and shoulder pain: a systematic review and meta-analysis. *Archives of physical medicine and rehabilitation*, 96(5): 944-955.

Loopik, M. F., Winters, M. and Moen, M. H. 2016. Atrophy and depigmentation after pretibial corticosteroid injection for medial tibial stress syndrome: two case reports. *Journal of sport rehabilitation*, 25(4): 380-381.

Loudon, J. K. and Dolphino, M. R. 2010. Use of Foot Orthoses and Calf Stretching for Individuals With Medial Tibial Stress Syndrome. Foot & Ankle Specialist, 3 (1): 15-20.

Magee, D. J. 2014. *Orthopedic physical assessment E-Book*. New York: Elsevier Health Sciences.

Martinez, R. E., Lopez, E. B., Cox, R. W., Stankevitz, D., Larkins, L., Baker, R. T. and May, J. 2020. Exploring treatment of medial tibial stress syndrome via posture and the MyoKinesthetic system. Journal of Bodywork & Movement Therapies, 24 (1): 82-87.

Mathes, T. and Pieper, D. 2017. Clarifying the distinction between case series and cohort studies in systematic reviews of comparative studies: potential impact on body of evidence and workload. *BMC medical research methodology*, 17(1): 107-107.

Mayo Clinic. 2020. *Peripheral Artery Disease (PAD) - Diagnosis and Treatment.* Available: www.mayoclinic.org/diseases-conditions/peripheral-artery-disease/diagnosis-treatment/drc-20350563 (Accessed 14 May 2020).

Medical Dictionary for the Health Professions and Nursing. 2012. *Medial tibial stress syndrome*. Available: https://medicaldictionary.thefreedictionary.com/medial+tibial+stress+syndrome(Accessed 20 July 2018).

Melnyk, B. M. and Fineout-Overholt, E. 2011. *Evidence-based practice in nursing & healthcare: A guide to best practice*. Philadelphia, Penn: Lippincott Williams & Wilkins.

Melzack, R., Ofiesh, J. and Mount, B. 1976. The Brompton mixture: effects on pain in cancer patients. *Canadian Medical Association Journal*, 115(2): 125.

Meulekamp, M. Z., Sauter, W., Buitenhuis, M., Mert, A. and van Der Wurff, P. 2016. Short-term results of a rehabilitation program for service members with lower leg pain and the evaluation of patient characteristics. Military Medicine, 181 (9): 1081-1087.

Minick, K. I., Kiesel, K. B., Burton, L., Taylor, A., Plisky, P. and Butler, R. J. 2010. Interrater reliability of the functional movement screen. *The Journal of Strength & Conditioning Research*, 24(2): 479-486.

Miranda, P., Nascimento, J., Estanqueiro, P. and Salgado, M. 2019. Physical exercise and leg pain-What is the relationship? *Nascer e Crescer – Birth and Growth Medical Journal*, 28(4): 220-222.

Moen, M., Tol, J., Weir, A., Steunebrink, M. and De Winter, T. 2009. Medial Tibial Stress Syndrome. Sports Medicine, 39(7): 523-546.

Moen, M. H., Bongers, T., Bakker, E. W., Weir, A., Zimmermann, W. O., van der Werve, M. and Backx, F. J. 2010. The additional value of a pneumatic leg brace in the treatment of recruits with medial tibial stress syndrome; a randomized study. Journal of the Royal Army Medical Corps, 156 (4): 236-240.

Moen, M. H., Holtslag, L., Bakker, E., Barten, C., Weir, A., Tol, J. L. and Backx, F. 2012. The treatment of medial tibial stress syndrome in athletes; a randomized clinical trial. Sports Medicine, Arthroscopy, Rehabilitation, Therapy and Technology, 4 (1)

Moen, M. H. 2012. Aetiology, imaging and treatment of medial tibial stress syndrome. Master's dissertation, Utrecht University.

Moen, M.H., Rayer, S., Schipper, M. Schmikli, S., Weir, A., Tol, J. L. and Backx, F. J. G. 2012. Shockwave treatment for medial tibial stress syndrome in athletes; a prospective controlled study. *Br J Sports Med*, 46(4): 253–7.

Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G. and the PRISMA Group. 2009. Preferred reporting items for systematic reviews and meta analyses: the PRISMA statement. Available: http://www.plosmedicine.org/article/info%3Adoi%2F10.1371%2Fjournal.pmed.1000097 (Accessed 24 March 2020).

Moher, D. 2015. Optimal strategies to consider when peer reviewing a systematic review and meta-analysis. *BMC Medicine*, 13, 1-4.

Mori, S., Li, J. and Kawaguchi, Y. 2001. The histological appearance of stress fractures. In: Burr, D. B. and Milgrom, C. eds.*Musculoskeletal fatigue and stress fractures*. CRC Press Boca Raton, 151-159.

Mubarak, S.J., Gould, R.N., Lee, Y.F., Schmidt, D.A. and Hargens, A.R., 1982. The medial tibial stress syndrome: a cause of shin splints. The American journal of sports medicine, 10(4), pp.201-205.

Mulligan, B., Hall, T., Rivett, D. A., Vicenzino, B. and Hing, W. 2015. *The Mulligan Concept of Manual Therapy-eBook: Textbook of Techniques*. New York: Elsevier Health Sciences.

Mulrow, C. D. 1994. Rationale for systematic reviews. *British Medical Journal*, 309: 597.

Murray, H. 2000. Effects of kinesio taping on muscle strength after ACL-repair. *J Orthop Sports Phys Ther*, 30(1): 14.

Naderi, A., Degens, H. and Sakinepoor, A. 2019. Arch-support foot-orthoses normalize dynamic in-shoe foot pressure distribution in medial tibial stress syndrome. European Journal of Sport Science, 19 (2): 247-257.

National Centre for Complementary and Alternative Medicine, 2004. *The use of complementary and alternative medicine in the United States*. Available: http://nccam.nih.gov/news/camsurvey_fs1.html (Accessed 24 March 2020).

National Pharmaceutical Association. 2004. *Homoeopathy – is it on your shelf?* Available: www.npa.atalink.co.uk/articles/article-391.phtml (Accessed 22 March 2020).

Newman, P., Waddington, G. and Adams, R. 2017. Shockwave treatment for medial tibial stress syndrome: A randomized double blind sham-controlled pilot trial. Journal of Science and Medicine in Sport, 20 (3): 220-224.

Nissen, L., Astvad, K. and Madsen, L. 1994. Low-energy laser therapy in medial tibial stress syndrome. *Ugeskrift for laeger*, 156(49): 7329-7331.

Noakes, T. D. 2001. *Lore of running*. 4th ed. Oxford: Oxford University Press.

Nunan, D., Heneghan, C. and Spencer, E. A. 2018. Catalogue of bias: allocation bias. *BMJ Evidence-Based Medicine*, 23(1): 20-21.

Odgaard-Jensen, J., Vist, G. E., Timmer, A., Kunz, R., Akl, E.A., Schünemann, H., Briel, M., Nordmann, A. J., Pregno, S. and Oxman, A. D. 2011. Randomisation to protect against selection bias in healthcare trials. *Cochrane Database of Systematic Reviews*, 4(MR000012). Available: https://www.cochrane.org/MR000012/METHOD_randomised-controlled-trials-as-a-safeguard-against-biased-estimates-of-treatment-effects (Accessed 12 May 2020).

Onwuegbuzie, A. J. 2016. *7 steps to a comprehensive literature review: a multimodal & cultural approach*. London: SAGE Publications.

Olivo, S. A., Macedo, L. G., Gadotti, I. C., Fuentes, J., Stanton, T. and Magee, D. J. 2008. Scales to Assess the Quality of Randomized Controlled Trials: A Systematic Review. *Physical Therapy*, 88(2): 156-175.

Oloff, L. 1994. *Musculoskeletal Disorders of The Lower Extremities*. Philadelphia: Saunders.

Orbetein, P., Kenton, R., Basford, J. and Stuart, M. 2000. *Medial tibial stress syndrome: Medicine and Science in Sports & Exercise*. Available: https://journals.lww.com/acsm-msse/Fulltext/2000/03001/Medial_tibial_stress_syndrome.5.aspx (Accessed 22 January 2020).

Padhiar, N., Curtin, M., Aweid, O., Awied, B., Morrissey, D., Chan, O., Malliaras, P. and Crisp, T. 2011. *The effectiveness of prolotherapy for recalcitrant medial tibial stress syndrome: a prospective case series*. *British Journal of Sports Medicine*, 2011;45:A16.

Park, K. C., Sohn, Y. D., Ahn, H. C., Ahn, J. Y., Park, S. M., Cho, K. Y., Kwon, H. S., Cho, G. C. and Choi, J. T. 2010. Effectiveness, preference and ease of passive release techniques using a syringe for endotracheal tube cuff inflation. *Journal of the Korean Society of Emergency Medicine*, 21(6): 795-800.

Payne, L. 2007. The relative effectiveness of three treatment protocols in the treatment of medial tibial stress syndrome type II. DUT Summons.

Peterson, D. H. and Bergmann, T. F. 2002. *Chiropractic technique: principles and procedures*. Philadelphia: Mosby.

Pernas, E. F. E. D. N. 2019. Physical exercise and leg pain - what is the relationship? *Drugs*, 5: 10.

Physiotherapy Evidence Database. 1999. PEDro Scale. Available: https://www.pedro.org.au/english/downloads/pedro-scale/ (Accessed 20/07/2019).

Pietrzak, M. 2014. Diagnosis and management of acute medial tibial stress syndrome in a 15 year old female surf life-saving competitor. Int J Sports Phys Ther, 9 (4): 525-539.

Pourhoseingholi, M. A., Baghestani, A. R. and Vahedi, M. 2012. How to control confounding effects by statistical analysis. *Gastroenterology and hepatology from bed to bench*, 5(2): 79.

Prandoni, P., Lensing, A. W., Prins, M. H., Frulla, M., Marchiori, A., Bernardi, E., Tormene, D., Mosena, L., Pagnan, A. and Girolami, A. 2004. Below-knee elastic compression stockings to prevent the post-thrombotic syndrome: a randomized, controlled trial. *Annals of internal medicine*, 141(4): 249-256.

Pransky, G. S., Benjamin, K. L., Savageau, J. A., Currivan, D. and Fletcher, K. 2005. Outcomes in work-related injuries: A comparison of older and younger workers. *American Journal of Industrial Medicine*, 47(2): 104-112.

Puranen, J. 1974. The medial tibial syndrome. *J Bone Joint Surg*, 4: 712-715.

Quigley, J. M., Thompson, J. C., Halfpenny, N. J. 2018. Critical appraisal of nonrandomized studies: A review of recommended and commonly used tools.*Journal of Evaluation in Clinical Practice*, 25(1): 44-52.

Leach, R. A. 2004. *The chiropractic theories: a textbook of scientific research*. New York: Lippincott Williams & Wilkins.

Rai, S., Raman, V., Varma, R and Mohanty, C. 2017. Hyperbaric oxygen therapy: An effective conservative treatment in medial tibial stress syndrome. *International Journal of Orthopaedics*, 3(1): 534-536.

Rajaraman, S. and Shroff, R. 2018. *Effects of kineseotaping on shin splints in runners*.*International Journal of Physical Education, Sports and Health*, 5(2): 124-125.

Rathleff, M. S., Mølgaard, C. M., Fredberg, U., Kaalund, S., Andersen, K., Jensen, T., Aaskov, S. and Olesen, J. 2015. High-load strength training improves outcome in patients with plantar fasciitis: A randomized controlled trial with 12-month follow-up. Scandinavian journal of medicine & science in sports, 25(3): e292-e300.

Resnik, D. B. and Elmore, S. A. 2018. Conflict of interest in journal peer review. Los Angeles, CA: SAGE Publications.

Robertson, M. E. 2003. The relative effectiveness of periosteal pecking combined with therapeutic ultrasound compared to therapeutic ultrasound in the treatment of medial tibial stress syndrome type II. DUT Summons.

Rompe, J.D., Cacchio, A., Furia, J.P. and Maffulli, N. 2010. Low-energy extracorporeal shock wave therapy as a treatment for medial tibial stress syndrome. *Am J Sports Med*, 38(1):125–32.

Ross-Hellauer, A. and Derrick, G. 2019. Decolonising the social sciences and humanities through peer review. In: *Proceedings of the Third Research Evaluation in the SSH Conference* (RESSH 2019). Valencia, 19-20 September. Available: https://ressh2019.webs.upv.es/wp-content/uploads/2019/10/ressh_2019_paper_2.pdf

Sahrmann, S. 2001. *Diagnosis and treatment of movement impairment syndromes*. New York: Elsevier Health Sciences.

Sathe, A. 2017. Medial tibial stress syndrome: A case study. Saudi J Sports Med 17:50-2

Sanderson, S., Tatt, I. D. and Higgins, J. P. 2007. Tools for assessing quality and susceptibility to bias in observational studies in epidemiology: a systematic review and annotated bibliography. *International Journal of Epidemiology*, 36(3): 666-676.

Sanz-Cabanillas, J., Ruano, J., Gomez-Garcia, F., Alcade-Mellano, P., Gay-Mimbrera, J., Aguilar-Luque, M., Maestre-Lopez, B.,Gonzalez-Padilla, M., Carmona-Fernandez, P., Velez Garcia-Nieto, A. and Isla-Tejera, B., 2017. Author-paper affiliation network architecture influences the methodological quality of systematic reviews and meta-analyses of psoriasis. *PLOS ONE*, 12(4): e0175419. Available: http://doi.org/10.137/1/journal.pone.0175419 (Accessed 16 February 2020).

Saxena, A., Fullem, B. and Gerdesmeyer, L. 2017. Treatment of Medial Tibial Stress Syndrome with Radial Soundwave Therapy in Elite Athletes: Current Evidence, Report on Two Cases, and Proposed Treatment Regimen. *Journal of Foot and Ankle Surgery*, 56(5): 985-989.

Schroeder, A. N. and Best, T. M. 2015. Is self myofascial release an effective preexercise and recovery strategy? A literature review. *Current sports medicine reports*, 14(3): 200-208.

Schulz, K. F., Altman, D. G., Moher, D. and Group, C. 2010. CONSORT 2010 statement: updated guidelines for reporting parallel group randomised trials. *Trials*, 11(1): 32.

Schulze, C. Finze, S. Bader, R. 2014. Treatment of Medial Tibial Stress Syndrome according to the Fascial Distortion Model: A Prospective Case Control Study. *Scientific World Journal*, 2014.

Scollen, R. and Scollen, W. S. 1995. *Intercultural Communication: A Discourse Approach*. Massachusetts: Blackwell.

Sedgwick, P. 2014. What is a non-randomised controlled trial? *British Medical Journal*, 348: g4115.

Shadduck, J. H. 2009. *Thermotherapy device: Google Patents*. Available: https://patents.google.com/patent/US7549987B2/en

Sharma, U. and Sinha, A. G. K. 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.

Shusterman, R. 2011. Muscle memory and the somaesthetic pathologies of everyday life. *Human Movement*, 12(1): 4-15.

Sievers, M. 2019. *The Relationship of Lower Extremity Range of Motion and Incidence of Shin Splints in Collegiate Runners: A Pilot Study*.Available: https://digitalcommons.owu.edu/cgi/viewcontent.cgi?article=1198&context=student symposium

Smith, W., Winn, F. and Parette, R. 1986. Comparative study using four modalities in shinsplint treatments. Journal of Orthopaedic and Sports Physical Therapy, 8 (2): 77-80.

Smith, M. M. F., Coates, S. S. and Creaby, M. W. 2014. A comparison of rigid tape and exercise, elastic tape and exercise and exercise alone on pain and lower limb function in individuals with exercise related leg pain: A randomised controlled trial. BMC Musculoskeletal Disorders, 15 (1).

Smith, B. E., Hendrick, P., Smith, T. O., Bateman, M., Moffatt, F., Rathleff, M. S., Selfe, J. and Logan, P. 2017. Should exercises be painful in the management of chronic musculoskeletal pain? A systematic review and meta-analysis. *British Journal of Sports Medicine*, 51(23): 1679-1687.

Song, J. W. and Chung, K. C. 2010. Observational studies: cohort and case-control studies. *Plastic and reconstructive surgery*, 126(6): 2234-2242.

Souza, T. A. 2009. *Differential diagnosis and management for the chiropractor: protocols and algorithms*. Burlington, Massachusetts:Jones & Bartlett Publishers.

Stang, A. 2010. Critical evaluation of the Newcastle-Ottawa scale for the assessment of the quality of nonrandomized studies in meta-analyses. *European Journal of Epidemiology*, 25(9): 603-605.

Stickley, C. D., Hetzler, R. K., Kimura, I. F. and Lozanoff, S. 2009. Crural fascia and muscle origins related to medial tibial stress syndrome symptom location. *Medicine & Science in Sports & Exercise*, 41(11): 1991-1996.

Spine Health. 1999. *Conservative Treatment*. Available: https://www.spine-health.com/glossary/conservative-treatment (Accessed 29 August 2018).

Tak, S. and Tak, S. 2013. Lower extremity deep vein thrombosis after heavy exertion. *BMJ case reports*, 2013: bcr2013201488.

Talmage, G. L. 2007. An exploratory mixed-methods study to determine factors which may affect satisfaction levels of patients outside of a clinical setting. M.Tech, Durban University of Technology.

Thacker, S. B., Gilchrist, J., Stroup, D. F. and Kimsey, C. D. 2002. The prevention of shin splints in sports: a systematic review of literature. *Medicine & Science in Sports & Exercise*, 34(1): 32-40.

Thalhamer, C. 2018. A fundamental critique of the fascial distortion model and its application in clinical practice. *Journal of bodywork and movement therapies*, 22(1): 112-117.

Thistle, Sara. 2018. Treatment of Medial Tibial Stress Syndrome Using the MyoKinesthetic System: A Case Serie. Senior Honors Theses. 208.

Thornton, R. D., Nurse, N., Snavely, L., Hackett-Zahler, S., Frank, K. and DiTomasso, R. A. 2017. Influences on patient satisfaction in healthcare centers: a semi-quantitative study over 5 years. *BMC health services research*, 17(1): 361.

Tierney, J. F. and Steward, L. A. 2005. Investigating patient exclusion bias in meta-analysis. *International Journal of Epidemiology*, 34(1): 79–87. Available: https://doi.org/10.1093/ije/dyh300 (Accessed 16 April 2020).

Tortora, G. J. and Derrickson, B. H. 2018. *Principles of anatomy and physiology*. New York: John Wiley & Sons.

Travell, J., Simons, D. and Simons, L. 1999. Myofascial Pain and Dysfunction. In: *The Trigger Point Manual. 2nd ed.Lower Half of Body*. Philadelphia: Williams and Wilkins.

Tutté ML, G. G. 2016. Shin Splints: Efficacy of Radial Extracorporeal Shock Wave Therapy in Ballet Dancers. A Series Of Cases. IOSR Journal of Dental and Medical Sciences (IOSR-JDMS, 15 (9): 22-24

Typaldos, S. 1994. Introducing the fascial distortion model. *AAO Journal*, 4(2): 14-18.

Vaile, J. M., Gill, N. D. and Blazevich, A. J. 2007. The effect of contrast water therapy on symptoms of delayed onset muscle soreness. *The Journal of Strength & Conditioning Research*, 21(3): 697-702.

Van Lingen, L. H. 1998. The effectiveness of ultrasound therapy as an adjunct to the treatment of medial tibial stress syndrome type 2 (shin splints). DUT Summons.

Vernon, H. and Schneider, M. 2009. Chiropractic management of myofascial trigger points and myofascial pain syndrome: a systematic review of the literature. *J Manipulative Physiol Ther*, 32(1):14-24.

Vickers, A. J. 2005. Parametric versus non-parametric statistics in the analysis of randomized trials with non-normally distributed data. *BMC medical research methodology*, 5(1): 35.

Walden, M. 2019. *Tibial stress fractures*. Available: https://www.sportsinjuryclinic.net/sport-injuries/lower-leg/shin-pain/tibia-stress-fracture#symptoms (Accessed 15 April 2020).

Webster, Merriam.2018. *Definition of META-ANALYSIS*. Available: https://www.merriam-webster.com/dictionary/meta-analysis (Accessed 17 August 2018).

Weerasekara, I., Osmotherly, P. G., Snodgrass, S. J., Tessier, J. and Rivett, D. A. 2019. Effects of mobilisation with movement (MWM) on anatomical and clinical characteristics of chronic ankle instability: a randomised controlled trial protocol. *BMC musculoskeletal disorders*, 20(1): 75.

Wells, G.A., Shea, B., O'Connell, D., Peterson, J., Welch, V., Losos, M., and Tugwell, P. 2003. *The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomised studies in meta-analyses.* Available: http://www.medicine.mcgill.ca/rtamblyn/Readings%5CThe%20Newcastle%20%20Scale%20for%20assessing%20the%20quality%20of%20nonrandomised%20studies%20in%20meta-analyses.pdf (Accessed 11th March 2019).

Winkelmann, Z. K., Anderson, D., Games, K. E. and Eberman, L. E. 2016. Risk factors for medial tibial stress syndrome in active individuals: an evidence-based review. *Journal of athletic training*, 51(12): 1049-1052.

Wilder, R. 2014. *Shin Splints Treatment*. Available: https://www.sports-health.com/sports-injuries/leg-injuries/shin-splints-treatment (Accessed: 17 June 2020).

Wilder, R. P. and Sethi, S. 2004. Overuse injuries: tendinopathies, stress fractures, compartment syndrome, and shin splints. *Clinics in sports medicine*, 23(1): 55-81.

Winters, M., Eskes, M., Weir, A., Moen, M. H., Backx, F. J. G., Bakker, E. W. P. 2013. Treatment of medial tibial stress syndrome: a systematic review. Sports Med, 43: 1315–33.

Winters, M., Veldt, H., Bakker, E. and Moen, M. 2013. Intrinsic factors associated with medial tibial stress syndrome in athletes: A large case-control study. South African Journal of Sports Medicine, 25(3): 63-66.

Winters, M., Barten, C. C., Teeuwen, R., Bakker, E. W., Moen, M. H., Backx, F. J. and Weir, A. 2016. Medial Tibial Stress Syndrome: Reliably Diagnosed using History and Clinical Examination? In: Proceedings of Medicine and Science in Sports and Exercise. Philadelphia: Lippincott Williams & Wilkins.

Winters, M., Moen, M. H., Zimmermann, W. O., Lindeboom, R., Weir, A., Backx, F. J. and Bakker, E. W. 2016. The medial tibial stress syndrome score: a new patient-reported outcome measure. British journal of sports medicine, 50(19): 1192-1199.

Winters, M. and Weir, A. 2017. Grey matters; on the importance of publication bias in systematic reviews. British Journal of Sports Medicine, 51(6), 488-489.

1111

Winters, M. 2017. Medial Tibial Stress Syndrome: Diagnosis, Treatment and Outcome Assessment. PhD thesis, Utrecht University.

Winters, M. 2018. Critically appraising the evidence to help our patients with overload syndromes: should we prioritise knowledge from observational studies and focus on 'the essentials'?*Br J Sports Med*, 52(22).

Winters, M. 2019. The diagnosis and management of medial tibial stress syndrome. *Der Unfallchirurg*, 123(1): 15-19.

Winters, M., Burr, D. B., van der Hoeven, H., Condon, K. W., Bellemans, J. and Moen, M. H. 2019. Microcrack-associated bone remodeling is rarely observed in biopsies from athletes with medial tibial stress syndrome. *Journal of Bone and Mineral Metabolism*, 37(3): 496-502.

Yang, L. J., Gala, V. C. and McGillicuddy, J. E. 2006. Superficial peroneal nerve syndrome: an unusual nerve entrapment: case report. *Journal of neurosurgery*, 104(5): 820-823.

Yamasaki, S. 2019. *A Review of the Treatment and Prevention Options for Medial Tibial Stress Syndrome*.Senior Honours Theses 896. Available: https://digitalcommons.liberty.edu/honors/896/

Yates, B., Allen. M. J. and 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. and White, S. 2004. The incidence and risk factors in the development of medial tibial stress syndrome among naval recruits. *Am J Sports Med*, 32(suppl 3): 772-780.

Yeomans, S. G. and Yeomans, S. G. 2000. *The clinical application of outcomes assessment*. Stamford: Appleton & Lange.

Yochum, T. R. and Rowe, L. J. 2005. *Yochum and Rowe's Essentials of Skeletal Radiology*. 3rd ed. Available: https://www.amazon.com/Yochum-Rowes-Essentials-Skeletal-Radiology/dp/B002VK6Y0C(Accessed: 12 May 2020).

Zimmermann, W. O., Hutchinson, M. R., Van Den Berg, R., Hoencamp, R., Backx, F. J. G. and Bakker, E. W. P. 2019. Conservative treatment of anterior chronic exertional compartment syndrome in the military, with a mid-term follow-up. BMJ Open Sport and Exercise Medicine, 5 (1)

Zolin, R., Stuetzer, M. and Watson, J. 2013. Challenging the female underperformance hypothesis. *International Journal of Gender and Entrepreneurship*, 5(2): 116-129

APPENDICES

Appendix A: FRC Approval

5 June, 2020

Ms Z Crous
Student No: 21514252

P O Box 46
Wolseley
6830

Dear Ms Crous

MASTER OF HEALTH SCIENCES: CHIROPRACTIC

I am pleased to advise that:

1. The Faculty Research Committee approved the following:

    (i) Your research proposal and dissertation title, being:

A systematic review of the conservative treatment options and their effectiveness in the treatment of medical tibial stress syndrome (MTSS).

Please note: ANY PROPOSED CHANGES in the DISSERTATION TITLE require the approval of your supervisor and the Faculty Research Committee.

    (ii) Supervisor – **Dr C Korporaal**

2. Your request for funding totalling **R 8 000.00** subject to any literature referred to in Section A of the PG 4a form being accessioned by this University, and any equipment purchased shall become the property of the department.

NOTE: - This funding is not paid directly to you but is controlled by the Faculty Office. Any proposed changes to this funding allocation needs the approval of your supervisor, and Faculty Research Committee

The University Research Committee has stipulated that:

(a) Ownership of any patent registered in respect of the results of your Master's studies is retained by you as the initiator of the project;

(b) Should you make any drift from the results of your Master's studies, you will be required

to repay pro rata, the **R 5 000.00** investment which the University Research Committee has made in approving your request for funding;

(c) If the Durban University of Technology provided the equipment/materials for the creation of artefacts, this cost would be refunded to the University if such artefacts were sold and

(d) Durban University of Technology is given first refusal in respect of any possible future sale by you of any patent that may be registered in respect of your said project.

(e) All journal articles, referenced in your dissertation, are to accompany your ring-bound copies when submitting for examination purposes.

Should you experience any problems relating to your research studies, your supervisor must be informed as soon as possible. If the difficulty persists, you must then approach your Head of Department and thereafter the Executive Dean of the Faculty.

Yours sincerely

Ms S Perumal
FACULTY RESEARCH OFFICER

Student's signature in acceptance of the conditions contained herein.

5 · 06 · 2020
Date:

Appendix B: Memorandum of Agreement

Title of Research Study: A systematic review of the conservative treatment options and their effectiveness in the treatment of medial tibial stress syndrome (MTSS)

Principle investigators: Miss Zanelé Crous (Researcher) B. Tech: Chiropractic

Co-investigators:Dr. C. Korporaal (Supervisor) M. Tech: Chiropractic

Brief Introduction and Purpose of the Study:

This study is a systematic review of literature pertaining to medial tibial stress syndrome and conservative treatment options and effectiveness.Articles are collected electronically via databases by the researcher, the articles included into the study are divided into different study types, of those randomised controlled clinical trials, case reports and non-randomised clinical trials are included in this study. Grouped articles are to be reviewed by a panel of two of nine blinded reviewers, using rating scales (specific to the study types listed above) and feedback from reviewers is collated and presented in a statistical presentation.

Outline of Procedures:

Reviewers will receive articles which have been grouped according to study type (Randomised clinical trials, Non-randomised clinical trials CT's or observational studies) as well as the corresponding scale rating sheet (Randomised clinical trials – PEDro scale, Non-randomised clinical trials– Newcastle-Ottawa scale or observational studies – Liddle scale) as well as an explanation sheet for each scale.The reviewer will then individually rate the articles according to its corresponding scale.Rating sheets are collected and collated for statistical analysis. A determined time period will be recommended for each article/group of articles review for feedback.

Benefits:Publication of the study:Should this study be published, all persons participating in the study will be included in the publication. Should the reviewer wish to be exempt from this, please strike through the paragraph and initial alongside.

Remuneration:An honorarium of R1, 000.00 will be awarded to each reviewer in appreciation of their time and dedication to this project. This will be made at the conclusion of this research project once submission for final marking has been completed.

Please state your qualifications and attach a Biosketch when returning your document.

Contact persons:Please do not hesitate to contact either the supervisor and/or researcher regarding any questions or queries via the following methods:

Dr Charmaine Korporaal (Supervisor):

Telephone: 031 373 2611

Cell no.:083 463 3562

E-mail:charmak@dut.ac.za

Miss Zanelé Crous (Researcher):

Cell no.: 0769342805

E-mail: zanelecrous@gmail.com

Statement of Agreement to Participate in the Research Study:

I …… (Subject's full name), ……..(Identity number/Passport number), have read this document in its entirety and understand its contents.Where I have had any questions or queries, these have been explained to me by …… to my satisfaction.Furthermore, I voluntarily agree to participate in this study as a reviewer.

Reviewer's name: ……..……..…

Reviewer's signature: ……..……..…

Date: ……..……..…

Supervisor name: ……..……..…

Supervisor signature: ……..……..…

Date: ……..……..…

Researcher name: ……..……..…

Researcher signature: ……..……..…

Date: ……..……..…

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004/ 004	**BMC SPORTS SCIENCE, MEDICINE AND REHABILITATION** TREATMENT OF MEDIAL TIBIAL STRESS SYNDROME IN ATHLETES; A RANDOMIZED CLINICAL TRIAL. (MOEN M.H. (et al)) 157974	3	8	24	R1.07	R42.63 *	R6.39	R49.02

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002/ 002	**BMC MUSCULOSKELETAL DISORDERS** COMPARISON OF RIGID TAPE AND EXERCISE, ELASTIC TAPE AND EXERCISE AND EXERCISE ALONE ON PAIN AND LOWER LIMB FUNCTION IN INDIVIDUALS WITH EXERCISE RELATED LEG PAIN: A RANDOMISED CONTROLLED TRIAL (SMITH Melinda M. Franettovich, COATES Sonia S., CREABY Mark W.) 158000	3	10	30	R1.07	R42.63 *	R6.39	R49.02
003/ 003	**IOSR JOURNAL OF DENTAL AND MEDICAL SCIENCES** SHIN SPLINTS: EFFICACY OF RADIAL EXTRACORPOREAL SHOCK WAVE THERAPY IN BALLET DANCERS. A SERIES OF CASES (TUTTE M.L., GALIN G.) 158001	3	3	9	R1.07	R42.63 *	R6.39	R49.02
004/ 004	**BMJ OPEN SPORT & EXERCISE MEDICINE** CONSERVATIVE TREATMENT OF ANTERIOR CHRONIC EXERTIONAL COMPARTMENT SYNDROME IN THE MILITARY, WITH A MID-TERM FOLLOW-UP. (ZIMMERMANN W.O. (et al)) 158003	3	7	21	R1.07	R42.63 *	R6.39	R49.02
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002/ 002	**AMERICAN JOURNAL OF SPORTS MEDICINE** LOW-ENERGY EXTRACORPOREAL SHOCK WAVE THERAPY AS A TREATMENT FOR MEDIAL TIBIAL STRESS SYNDROME. (ROMPE J.D. (et al)) 157981	3	8	24	R1.07	R42.63 *	R6.39	R49.02
003/ 003	**SAUDI JOURNAL OF SPORTS MEDICINE** MEDIAL TIBIAL STRESS SYNDROME: A CASE STUDY (SATHE Abhinav) 157982	3	3	9	R1.07	R42.63 *	R6.39	R49.02
004/ 004	**JOURNAL OF FOOT & ANKLE SURGERY** TREATMENT OF MEDIAL TIBIAL STRESS SYNDROME WITH RADIAL SOUNDWAVE THERAPY IN ELITE ATHLETES: CURRENT EVIDENCE, REPORT ON TWO CASES, AND PROPOSED TREATMENT REGIMEN (SAXENA A. (et al)) 157984	3	5	15	R1.07	R42.63 *	R6.39	R49.02

Appendix D: PROSPERO Registration

Gmail

Zanele` Crous <[redacted]>

PROSPERO Registration message [185006]

1 message

CRD-REGISTER <[redacted], Jul 6, 2020 at 4:30 PM

Reply-To: CRD-REGISTER <[redacted]

To: '[redacted]'<[redacted]com>

Dear Miss Crous,

We apologise for the delay in dealing with your registration, an ever-increasing number of applications has led to a backlog and substantial delays for some users.

PROSPERO is currently prioritising submissions related to COVID-19. To enable us to focus on these submissions, and to avoid additional delay, during the pandemic we will automatically publish submissions that have been waiting more than 30 days for registration.

This applies to your systematic review 'A systematic review of the conservative treatment options and their effectiveness in the treatment of medial tibial stress syndrome (MTSS).' which was published on our website on 5th July 2020.

The records will be published exactly as submitted, without review by the PROSPERO team, so the public record will indicate:

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records, and high-quality well-written records will continue to speak for themselves.

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Best wishes for the successful completion of your review.

Yours sincerely,

PROSPERO Administrator

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PROSPERO is funded by the National Institute for Health Research and produced by CRD, which is an academic department of the University of York.

Other non-commercial resources that may be of interest

Appendix E: Database List

Author	Year	Title
	2018	MEDIAL TIBIAL STRESS SYNDROME (SHIN SPLINTS) IN RUNNERS
Aebi, J., Horisberger, M. and Frigg, A	2017	Radiographic Study of Pes Planovarus. *Foot and Ankle International*
Akiyama, K., Akagi, R., Hirayama, K., Hirose, N., Takahashi, H. and Fukubayshi, T	2016	Shear modulus of the lower leg muscles in patients with medial tibial stress syndrome
Alpert, J., Flannery, R., Epstein, R., Monaco, R. and Prendergast, N	2014	Humeral stress edema: An injury in overhead athletes quarterback with humeral 'shin' splints-a case report.
Andrish, J. T.,Bergfeld, J. A. and Walheim, J	1974	A prospective study on the management of shin splints
Aoki, K., Matsubara, Y. and Miyamoto, T	2017	Physical characteristics of college runners with a history of medial tibial stress syndrome: Range of motion of the toe and muscle cross-sectional area of the lower leg
Arnold, M. J. and Moody, A. L	2018	Common Running Injuries: Evaluation and Management
Austin, W. M	1996	Shin splints with underlying posterior tibial tendinitis: A case report
Balink, H	2009	Shin splints an unexpected effect of bisphosphonates in osteogenesis imperfecta
Barry, N. N. and McGuire, J. L	1996	Acute injuries and specific problems in adult athletes
Barton, C. J., Bonanno, D. R., Carr, J., Neal, B. S., Malliaras, P., Franklyn-Miller, A. and Menz, H. B	2016	Running retraining to treat lower limb injuries: a mixed-methods study of current evidence synthesised with expert opinion
Batt, M. E., Ugalde, V., Anderson, M. W. and Shelton, D. K	1998	A prospective controlled study of diagnostic imaging for acute shin splints
Beaudart, C., Hagelstein, T., Van Beveren, J., Godon, B., Bruyere, O. and Kaux, J. F	2018	French translation and validation of the exercise-induced leg pain Questionnaire
Beck, B. R., Rudolph, K., Matheson, G. O., Bergman, A. G. and Norling, T. L	2015	Risk factors for tibial stress injuries: A case-control study
Begley, A., Briggs, A. and Williams, C	2018	3 progressive leg pain and weakness in a 16-year-old boy
Becker, J., Nakajima, M. and Wu, W. F. W	2018	Factors Contributing to Medial Tibial Stress Syndrome in Runners: A Prospective Study
Bennett, J. E., Reinking, M. F., Pluemer, B., Pentel, A., Seaton, M. and Killian, C	2001	Factors contributing to the development of medial tibial stress syndrome in high school runners.
Bergtholdt, H. T	1976	Thermography and athletic injuries
Bintoudi, A., Goumenakis, M. and Karantanas, A	2012	Suprapatellar fat pad inflammation in step aerobics athletes: MR imaging evaluation of two cases
Bonanno, D. R., Munteanu, S. E., Murley, G. S., Landorf, K. B. and Menz, H. B	2018	Risk factors for lower limb injuries during initial naval training: A prospective study
Bonanno, D. R., Murley, G. S., Munteanu, S. E., Landorf, K. B. and Menz, H. B.	2015	Foot orthoses for the prevention of lower limb overuse injuries in naval recruits: Study protocol for a randomised controlled trial
Bonanno, D. R., Murley, G. S., Munteanu, S. E., Landorf, K. B. and Menz, H. B.	2018	Effectiveness of foot orthoses for the prevention of lower limb overuse injuries in naval recruits: a randomised controlled trial
Chang, G. H., Paz, D. A., Dwek, J. R. and Chung, C. B.	2013	Lower extremity overuse injuries in pediatric athletes: Clinical presentation, imaging findings, and treatment
Chou, L. H., Akuthota, V., Drake, D. F., Toledo, S. D. and Nadler, S. F	2004	Lower-limb injuries in endurance sports

Couture, C. J. and Karlson, K. A	2002	Tibial stress injuries: Decisive diagnosis and treatment of 'shin splints'
Craig, D. I	2008	Medial tibial stress syndrome: Evidence-based prevention
Craig, D. I	2009	Current developments concerning medial tibial stress syndrome
de Bruijn, J., Winkes, M., van Eerten, P. and Scheltinga, M	2019	Chronic exertional compartment syndrome as a cause of anterolateral leg pain-German version
de Bruijn, J., Winkes, M., van Eerten, P. and Scheltinga, M	2020	Chronic exertional compartment syndrome as a cause of anterolateral leg pain
De la Fuente, C., Henriquez, H., Andrade, D. C. and Yañez, A.	2019	Running footwear with custom insoles for pressure distribution are appropriate to diminish impacts after shin splints
De Vries, H. A	1961	Electromyographic observations of the effects of static stretching upon muscular distress
Ehlinger, M., Schneider, L., Lefebvre, Y., Jacquot, X., Cognet, J. M. and Simon, P	2004	Exercise-induced acute bilateral isolated anterolateral compartment syndrome of the leg: A case report of a rare condition
Eickhoff, C. A., Hossain, S. A. and Slawski, D. P	2000	Effects of prescribed foot orthoses on medial tibial stress syndrome in collegiate cross-country runners
Enke, R. C. and Gallas, J. E	2012	Diagnosis, treatment, and prevention of common running injuries
Feldman, J. J., Bowman, E. N., Phillips, B. B. and Weinlein, J. C	2016	Tibial Stress Fractures in Athletes
Fick, D. S., Albright, J. P. and Murray, B. P	1992	Relieving Painful 'Shin Splints'
Fields, K. B	2011	Running injuries V changing trends and demographics
Finch, P. M	1998	Chronic shin splints: A review of the deep posterior compartment
Flandry, F. and Sanders, R. A	1987	Tibiofibular synostosis: an unusual cause of shin splint-like pain
Fogarty, S	2015	Massage treatment and medial tibial stress syndrome; A commentary to provoke thought about the way massage therapy is used in the treatment of MTSS
Fourchet, F. and Gojanovic, B	2016	Foot core strengthening: Relevance in injury prevention and rehabilitation for runners
Fredericson, M., Bergman, A. G., Hoffman, K. L. and Dillingham, M. S	1995	Tibial Stress Reaction in Runners: Correlation of Clinical Symptoms and Scintigraphy with a New Magnetic Resonance Imaging Grading System
Fullem, B. W	2015	Overuse lower extremity injuries in sports
Galbraith, R. M. and Lavallee, M. E.	2009	Medial tibial stress syndrome: Conservative treatment options
Galloway, H. R	2013	Overuse Injuries of the Lower Extremity
George, C. A. and Hutchinson, M. R	2012	Chronic Exertional Compartment Syndrome
Gerow, G., Matthews, B., Jahn, W. and Gerow, R	1993	Compartment syndrome and shin splints of the lower leg
Gershuni, D. H., Gosink, B. B., Hargens, A. R., Gould, R. N., Forsythe, J. R., Mubarak, S. J. and Akeson, W. H	1982	Ultrasound evaluation of the anterior musculofascial compartment of the leg following exercise
Gibson, K., Morrison, N., Kolluri, R., Vasquez, M., Weiss, R., Cher, D., Madsen, M. and Jones, A	2018	Twenty-four month results from a randomized trial of cyanoacrylate closure versus radiofrequency ablation for the treatment of incompetent great saphenous veins
Gomez Garcia, S., Ramon Rona, S., Gomez Tinoco, M. C., Benet Rodriguez, M., Chaustre Ruiz, D. M., Cardenas Letrado, F. P., Lopez-Illescas Ruiz, A. and Alarcon Garcia, J. M	2017	Shockwave treatment for medial tibial stress syndrome in military cadets: A single-blind randomized controlled trial
Gooch, J. L., Geiringer, S. R. and Akau, C. K	1993	Lower extremity injuries

Griebert, M. C., Needle, A. R., McConnell, J. and Kaminski, T. W	2016	Lower-leg Kinesio tape reduces rate of loading in participants with medial tibial stress syndrome
Grzybowski, A. and Pietrzak, K	2016	Tomasz Drobnik (1858–1901).
Henry, H. T., Szolomayer, L. K., Sumpio, B. E. and Sutton, K. M	2018	Popliteal artery entrapment syndrome: Bilateral lower extremity involvement
Herring, K. M	2006	A plyometric training model used to augment rehabilitation from tibial fasciitis
Hislop, M., Brideaux, A. and Dhupelia, S	2017	Functional popliteal artery entrapment syndrome: use of ultrasound guided Botox injection as a non-surgical treatment option
Hume, P., Hopkins, W., Rome, K., Maulder, P., Coyle, G. and Nigg, B.	2008	Effectiveness of foot orthoses for treatment and prevention of lower limb injuries: a review
Jin, J	2014	Running injuries
Johnston, E., Flynn, T., Bean, M., Breton, M., Scherer, M., Dreitzler, G. and Thomas, D	2006	A Randomized Controlled Trial of a Leg Orthosis versus Traditional Treatment for Soldiers with Shin Splints - A Pilot Study
Jovicić, M., Jovicić, V., Hrković, M. and Lazović, M	2014	Medial tibial stress syndrome: case report
Joy, S. M. and Raudales, R	2015	Popliteal Artery Entrapment Syndrome
Kahanov, L., Eberman, L. E., Games, K. E. and Wasik, M	2015	Diagnosis, treatment, and rehabilitation of stress fractures in the lower extremity in runners
Karavana, H. A., Petcu, D., Gu¨lu¨mser, G. and Zengin, A. C. A	2016	Comfort and antifungal properties of orthotic materials used in footwear
Kellett, J. J., Lovell, G. A., Eriksen, D. A. and Sampson, M. J	2018	Diagnostic imaging of ankle syndesmosis injuries: A general review
Kelly, J. L. and Valier, A. R	2018	The use of orthotic insoles to prevent lower limb overuse injuries: A critically appraised topic
Khan, M. N., Jacobs, B. C. and Ashbaugh, S	2013	Considerations in Footwear and Orthotics
Khodaee, M. and Ansari, M	2012	Common ultramarathon injuries and illnesses: Race day management
Knight, R. R	2010	Integration of manual therapy, rehabilitation and acupuncture in the treatment of a 17-year-old male professional football player with chronic medial tibial stress syndrome
Knobloch, K., Thermann, H. and Hufner, T	2007	Achilles tendon rupture--early functional and surgical options with special emphasis on rehabilitation issues
Korakakis, V., Malliaropoulos, N., Baliotis, K., Papadopoulou, S., Padhiar, N., Nauck, T. and Lohrer, H	2015	Cross-cultural adaptation and validation of the exercise-induced leg pain questionnaire for English-and Greek-speaking individuals
Korakakis, V., Whiteley, R., Tzavara, A. and Malliaropoulos, N	2018	The effectiveness of extracorporeal shockwave therapy in common lower limb conditions: a systematic review including quantification of patient-rated pain reduction
Krabak, B. J., Snitily, B. and Milani, C. J. E	2016	Running Injuries During Adolescence and Childhood
Krenner, B. J	2002	Case report: comprehensive management of medial tibial stress syndrome
Krivickas, L. S	1997	Anatomical factors associated with overuse sports injuries
Lakkol, S., Singisetti, K. and Anand, S	2010	An overview of common lower extremity soft tissue injuries in athletes
Lam, W. K., Liebenberg, J., Woo, J., Park, S. K., Yoon, S. H., Cheung, R. T. and Ryu, J.	2018	Do running speed and shoe cushioning influence impact loading and tibial shock in basketball players?

Larsen, K., Weidich, F. and Leboeuf-Yde, C	2002	Can custom-made biomechanic shoe orthoses prevent problems in the back and lower extremities? A randomized, controlled intervention trial of 146 military conscripts
Leal, C., Berumen, E., Fernandez, A., Bucci, S. and Castillo, A.	2018	Extracorporeal Shockwave Therapy and Sports-Related Injuries.
Lee, J. H., Kwok, S. K., Park, S. H., Kim, H. Y. and Park, K. S	2014	Medial tibial stress syndrome progressing to tibial fracture in rheumatoid arthritis
Leumann, A., Pagenstert, G., Frigg, A., Ebneter, L., Hintermann, B. and Valderrabano, V	2006	Foot and lower leg stress fractures in sports
Logan, K	2007	Stress fractures in the adolescent athlete
Lohrer, H., Malliaropoulos, N., Korakakis, V. and Padhiar, N	2019	Exercise-induced leg pain in athletes: diagnostic, assessment, and management strategies
Loopik, M. F., Winters, M. and Moen, M. H	2016	Atrophy and depigmentation after pretibial corticosteroid injection for medial tibial stress syndrome: Two case reports
Loudon, J. K. and Dolphino, M. R	2010	Use of Foot Orthoses and Calf Stretching for Individuals With Medial Tibial Stress Syndrome
Madeley, L. T., Munteanu, S. E. and Bonanno, D. R	2007	Endurance of the ankle joint plantar flexor muscles in athletes with medial tibial stress syndrome: A case-control study
Martinez, R. E., Lopez, E. B., Cox, R. W., Stankevitz, D., Larkins, L., Baker, R. T. and May, J	2020	Exploring treatment of medial tibial stress syndrome via posture and the MyoKinesthetic system
Mattock, J., Steele, J. R. and Mickle, K. J	2018	A protocol to prospectively assess risk factors for medial tibial stress syndrome in distance runners
Mayo, M., Seijas, R. and Alvarez, P	2014	Structured neuromuscular warm-up for injury prevention in young elite football players
Meininger, A. K	2012	Preface.
Meulekamp, M. Z., Sauter, W., Buitenhuis, M., Mert, A. and van Der Wurff, P.	2016	Short-term results of a rehabilitation programme for service members with lower leg pain and the evaluation of patient characteristics
Moen, M. H., Bongers, T., Bakker, E. W., Weir, A., Zimmermann, W. O., van der Werve, M. and Backx, F. J	2010	The additional value of a pneumatic leg brace in the treatment of recruits with medial tibial stress syndrome; a randomized study
Moen, M. H., Holtslag, L., Bakker, E., Barten, C., Weir, A., Tol, J. L. and Backx, F	2012	The treatment of medial tibial stress syndrome in athletes; a randomized clinical trial
Moen, M. H., Ratnayake, A., Weir, A., Suraweera, H. J. and Backx, F. J. G.	2011	The treatment of medial tibial stress syndrome with bisphosphonates: A report of two cases
Moen, M. H., Rayer, S., Schipper, M., Schmikli, S., Weir, A., Tol, J. L. and Backx, F. J. G	2012	Shockwave treatment for medial tibial stress syndrome in athletes; A prospective controlled study
Moraux, A., Gitto, S. and Bianchi, S	2019	Ultrasound Features of the Normal and Pathologic Periosteum
Muché, J. A	2003	Efficacy of therapeutic ultrasound treatment of a meniscus tear in a severely disabled patient: A case report
Müller-Rath, R., Rußе, K., Kaufmann, M. and Siebert, C. H	2002	Medial tibial stress syndrome as an overuse injury in karate
Naderi, A., Degens, H. and Sakinepoor, A	2019	Arch-support foot-orthoses normalize dynamic in-shoe foot pressure distribution in medial tibial stress syndrome
Natsuyama, M	2005	Medical practice for sports injuries and disorders of the lower limb
Newman, P., Waddington, G. and Adams, R	2017	Shockwave treatment for medial tibial stress syndrome: A randomized double blind sham-controlled pilot trial
Nielsen, R. O., Parner, E. T., Nohr, E. A., Sørensen, H., Lind, M. and Rasmussen, S	2014	Excessive progression in weekly running distance and risk of running-related injuries: An association which varies according to type of injury
Nissen, L. R., Astvad, K. and Madsen, L	1994	Low-energy laser therapy in medial tibial stress syndrome

O'Brien, T. S., French, R. and Kinnison, L	2000	From the field. Influence of continuous musical tempo on performance of a walk/jog activity for adolescents with mental retardation
Okunuki, T., Koshino, Y., Yamanaka, M., Tsutsumi, K., Igarashi, M., Samukawa, M., Saitoh, H. and Tohyama, H	2019	Forefoot and hindfoot kinematics in subjects with medial tibial stress syndrome during walking and running
O'Reilly, O. C., Carruthers, K. H. and Siparsky, P. N.	2017	Bilateral, atraumatic proximal tibiofibular joint instability treated with suspensory button fixation.
Paik, R. S., Pepples, D. and Hutchinson, M. R	2013	Chronic exertional compartment syndrome
Pandit, K. and Stumbo, J	2014	IT'S HARD TO SPRINT WITH A THIGH SPLINT
Patel, D. R	2010	Fractures: Diagnosis and Management in the Primary Care Setting
Patel, D. S., Roth, M. and Kapil, N	2011	fractures: Diagnosis, treatment, and prevention
Patil, S. S. D	2017	Shin splints. In: *Foot and Ankle Sports Orthopaedics*
Payne, L	2007	The relative effectiveness of three treatment protocols in the treatment of medial tibial stress syndrome type II
Petrin, Z., Wowkanech, C., Sinha, A. N., Gupta, S. and Patel, M. K	2018	Runner With Painful Left Thigh Swelling: A Case of May-Thurner Syndrome
Pham, T. T., Kapur, R. and Harwood, M. I	2007	Exertional leg pain: Teasing out arterial entrapments
Pietrzak, M	2014	Diagnosis and management of acute medial tibial stress syndrome in a 15 year old female surf life-saving competitor
Pinshaw, R., Atlas, V. and Noakes, T. D	1984	The nature and response to therapy of 196 consecutive injuries seen at a runners' clinic
Plisky, M. S., Rauh, M. J., Heiderscheit, B., Underwood, F. B. and Tank, R. T	2007	Medial tibial stress syndrome in high school cross-country runners: incidence and risk factors
Preston Wiley, J., Short, W. B., Wiseman, D. A. and Miller, S. D	1990	Ultrasound catheter placement for deep posterior compartment pressure measurements in chronic compartment syndrome
Pujalte, G. G. A. and Silvis, M. L	2014	The injured runner
Quested, R., Hislop, M. and Gomes, Z	2015	Popliteal artery entrapment in a classical ballet dancer: Successful conservative management
Reinking, M. F., Austin, T. M. and Hayes, A. M	2007	Exercise-related leg pain in collegiate cross-country athletes: extrinsic and intrinsic risk factors.
Reilly, J. M., Bluman, E. and Tenforde, A. S	2018	Effect of Shockwave Treatment for Management of Upper and Lower Extremity Musculoskeletal Conditions: A Narrative Review
Rennerfelt, K., Zhang, Q., Karlsson, J. and Styf, J	2016	Changes in muscle oxygen saturation have low sensitivity in diagnosing chronic anterior compartment syndrome of the leg
Renstrom, P. and Johnson, R. J	1989	Cross-Country Skiing Injuries and Biomechanics
Reshef, N. and Guelich, D. R	2012	Medial Tibial Stress Syndrome
Roberts, A., Roscoe, D., Hulse, D., Bennett, A. N. and Dixon, S	2017	Biomechanical differences between cases with chronic exertional compartment syndrome and asymptomatic controls during walking and marching gait
Robertson, M. E	2003	The relative effectiveness of periosteal pecking combined with therapeutic ultrasound compared to therapeutic ultrasound in the treatment of medial tibial stress syndrome type II
Rodenberg, R. E., Bowman, E. and Ravindran, R	2013	Overuse injuries
Rompe, J. D., Cacchio, A., Furia, J. P. and Maffulli, N	2010	Low-energy extracorporeal shock wave therapy as a treatment for medial tibial stress syndrome
Rudy, E. B. and Estok, P. J	1985	Specific areas of concern for the female jogger
Sathe, A	2017	Medial tibial stress syndrome: A case study

Saxena, A., Fullem, B. and Gerdesmeyer, L	2017	Treatment of Medial Tibial Stress Syndrome With Radial Soundwave Therapy in Elite Athletes: Current Evidence, Report on Two Cases, and Proposed Treatment Regimen
Schiraldi, F., Sloan, P. and Chariton, J	1988	Shin splint syndrome: Literature review and case study
Schissel, D. J. and Godwin, J	1999	Effort-related chronic compartment syndrome of the lower extremity
Schulze, C., Finze, S., Bader, R. and Lison, A	2014	Treatment of medial tibial stress syndrome according to the fascial distortion model: A prospective case control study
Sharma, J., Greeves, J. P., Byers, M., Bennett, A. N. and Spears, I. R	2015	Musculoskeletal injuries in British Army recruits: a prospective study of diagnosis-specific incidence and rehabilitation times
Simpson, C., Roscoe, D., Hughes, S., Hulse, D. and Guthrie, H.	2019	Surgical outcomes for chronic exertional compartment syndrome following improveddiagnostic criteria
Singh, V., Green Iii, J. R. and Krabak, B. J	2010	Chronic Knee Synovitis in an Adolescent Dancer
Smith, M. M. F., Coates, S. S. and Creaby, M. W	2014	A comparison of rigid tape and exercise, elastic tape and exercise and exercise alone on pain and lower limb function in individuals with exercise related leg pain: A randomised controlled trial
Smith, W., Winn, F. and Parette, R	1986	Comparative study using four modalities in shinsplint treatments
Spitz, D. J. and Newberg, A. H	2002	Imaging of stress fractures in the athlete
Steinberg, N., Dar, G., Dunlop, M. and Gaida, J. E	2017	The relationship of hip muscle performance to leg, ankle and foot injuries: a systematic review
Stiegler, H., Brandl, R. and Krettek, C	2009	Chronic relapsing compartment syndrome
Stollsteimer, G. T. and Shelton, W. R.	1997	Acute atraumatic compartment syndrome in an athlete: a case report
Taylor, A. J. and George, K. P	2004	Syndromes in Young Endurance Athletes: Implications for Clinicians
Taylor, A. J. and Kerry, R	2017	When Chronic Pain Is Not ‘Chronic Pain’
Tenforde, A. S., Sayres, L. C., McCurdy, M. L., Collado, H., Sainani, K. L. and Fredericson, M	2011	Overuse Injuries in High School Runners: Lifetime Prevalence and Prevention Strategies
Thacker, S. B., Gilchrist, J., Stroup, D. F. and Kimsey, C. D	2002	The prevention of shin splints in sports: A systematic review of literature
Thistle, Sara	2018	Treatment of Medial Tibial Stress Syndrome Using the MyoKinesthetic System: A Case Series
Thomas, R. L., Hemingway, R., Keenan, A. and Wood, A	2018	Chronic exertional compartment syndrome: diagnosis, investigation, management and return to training
Toepfer, A., Harrasser, N., Lenze, U., Liska, F., Muhlhofer, H., von Eisenhart-Rothe, R. and Banke, I. J	2015	Bilateral diaphyseal bone cysts of the tibia mimicking shin splints in a young professional athlete--a case report and depiction of a less-invasive surgical technique
Tolbert, T. A. and Binkley, H. M	2009	Treatment and prevention of shin splints
Tonegawa, N., Urabe, Y., Numano, S., Fukui, K. and Maeda, N	2018	Survey of sports injuries and heatstroke in college badminton players
Tonoli, C., Cumps, E., Aerts, I., Verhagen, E. and Meeusen, R	2010	Incidence, risk factors and prevention of running related injuries in long-distance running: A systematic review injury, location and type
Touliopolous, S. and Hershman, E. B	1999	Lower leg pain. Diagnosis and treatment of compartment syndromes and other pain syndromes of the leg
Tschopp, M. and Brunner, F	2017	Diseases and overuse injuries of the lower extremities in long distance runners
Tutté ML, G. G	2016	Shin Splints: Efficacy of Radial Extracorporeal Shock Wave Therapy in Ballet Dancers. A Series Of Cases
Ugalde, V., Batt, M. E. and Chir, M. B. B	2001	Shin splints: Current theories and treatment
Usewicz, P. A. and Young, G	1998	Injuries of the tibialis posterior muscle and tendon: Acute and chronic tendon rupture

Van Lingen, L. H.	1998	he effectiveness of ultrasound therapy as an adjunct to the treatment of medial tibial stress syndrome type 2 (shin splints)
Van Zantvoort, A. P. M., Cuppen, P. and Scheltinga, M. R	2017	Management and patients perspective regarding a common peroneal nerve schwannoma: A rare cause of lower leg pain in a young individual
Walcher, M. G., Leumann, A., Wiewiorski, M., Pagenstert, G. and Valderrabano, V.	2010	Ankle joint and foot diseases among soccer players
Wanich, T., Hodgkins, C., Columbier, J. A., Muraski, E. and Kennedy, J. G	2007	Cycling injuries of the lower extremity
Waryasz, G. R., Daniels, A. H., Gil, J. A., Suric, V. and Eberson, C. P	2016	NCAA strength and conditioning coach demographics, current practice trends and common injuries of athletes during strength and conditioning sessions
Waryasz, G. R., Daniels, A. H., Gil, J. A., Suric, V. and Eberson, C. P	2016	Personal trainer demographics, current practice trends and common trainee injuries
Weise, K	1991	Injuries in track and field sports
Whitelaw, G. P., Wetzler, M. J., Levy, A. S., Segal, D. and Bissonnette, K.	1991	A pneumatic leg brace for the treatment of tibial stress fractures
Wiley, J. P., Short, W. B., Wiseman, D. A. and Miller, S. D	1990	Ultrasound catheter placement for deep posterior compartment pressure measurements in chronic compartment syndrome
Willems, T. M., De Clercq, D., Delbaere, K., Vanderstraeten, G., De Cock, A. and Witvrouw, E	2006	A prospective study of gait related risk factors for exercise-related lower leg pain
Willems, T. M., Witvrouw, E., De Cock, A. and De Clercq, D.	2007	Gait-related risk factors for exercise-related lower-leg pain during shod running
Winters, M., Bon, P., Bijvoet, S., Bakker, E. W. P. and Moen, M. H.	2017	Are ultrasonographic findings like periosteal and tendinous edema associated with medial tibial stress syndrome? A case-control study
Winters, M., Eskes, M., Weir, A., Moen, M. H., Backx, F. J. and Bakker, E. W	2013	Treatment of medial tibial stress syndrome: a systematic review
Yeung, S. S., Yeung, E. W. and Gillespie, L. D	2011	Interventions for preventing lower limb soft-tissue running injuries
Zimmermann, W. O. and Bakker, E. W. P	2019	Reducing vertical ground reaction forces: The relative importance of three gait retraining cues
Zimmermann, W. O., Hutchinson, M. R., Van Den Berg, R., Hoencamp, R., Backx, F. J. G. and Bakker, E. W. P	2019	Conservative treatment of anterior chronic exertional compartment syndrome in the military, with a mid-term follow-up

Appendix F: Master List

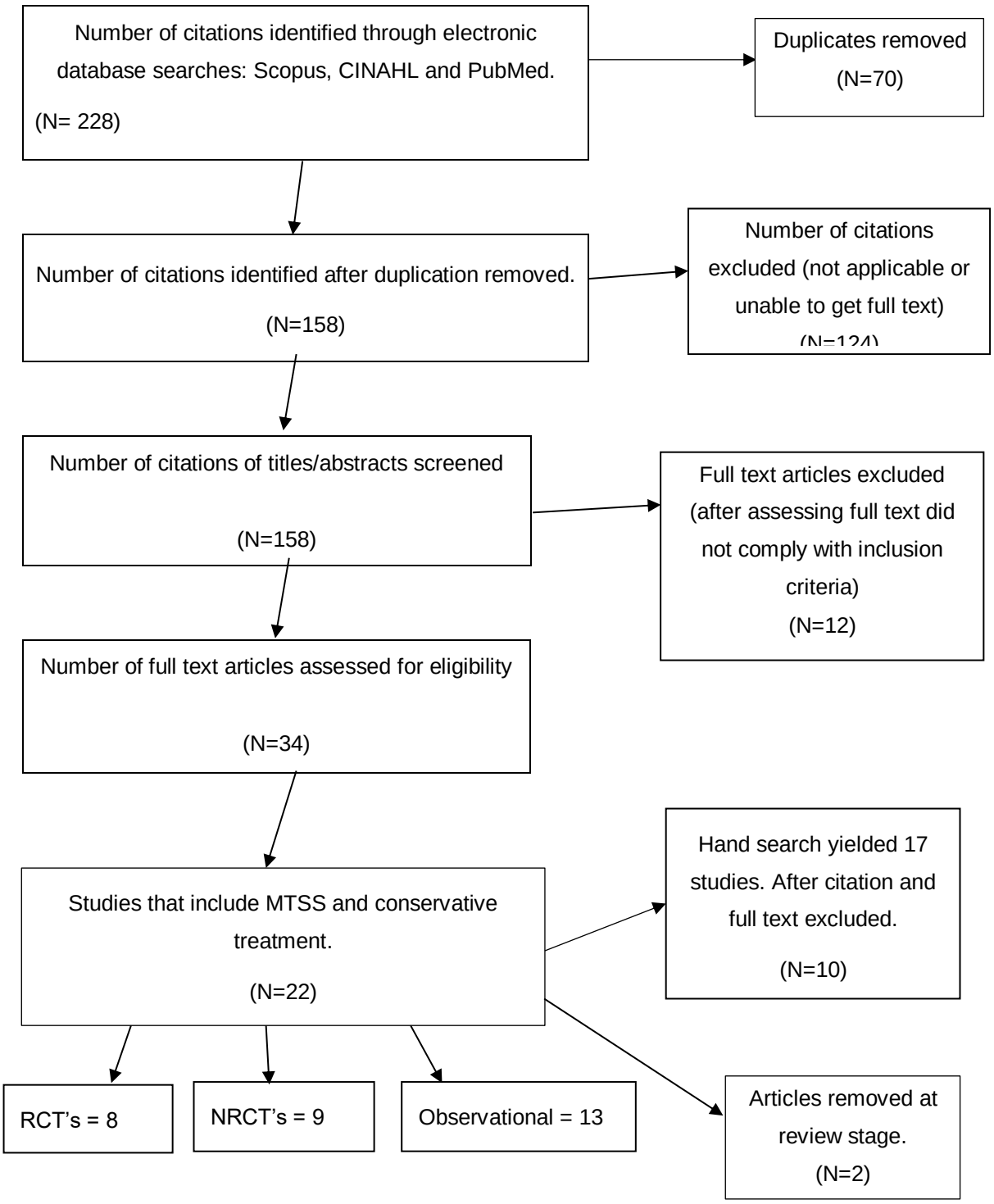
AUTHOR(S)		YEAR	TITLE	REFERENCE	STUDY TYPE	INCLUDED
1	Andrish, J. T., Bergfeld, J. A. and Walheim, J.	1974	A prospective study on the management of shin splints	Andrish, J. T., Bergfeld, J. A. and Walheim, J. 1974. A prospective study on the management of shin splints. Journal of Bone and Joint Surgery - Series A, 56 (8): 1697-1700.	RCT	Yes
2	Austin, W. M	1996	Shin splints with underlying posterior tibial tendinitis: A case report.	Austin, W. M. 1996. Shin splints with underlying posterior tibial tendinitis: A case report. *Journal of Sports Chiropractic and Rehabilitation*, 10 (4): 163-168.	Case report	Yes
3	Bonanno, D. R., Munteanu, S. E., Murley, G. S., Landorf, K. B. and Menz, H. B.	2018	Risk factors for lower limb injuries during initial naval training: A prospective study.	Bonanno, D. R., Munteanu, S. E., Murley, G. S., Landorf, K. B. and Menz, H. B. 2018. Risk factors for lower limb injuries during initial naval training: A prospective study. *Journal of the Royal Army Medical Corps*, 164 (5): 347-351.	Prospective study	Yes
4	De la Fuente, C., Henriquez, H., Andrade, D. C. and Yañez, A.	2019	Running footwear with custom insoles for pressure distribution are appropriate to diminish impacts after shin splints	De la Fuente, C., Henriquez, H., Andrade, D. C. and Yañez, A. 2019. Running footwear with custom insoles for pressure distribution are appropriate to diminish impacts after shin splints. *Asian Journal of Sports Medicine*, 10 (3)	Experimental	Yes
5	De Vries, H.A.	1961	Electromyographic observations of the effects of static stretching upon muscular distress	De Vries, H. A. 1961. Electromyographic observations of the effects of static stretching upon muscular distress. *Research Quarterly of the American Association for Health, Physical Education and Recreation*, 32 (4): 468-479.	Case series	Yes
6	Fick, D. S., Albright, J. P. and Murray, B. P.	1992	Relieving Painful 'Shin Splints'	Fick, D. S., Albright, J. P. and Murray, B. P. 1992. Relieving Painful 'Shin Splints'. *Phys Sportsmed*, 20 (12): 105-113.	Case study	Yes
7	Gomez Garcia, S., Ramon Rona, S., Gomez Tinoco, M. C., Benet Rodriguez, M., Chaustre Ruiz, D. M., Cardenas Letrado, F. P., Lopez-Illescas Ruiz, A. and Alarcon Garcia, J. M.	2017	Shockwave treatment for medial tibial stress syndrome in military cadets	Gomez Garcia, S., Ramon Rona, S., Gomez Tinoco, M. C., Benet Rodriguez, M., Chaustre Ruiz, D. M., Cardenas Letrado, F. P., Lopez-Illescas Ruiz, A. and Alarcon Garcia, J. M. 2017. Shockwave treatment for medial tibial stress syndrome in military cadets: A single-blind randomized controlled trial. *Int J Surg*, 46: 102-109.	RCT	Yes
8	Griebert, M. C., Needle, A. R., McConnell, J. and Kaminski, T. W	2016	Lower-leg Kinesio tape reduces rate of loading in participants with medial tibial stress syndrome	Griebert, M. C., Needle, A. R., McConnell, J. and Kaminski, T. W. 2016. Lower-leg Kinesio tape reduces rate of loading in participants with medial tibial stress syndrome. Physical Therapy in Sport, 18: 62-67.	NRCT	Yes
9	Johnston, E., Flynn, T., Bean, M., Breton, M., Scherer, M., Dreitzler, G. and Thomas, D	2006	A Randomized Controlled Trial of a Leg Orthosis versus Traditional Treatment for Soldiers with	Johnston, E., Flynn, T., Bean, M., Breton, M., Scherer, M., Dreitzler, G. and Thomas, D. 2006. A Randomized Controlled Trial of a Leg Orthosis versus Traditional Treatment for	RCT	Yes

			Shin Splints - A Pilot Study	Soldiers with Shin Splints - A Pilot Study. Military Medicine, 171 (1): 40-44.		
10	Jovicić, M., Jovicić, V., Hrković, M. and Lazović, M.	2014	Medial tibial stress syndrome: case report	Jovicić, M., Jovicić, V., Hrković, M. and Lazović, M. 2014. Medial tibial stress syndrome: case report. *Medicinskipregled*, 67 (7-8): 247-251.	Case report	Yes
11	Knight, R.R	2010	Integration of manual therapy, rehabilitation and acupuncture in the treatment of a 17-year-old male professional football player with chronic medial tibial stress syndrome	Knight, R. R. 2010. Integration of manual therapy, rehabilitation and acupuncture in the treatment of a 17-year-old male professional football player with chronic medial tibial stress syndrome. *Journal of the Acupuncture Association of Chartered Physiotherapists*: 81-87.	Case report	Yes
12	Loudon, J. K. and Dolphino, M. R.	2010	Use of Foot Orthoses and Calf Stretching for Individuals With Medial Tibial Stress Syndrome	Loudon, J. K. and Dolphino, M. R. 2010. Use of Foot Orthoses and Calf Stretching for Individuals With Medial Tibial Stress Syndrome. *Foot & Ankle Specialist*, 3 (1): 15-20.	NRCT	Yes
13	Martinez, R. E., Lopez, E. B., Cox, R. W., Stankevitz, D., Larkins, L., Baker, R. T. and May, J.	2020	Exploring treatment of medial tibial stress syndrome via posture and the MyoKinesthetic system	Martinez, R. E., Lopez, E. B., Cox, R. W., Stankevitz, D., Larkins, L., Baker, R. T. and May, J. 2020. Exploring treatment of medial tibial stress syndrome via posture and the MyoKinesthetic system. Journal of Bodywork & Movement Therapies, 24 (1): 82-87.	Case series	Yes
14	Meulekamp, M. Z., Sauter, W., Buitenhuis, M., Mert, A. and van Der Wurff, P.	2016	Short-term results of a rehabilitation programme for service members with lower leg pain and the evaluation of patient characteristics	Meulekamp, M. Z., Sauter, W., Buitenhuis, M., Mert, A. and van Der Wurff, P. 2016. Short-term results of a rehabilitation programme for service members with lower leg pain and the evaluation of patient characteristics. *Military Medicine*, 181 (9): 1081-1087.	NRCT	Yes
15	Moen, M. H., Bongers, T., Bakker, E. W., Weir, A., Zimmermann, W. O., van der Werve, M. and Backx, F. J.	2010	The additional value of a pneumatic leg brace in the treatment of recruits with medial tibial stress syndrome; a randomized study	Moen, M. H., Bongers, T., Bakker, E. W., Weir, A., Zimmermann, W. O., van der Werve, M. and Backx, F. J. 2010. The additional value of a pneumatic leg brace in the treatment of recruits with medial tibial stress syndrome; a randomized study. *Journal of the Royal Army Medical Corps*, 156 (4): 236-240.	RCT	Yes
16	Moen, M. H., Holtslag, L., Bakker, E., Barten, C., Weir, A., Tol, J. L. and Backx, F.	2012	The treatment of medial tibial stress syndrome in athletes; a randomized clinical trial	Moen, M. H., Holtslag, L., Bakker, E., Barten, C., Weir, A., Tol, J. L. and Backx, F. 2012. The treatment of medial tibial stress syndrome in athletes; a randomized clinical trial. *Sports Medicine, Arthroscopy, Rehabilitation, Therapy and Technology*, 4 (1)	RCT	Yes
17	Moen, M. H., Rayer, S., Schipper, M., Schmikli, S., Weir, A., Tol, J.	2012	Shockwave treatment for medial tibial stress syndrome in athletes; A	Moen, M. H., Rayer, S., Schipper, M., Schmikli, S., Weir, A., Tol, J. L. and Backx, F. J. G. 2012. Shockwave treatment for medial tibial stress syndrome in athletes; A prospective	NRCT	Yes

	L. and Backx, F. J. G.		prospective controlled study	controlled study. *British Journal of Sports Medicine*, 46 (4): 253-257.		
18	Naderi, A., Degens, H. and Sakinepoor, A.	2019	Arch-support foot-orthoses normalize dynamic in-shoe foot pressure distribution in medial tibial stress syndrome	Naderi, A., Degens, H. and Sakinepoor, A. 2019. Arch-support foot-orthoses normalize dynamic in-shoe foot pressure distribution in medial tibial stress syndrome. *European Journal of Sport Science*, 19 (2): 247-257.	NRCT	Yes
19	Newman, P., Waddington, G. and Adams, R.	2017	Shockwave treatment for medial tibial stress syndrome: A randomized doubleblind sham-controlled pilot trial	Newman, P., Waddington, G. and Adams, R. 2017. Shockwave treatment for medial tibial stress syndrome: A randomized double blind sham-controlled pilot trial. *Journal of Science and Medicine in Sport*, 20 (3): 220-224.	RCT	Yes
20	Payne, L.	2007	The relative effectiveness of three treatment protocols in the treatment of medial tibial stress syndrome type II.	Payne, L. 2007. The relative effectiveness of three treatment protocols in the treatment of medial tibial stress syndrome type II. DUT Summons.	RCT	Yes
21	Pietrzak, M.	2014	Diagnosis and management of acute medial tibial stress syndrome in a 15 year old female surf life-saving competitor	Pietrzak, M. 2014. Diagnosis and management of acute medial tibial stress syndrome in a 15 year old female surf life-saving competitor. *Int J Sports Phys Ther*, 9 (4): 525-539.	Case report	Yes
22	Robertson, M. E.	2003	The relative effectiveness of periosteal pecking combined with therapeutic ultrasound compared to therapeutic ultrasound in the treatment of medial tibial stress syndrome type II.	Robertson, M. E. 2003. The relative effectiveness of periosteal pecking combined with therapeutic ultrasound compared to therapeutic ultrasound in the treatment of medial tibial stress syndrome type II. DUT Summons.	RCT	Yes
23	Rompe, J. D., Cacchio, A., Furia, J. P. and Maffulli, N.	2010	Low-energy extracorporeal shock wave therapy as a treatment for medial tibial stress syndrome	Rompe, J. D., Cacchio, A., Furia, J. P. and Maffulli, N. 2010. Low-energy extracorporeal shock wave therapy as a treatment for medial tibial stress syndrome. *American Journal of Sports Medicine*, 38 (1): 125-132.	NRCT	Yes
24	Sathe, A.	2017	Medial tibial stress syndrome: A case study	Sathe, A. 2017. Medial tibial stress syndrome: A case study. Saudi J Sports Med 17:50-2	Case serie	Yes
25	Saxena, A., Fullem, B. and Gerdesmeyer, L.	2017	Treatment of Medial Tibial Stress Syndrome With Radial Soundwave Therapy in Elite Athletes: Current	Saxena, A., Fullem, B. and Gerdesmeyer, L. 2017. Treatment of Medial Tibial Stress Syndrome With Radial Soundwave Therapy in Elite Athletes: Current Evidence, Report on Two Cases, and Proposed Treatment Regimen. *Journal of Foot and Ankle Surgery*, 56 (5): 985-989.	Case report	Yes

			Evidence, Report on Two Cases, and Proposed Treatment Regimen			
26	Schulze, C., Finze, S., Bader, R. and Lison, A.	2014	Treatment of medial tibial stress syndrome according to the fascial distortion model: A prospective case control study	Schulze, C., Finze, S., Bader, R. and Lison, A. 2014. Treatment of medial tibial stress syndrome according to the fascial distortion model: A prospective case control study. Scientific World Journal, 2014	NRCT	Yes
27	Smith, W., Winn, F. and Parette, R.	1986	Comparative study using four modalities in shinsplint treatments	Smith, W., Winn, F. and Parette, R. 1986. Comparative study using four modalities in shinsplint treatments. *Journal of Orthopaedic and Sports Physical Therapy*, 8 (2): 77-80.	NRCT	Yes
28	Thistle, S.	2018	Treatment of Medial Tibial Stress Syndrome Using the MyoKinesthetic System: A Case Serie	Thistle, Sara. 2018. Treatment of Medial Tibial Stress Syndrome Using the MyoKinesthetic System: A Case Serie. Senior Honors Theses. 208.	Case series	Yes
29	Tutté, M.L. and Galin, G.	2016	Shin Splints: Efficacy of Radial Extracorporeal Shock Wave Therapy in Ballet Dancers. A Series Of Cases	Tutté ML, G. G. 2016. Shin Splints: Efficacy of Radial Extracorporeal Shock Wave Therapy in Ballet Dancers. A Series Of Cases. IOSR Journal of Dental and Medical Sciences (IOSR-JDMS, 15 (9): 22-24	Case series	Yes
30	Van Lingen, L. H.	1998	The effectiveness of ultrasound therapy as an adjunct to the treatment of medial tibial stress syndrome type 2 (shin splints).	Van Lingen, L. H. 1998. The effectiveness of ultrasound therapy as an adjunct to the treatment of medial tibial stress syndrome type 2 (shin splints). DUT Summons.	NRCT	Yes

Appendix G: Flow Chart



Appendix H: PEDro Scale

Randomised Controlled Clinical Trial Rating

The PEDro scale is centred on the Delphi list (Delphi list: a criteria list for quality assessment of RCTs for conducting systematic reviews developed by the Delphi consensus.Journal of Clinical Epidemiology, 51(12): 1235-1241).

The PEDro scale contains 11 criteria. Criterion 1 aims to evaluate the applicability of the trial. Criteria 2-9 look at the 'internal validity,' while criteria 10-11 evaluate the statistical information of the RCT and determines whether those statistics are interpretable.

The area labelled 'Reference Page' is provided in the event that discordance is found between reviewers. This will be used to find where the information was accessed from.

One point may be awarded should a criterion be appropriately met. Should a 'yes' answer be required, one point will be awarded for that criterion.

Definitions:

Blinding: refers to the person (subject, therapist or assessor) not knowing which group the subject had been assigned to.

A point measure: measures the magnitude of the treatment outcome/effect.

Measures of variability: comprises standard errors, confidence intervals, standard deviations, ranges and interquartile ranges (or other quantile ranges).

A between-group statistical comparison: comprises statistical comparison of one group with another (control or treatment).

Intention to treat: Fisher *et al.* (1990) defines 'intention to treat' as a method for the examination of RCTs. This policy links patients to the groups that they were initially randomly allocated to.In general, this is understood as comprising all patients, irrespective of whether:

- They satisfied the inclusion criteria
- Treatment was inferred
- Withdrawal from the study
- Derivation from the procedure

Without the intention to treat protocol, the clinical effectiveness of an RCT can be overemphasised.

References:

Fisher, L.D., Dixon, D.O., Herson, J., Frankowski, R.K., Hearon, M.S. and Pearce, K.E.1990.Intention to treat in clinical trials.In: Pearce, K.E., ed.Statistical issues in drug research and development.Marcel Decker Inc – New York.331-350.

PEDro scale (online).1999.Available at: www.pedro.org.au (Accessed 17 February 2020).

PEDro Scale:

Reviewer:	
Article Title:	

Please select YES or NO for each criterion:

CRITERION				REFERENCE PAGE
1	Eligibility criteria were specified.	YES	NO	
2	Subjects were randomly allocated to groups (in a crossover study, subjects were randomly allocated an order in which treatments were received).	YES	NO	
3	Allocation was concealed.	YES	NO	
4	The groups were similar at baseline regarding the most important prognostic indicators.	YES	NO	
5	There was blinding of all subjects.	YES	NO	
6	There was blinding of all therapists who administered the therapy.	YES	NO	
7	There was blinding of all assessors who measured at least one key outcome.	YES	NO	
8	Measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups.	YES	NO	
9	All subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome was analysed by 'intention to treat'.	YES	NO	
10	The results of between-group statistical comparisons are reported for at least one key outcome.	YES	NO	
11	The study provides both point measures and measures of variability for at least one key outcome.	YES	NO	

Adapted from:PEDro scale (online) 1999.

Appendix I: Newcastle-Ottawa Scale

Non-Randomised Studies

The Newcastle-Ottawa is composed of eightquestions that pertain to the following threecategories: selection, comparability and exposure.

For the selection and exposure sections, one response per question is required (a, b, or c, etc.) For the comparability section, multiple or no responses can be made.

One star can be presented per question, except comparability, where two stars may be awarded.The maximum amount of stars that a study can be awarded is nine stars.

Should a study contain only one group of subjects, comparability cannot be done, and should be omitted from the scale.

Definition: Ascertainment: To discover with certainty, as through examination or experimentation. (The free dictionary (online)).

Reference:

Stang, A.2010.Critical evaluation of the Newcastle-Ottawa scale for the assessment of the quality of nonrandomized studies in meta-analyses.European Journal of Epidemiology. 25(9): 603-605.

Newcastle-Ottawa Quality Assessment Scale:

Non-Randomised Studies

Reviewer:	
Article Title:	

A study can be awarded a maximum of one star for each numbered item within the selection and **exposure** categories.A maximum of twostars can be awarded for **comparability**.

Please circle the letter you award for each point:

SELECTION:

1. Is the case definition adequate?
    a. Yes, with independent validation *
    b. Yes, e.g. record linkage or based on self-reports
    c. No description

2. Representativeness of the cases
    a. Consecutive or obviously representative series of cases *
    b. Potential for selection biases or not stated

3. Selection of controls
    a) Community controls *
    b) Hospital controls
    c) No description

4. Definition of controls
    a) No history of disease (endpoint) *
    b) No description of source

COMPARABILITY:

1. Comparability of cohorts on the basis of design or analysis
    a) Study controls for(Select most important factor) *
    b) Study controls for **any** additional factor *

EXPOSURE:

1. Ascertainment of exposure

    a. Secure record (e.g. surgical records) *
    b. Structured interview where blind to case/control status *
    c. Interview not blinded to case/control status
    d. Written self-report or medical record only
    e. No description

2. Same method of ascertainment for cases and controls
    a) Yes *
    b) No

3. Non-response rate
    a) Same rate for both groups *
    b) Non respondents described
    c) Rate different and no designation

Adapted from: Wells *et al.* 2003.The Newcastle-Ottawa Scale (NOS) for assessing the quality of non-randomized studies in meta-analyses.

Appendix J: Liddle scale

The Liddle scale had fivedifferent checklists. For the purpose of this study Checklist 2 will be used. Each study checklist contains three sections requiring completion by the reviewer:

1. Descriptive information about the study covering authors and year of publication, a description of the study intervention, outcomes both beneficial and harmful, other factors that might affect the outcome, characteristics of the study population and setting, and the number of groups or sites in the study.

2. Evaluation criteria for the study containing the main components of study quality to be considered. The evaluation of the quality of a study, review or guideline, provides information to assist in deciding whether researchers or guideline developers have taken the necessary steps to prevent the over or underestimation of the true effect of interventions, risk factors, diagnostic test accuracy and guideline recommendations. Table 2 sets out the codes to be used for the evaluation criteria. The codes are descriptive aids and are not a quantitative scoring system. Spaces are available on the checklist for reviewers to include comments about how and why they decided on a particular code for each evaluation criterion.

Table J1: Coding for evaluation criteria

Evaluation criteria are coded according to the extent to which the criteria are fulfilled	**Code**
Criterion entirely fulfilled	A
Criterion mostly fulfilled	b 1
Criterion mostly not fulfilled	b2
Criterion not at all fulfilled	C
Criterion not described adequately to classify as a, b1, b2 or c	?
Criterion not applicable	n/a

3. Overall assessment of the study allows the reviewer to assess and code the overall quality of the study using the codes in Table 3. Study quality is coded as A, B1, B2, C. These codes are intended to be compatible with those of the Cochrane Collaboration.

Table J2: Codes for overall assessment of quality of study checklists

Low risk of bias	A	All or most evaluation criteria from the checklist are fulfilled. Where evaluation criteria are not fulfilled, the conclusions of the study or review are thought very unlikely to alter.
Low - moderate risk of bias	B1	Some evaluation criteria from the checklist are fulfilled. Where evaluation criteria are not fulfilled or are not adequately described, the conclusions of the study or review are thought unlikely to alter.
Moderate - high risk of bias	B2	Some evaluation criteria from the checklist are fulfilled. Where evaluation criteria are not fulfilled or are not adequately described, the conclusions of the study or review are thought likely to alter.
High risk of bias	C	Few or no evaluation criteria fulfilled. Where evaluation criteria are not fulfilled or are not adequately described, the conclusions of the study or review are thought very likely to alter.

Space is available for the reviewer's comments about how and why they decided upon a particular code for the overall assessment of quality. Comments set down explicitly the reasons for a reviewer's assessment of quality.Comments are encouraged as they are useful for explaining reviewers' reasons for coding evaluation criteria.

References:

Liddle, J., Williamson, M. and Irwig, I. 1996. Method for Evaluating Research and Guideline Evidence.

Table J3: The effect of interventions

Reviewer			
Article			
DESCRIPTIVE INFORMATION ABOUT THE STUDY	NOTES	DESCRIPTION	CODE OPTIONS a, b1, b2, c, ?, n/a
Study Identification	Include author, title, reference and year of publication (if available) and the study timeframe.		
How is the study type described?	Randomised Controlled Trials (RCT), Non-Randomised Control Trials (N-RCS), Cohorts, Before and After Studies (BAS) with/without controls, Case Control Studies (C-CS) - define whether population- or hospital- based case control study.		
What interventions are considered and how are they implemented?			
Is the intervention aimed at individuals or populations?	For example, drug trial (for individuals), mass media campaign (for populations)		
What outcomes are considered?	That is,benefits and harms.		
What factors other than the intervention could affect the outcome?	Include potential confounding factors, differences in baseline characteristics between intervention and control groups.		
What are the characteristics of the population and study setting?	Population characteristics, e.g. age, sex, disease characteristics of the population, disease prevalence. Study setting, e.g. rural, urban, hospital inpatient or outpatient, general practice, community.		
How many groups/sites in the study?			

Adapted from Checklist 2 - Studies assessing the effect of interventions (Liddle *et al*. 1996).