Intrinsic Foot Muscle Training for Medial Tibial Stress Syndrome

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ABSTRACT

Medial tibial stress syndrome (MTSS), a common condition in physically active individuals, is widely studied, yet effective and efficient intervention is elusive. We compared the effects of a 2-week neuromuscular-based intervention to the "usual treatment" in a non-randomized trial involving intercollegiate athletes with complaints of MTSS involving soft tissue. The neuromuscular-based intervention focused on relieving trigger points in the deep compartment and improving intrinsic foot muscle (IFM) function. The control group received "usual treatment" that did not include the study exercises, but did include rest, modalities, stretching, and/or strengthening exercises. Pre- and post-intervention measures included pain at rest, during activities of daily living (ADL), and during activity; pressure-pain threshold on soft tissue; the Foot & Ankle Ability Measure (FAAM); FAAM Sports Subscale; and Exercise-Induced Leg Pain Questionnaire (EILPQ). Patients were followed for 3 months for recurring symptoms. The experimental group (NMTx) had significantly greater improvement in pain during activities of daily living (change -2.5 NMTx; -0.5 CON; P=.03), pain during activity (change -4.5 NMTx; -0.33 CON; P<.001), and pressure-pain threshold (change +2.41 NMTx; -0.03 CON; P=.001). The NMTx group also reported greater improvement on the self-reported FAAM Sport-Subscale (change +40 NMTx; +6.5 CON; P=.001) and had a higher global rating of change (4.71 NMTx; 3.5 CON; P=.008). Recurrence of symptoms within 3 months was reported by 7% of NMTx and 87% of CON. This study demonstrates a neuromuscular-based intervention aimed at relieving soft tissue tenderness in the deep compartment and improving IFM function provides significant and sustained relief of leg pain.

Content Focus
Health Care Competence

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Full Citation
Newsham K, Boyd M, Lauber C. Intrinsic foot muscle training for medial tibial stress syndrome. *Clin Pract Athl Train*. 2023;6(1): 1-12. https://doi.org/10.31622/2023/0006.01.2.

INTRODUCTION

Exercise-induced leg pain (EILP), or exercised-related leg pain (ERLP), is common among physically active individuals, accounting for 13-20% of all injuries among runners and up to 35% among military recruits.[1,2] EILP/ERLP is a vague descriptor encompassing many conditions associated with microtrauma, including exertional compartment syndrome, popliteal artery entrapment, nerve entrapments, tibial and fibular stress fractures, periosteal reactions, and various tendinopathies.[3] Medial tibial stress syndrome (MTSS) localizes the pain to the posteromedial aspect of the tibia, but also describes a continuum of conditions including muscle strain, tendinopathy, and bone stress reaction.[2,4] Despite the prevalence of MTSS, the pathophysiology of the condition is not well understood.[3] Recent investigations of MTSS have identified alterations in bone as well as soft tissue, including the flexor digitorum longus, tibialis posterior, soleus, and crural fascia.[5-8] A reliable MTSS diagnosis can be made through history and physical exam.[9]

Effective interventions are elusive, and interventions are poorly described in the literature. Rest is a mainstay of treatment, yet it does not appear to be effective in the long term.[4] Stretching, strengthening, taping, orthotics, and various therapeutic modalities have been employed as interventions with mixed and limited results.[10-13] Extracorporeal shock-wave therapy (ESWT) has demonstrated positive effects, particularly with recalcitrant cases; however, return to sport may take 2-15 months.[12,13] Ultimately, clinicians are left with few choices for effective and efficient treatments.

Clearly, MTSS is problematic as it interrupts training and adversely affects performance. Further, the frequency of re-injury is concerning with up to 80% of individuals reporting recurrence of MTSS.[6,14] The combination of adverse impact on performance, duration of therapeutic interventions, and frequency of recurrence is likely discouraging to individuals with MTSS. Limited success in treating MTSS may be attributed to failing to appropriately treat pain generating tissue and related dysfunction. Myofascial trigger points in the deep compartment can be a source of pain in MTSS and shortened extrinsic flexors can contribute to inhibition of intrinsic foot muscles.[15,16] Interventions addressing trigger points, and muscle inhibition specifically, are critical to alleviating pain and correcting somatic dysfunction.[17,18] Proprioceptive neuromuscular facilitation (PNF) techniques, using both reciprocal and autogenic inhibition, have been found to aid in deactivation of trigger points through analgesic effects, an increase in sarcomere extension, and an increase in stretch tolerance.[19] The theoretical framework for this approach to managing MTSS is sound, but has not been described in the literature.

Measuring effectiveness of interventions is as varied as interventions themselves. Return to sport or occupation is a commonly reported outcome for intervention studies.[11,12,20,21] Some have reported numeric pain scale and patient-specific functional outcome, while others have criticized a lack of a condition specific patient-reported outcome.[11,12,22] Still others have explored pressure-pain threshold as a means of quantifying pain from palpation.[16,20] Reports of persistence of the effect of interventions were lacking, though 2 studies required participants to be pain-free for 3 weeks to be classified as recovered.[23,24] As with any evaluation, multiple measures provide a more robust assessment; dependence on a single dependent variable may not provide a complete picture.

The purpose of this study was to explore the efficacy of a 2-week neuromuscular focused intervention for MTSS involving soft tissue injury. The intervention utilized PNF techniques to relieve trigger points, inhibit tight and over-active muscles, and facilitate inhibited intrinsic foot muscles (IFM) before employing more familiar isotonic strengthening exercises. Borrowing from deficiencies described in the literature, we proposed to measure efficacy through patient-oriented data that allowed participants to describe their perceptions of pain, pain related to activity, and impact of MTSS on daily and sport activities utilizing standard patient-reported outcome measures. A secondary purpose was to develop minimal clinically important differences specific to MTSS for patient-reported outcomes and pain related measures.

METHODS

Participants

Any intercollegiate athlete reporting to one of three university (NCAA Division II) athletic training clinics with complaint of exercise-related medial leg pain consistent with MTSS (i.e., medial tibial tenderness extending >5cm, trigger points in the deep compartment, no neurologic or vascular symptoms) was invited to participate in this study.[9] Clinical diagnoses were established by athletic trainers (≥5 years clinical experience in collegiate setting). Patients demonstrating neurologic or vascular symptoms or focal bony tenderness suggestive of stress fracture (<5cm) were not included in this study. Each participant provided informed consent prior to participation in this IRB approved study. Institutions (universities) were designated as treatment or control sites rather than assigning individuals to intervention. This was done to limit potential contamination from participants observing other patients and mimicking their exercises.

Participants reported duration of symptoms and level of pain during sport activity, activities of daily living, and at rest. Pain was quantified on an 11-point numeric rating scale; 0 indicated no pain and 10 indicated unbearable pain.[25] Trigger points in the deep compartment were identified through careful palpation;[17,18] locations were mapped and recorded for accuracy in subsequent trigger point measures. With the participant seated, knees flexed to 60°, and the foot supported, the pressure-pain threshold was measured with an algometer (Wagner Instruments, Greenwich CT, USA) by instructing the participant to notify the investigator when the pressure applied to a trigger point transitioned from pressure to pain.[18] The pressure indicated on the algometer at that point was recorded. Lower scores indicate greater trigger point sensitivity, while higher scores indicate greater load capacity.[26] For participants with bilateral symptoms, pain related measures were obtained from the side with greater pain.

The participant remained seated and the knee was flexed to 90° with the foot flat on a firm surface for IFM evaluation. IFM dysfunction was defined as the inability to extend the great toe while the lesser toes remained in a neutral position and/or the inability to extend the lesser toes while the great toe remained in a neutral position.[15,16] The participant completed the Foot and Ankle Ability Measure (FAAM), the FAAM Sports Subscale, and the Exercise-Induced Leg Pain Questionnaire (EILPQ).[27] In addition to rating difficulty performing certain tasks, the FAAM forms include self-reported level of function relative to "normal." The EILPQ is similar to FAAM, but is specific to leg pain. It has been found to be valid and reliable, though is not widely represented in the literature.[27] A post-intervention data collection session was performed 14 days after initial testing (pain scale, pressure-pain threshold, FAAM, FAAM Sports Subscale, EILPQ and Global Rating of Change (GROC)). The GROC allowed participants to express overall improvement or worsening of symptoms after the intervention.[28] Patients were followed for 3 months to assess recurrence of MTSS symptoms.

Intervention

The neuromuscular intervention, provided by athletic trainers (all with ≥5 years clinical experience and trained in study procedures), utilized neuromuscular facilitation and inhibition techniques common to physical medicine and rehabilitation (**Table 1**).

Phase 1

Each session in week 1 began with PNF techniques (e.g., Slow-Reversal, Hold-Relax, Contract-Relax) to relieve trigger points in the deep compartment. The flexor hallucis longus and flexor digitorum longus were targeted with 4-5 repetitions of each technique for the great toe and then for the lesser toes (as a group). Release techniques were followed by re-education, or facilitation, of the toe extensors and intrinsic foot muscles. Participants were seated with the foot flat on the floor and instructed to extend the great toe without moving the lesser toes. Visual and tactile stimulation, passive positioning, and isometric and eccentric contractions were employed to assist skill acquisition. When participants could extend the great toe without extraneous movement of the lesser toes, they alternated to extending the lesser toes without tensing or flexing the great toe and/or arch. Participants in the NMTx group performed exercises daily (Monday – Friday) under the supervision of the treating athletic trainer and again a second time in the evening unsupervised.

Phase 2

In the second phase, PNF stretching techniques and toe extension exercises continued. Manual resistance was added and, in some instances, light resistance facilitated extension. The participant was instructed in the short foot exercise (SFE), increasing IFM activity with a submaximal contraction. The participant

Table 1. Intervention exercises

Exercise	Volume	Intensity
Relieve trigger points in deep compartment [a]		
slow-reversal	4-5 reps	low to moderate
contract -relax	4-5 reps	low to moderate
hold-relax	4-5 reps	low to moderate
Activate inhibited muscles		
Passive positioning, tactile stimulation, eccentric contraction; progress to concentric [a]	2 sets to fatigue	Minimal resistance; high mental focus
Manual resistance [b]	2-3 sets 5-15 reps	Low to moderate
Short-foot exercise seated [b]	2 sets 5-15 reps	Low
Stretch shortened structures: low-load long-duration (slant board) [a]	3-5 min	Low
Incorporate functional activity [c]		
Short foot exercises standing, progress to staggered stance;	10 X 10s progress as tolerated	Low to moderate
Resisted inversion, eversion, dorsiflexion	2 x 8-15 reps	Low to moderate

[a] Phase 1 (days 1 and 2)
[b] Phase 2 Initiate manual resistance and SFE; continue with phase 1 exercises (days 3-5)
[c] Phase 3 Initiate functional activity and continue with slant board stretching (days 8-14)

attempted to draw the heads of the metatarsals toward the calcaneus without toe activity. The SFE was introduced with the participant in a seated position with the foot on the floor. Passive modeling was utilized to facilitate exercise.

Phase 3

In Phase 3, PNF release techniques were discontinued; resisted toe extension exercises were continued. The SFE was advanced to the standing position, where the participant was instructed to assume the short foot position and hold it while in a weight bearing stance. Resisted inversion, eversion, and dorsiflexion exercises for the extrinsic muscles of the foot were introduced. Treatment sessions included 3-5 minutes of static stretching for the gastrocnemius-soleus complex after completing exercises.

No taping, bracing, or orthoses were used to address MTSS symptoms. Further, no restrictions on training and exercise were imposed on the participants; normal athletic participation was encouraged.

The CON group did not receive the neuromuscular intervention (i.e., PNF techniques and IFM exercises); rather, they followed an individualized prescription from their providers. This treatment represented the "usual treatment" for this condition and included rest, various therapeutic modalities, stretching, and/or strengthening of the leg muscles.

Means and standard deviations were calculated for baseline and post-intervention measures. A one-way analysis of variance (ANOVA) was performed to evaluate group differences at baseline and to evaluate differences in change scores. Change scores were calculated by subtracting the baseline score from the post-intervention score. Pain at rest was not included in the change score analysis as pre-test ratings were minimal at baseline (<1.5), limiting meaningful change. Wilcoxon signed-rank tests were used to analyze results for ordinal data for Level of Function and GROC. A minimal clinically important difference (MCID) was calculated using participant report of global improvement (GROC) and change scores. Effect sizes

 ISSN Online 2577-8188

(omega squared) were calculated using an interpretation of small (0.01), medium (0.06), or large (0.14).[29] Statistical analyses were performed using SPSS Version 27.0 (IBM, Armonk, NY) and level of significance was set at $P<.05$.

RESULTS

Twenty-seven athletes initially presented to one of the athletic training clinics with a chief complaint of exercise-related medial leg pain and trigger points in the soft tissue of the medial aspect of the leg. Complaints were bilateral in 15 (55.5%) participants; 5 (18.5%) were left-sided and 7 (26%) right-sided; 81% (22/27) demonstrated IFM dysfunction (defined above). Seven participants in the NMTx group withdrew from the study due to scheduling conflicts (n=4) or were withdrawn for a failure to complete >50% of physical rehabilitation sessions (n=3). Twenty participants (mean 19.6, SD 1.43 years) provided complete, usable pre- and post-test data.

The sport and sex distribution differed between the NMTx group (n=14; 35% female) and the CON group (n=6; 100% female) (**Table 2**). The NMTx group included football, soccer, swimming, baseball, and track & field athletes, while the CON group included basketball, cross-country, and track & field. The CON group reported a longer duration of symptoms (approximately 10 days longer) prior to treatment *(P=.05)* One hundred percent (100%) of the CON group (6/6) and 65% of the NMTx group (9/14) demonstrated IFM dysfunction at baseline. There were no significant differences in pain or patient-reported outcome measures at baseline (**Table 3**).

Table 2. Participant Characteristics at Baseline

	Control Baseline Average (SD)	NMTx Baseline Average (SD)	95% Confidence Interval	*P* value
Age (years)	19.8 (1.47)	19.5 (1.45)	-1.16, 1.82	.64
Duration of symptoms (days)*	25.33 (5.1)	14.8 (11.5)	0.09, 21.00	.05
IFM Dysfunction	100% (n=6)	64% (n=9)		
Sex				
Male	0	9		
Female	6	5		

SD, Standard Deviation; IFM, Intrinsic Foot Muscle; *Statistically significant difference

Change scores for pain related measures were significantly different between groups after the 2-week intervention. The NMTx group improved significantly on pain during ADLs, pain during activity, and pressure-pain threshold; no significant differences were observed in CON (**Figure 1**, **Table 4**). NMTx also reported significant improvement in FAAM Sports Subscale; EILPQ difference was not significant, though a large effect size is noted (**Figure 2**, **Table 4**). Overall, medium (0.06) to large (0.14) effect sizes were noted for NMTx, indicating substantial change from baseline independent of sample size differences.

A significant difference was found between groups on a 5-point GROC. All participants in the NMTx group reported being "a little better" (n=4) or "a great deal better" (n=10); in the CON group, 1 participant reported being "a great deal better," 2 reported being "a little better," 2 reported "no change," and 1 reported being "a little worse" at 2 weeks ($z = -2.66$, $P=.008$). Similarly, NMTx reported significant increase in self-reported level of function on the FAAM Sports Subscale compared to CON (NMTx $z= -2.92$; $P=.004$; CON $z=1.00$; $P=.32$) (**Figure3**). In addition, none of the NMTx group (0/14) demonstrated IFM dysfunction after the intervention period, though dysfunction persisted in the CON group (6/6). Recurrence of MTSS symptoms during the 90-day follow-up was reported by 7% (n=1) of the NMTx group and 83% (n=5) of the CON group.

Table 3. Patient-Reported Outcomes Baseline Measures

	Control Baseline Average (SD)	Experimental Baseline Average (SD)	95% Confidence Interval	*P* value
Pain at rest	1.0 (1.26)	1.43 (1.22)	-1.69, 0.84	.49
Pain in ADL (0-10)	2.5 (1.05)	3.1 (1.38)	-1.90, 0.76	.38
Pain ACT (0-10)	6.8 (1.27)	6.43 (1.46)	-1.34, 2.15	.63
PPT (kg)	2.58 (0.64)	2.61 (1.45)	-1.34, 1.29	.97
FAAM (%)	83.67 (9.80)	79.43 (13.90)	-9.02, 17.49	.51
FAAM Function (%)	90.33 (4.90)	88.29 (11.10)	-8.96, 11.06	.83
FAAM Sport (%)	59.33 (13.40)	47.86 (15.2)	-3.64, 26.60	.13
FAAM Sport Function (%)	66.7 (15.30)	75.36 (9.10)	-20.17, 2.79	.13
EILPQ	62.83 (11.90)	56.11 (16.50)	-9.03, 22.48	.38

Abbreviations: SD, standard deviation; ADL, activities of daily living; Pain ACT, pain during activity; PPT, pressure-pain threshold; FAAM, Foot and Ankle Ability Measure; FAAM Sport, Sport Sub-scale; EILPQ, Exercise-Induced Leg Pain Questionnaire.

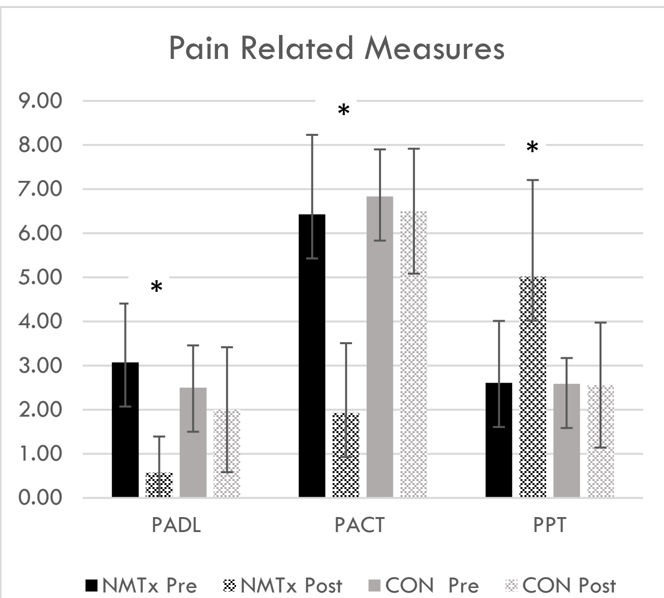

Figure 1. Pain related mean scores Pre- Post-Intervention; bars represent standard deviation.
Abbreviations: PADL, pain activities of daily living; PACT, pain during activity; PPT, pressure-pain threshold.
*Statistically significant change *P*≤.05

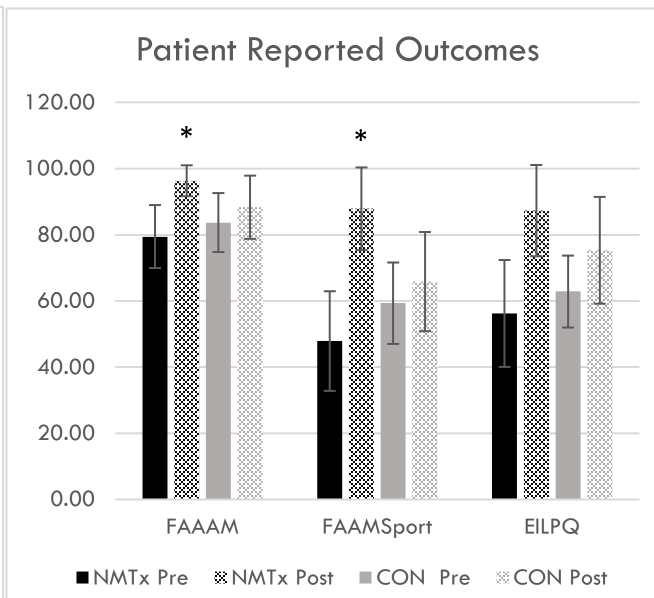

Figure 2. Patient Reported Outcomes mean scores Pre-Post-Intervention; bars represent standard deviation. Abbreviations: FAAM, Foot & Ankle Ability Measure; FAAM Sport, Sub-scale; EILPQ, Exercise Induced Leg Pain Questionnaire. *Statistically significant change *(P*=.001)

A significant difference was found between groups on a 5-point GROC. All participants in the NMTx group reported being "a little better" (n=4) or "a great deal better" (n=10); in the CON group, 1 participant reported being "a great deal better," 2 reported being "a little better," 2 reported "no change," and 1 reported being "a little worse" at 2 weeks (z = -2.66, *P*=.008). Similarly, NMTx reported significant increase in self-reported level of function on the FAAM Sports Subscale compared to CON (NMTx z= -2.92; *P*=.004; CON z=1.00; *P*=.32) (**Figure3**). In addition, none of the NMTx group (0/14) demonstrated IFM dysfunction after the intervention period, though dysfunction persisted in the CON group (6/6). Recurrence of MTSS symptoms during the 90-day follow-up was reported by 7% (n=1) of the NMTx group and 83% (n=5) of the CON group.

Table 4. Change in Pain and Patient-Reported Outcomes Scores From Baseline to 2-weeks

	Control Change Average (SD)	Experimental Change Average (SD)	*P* value	Effect size ω^2	95% CI
Pain in ADL (0-10)	-0.50 (2.16)	-2.50 (1.51)*	.03	0.19	-0.05, 0.46
Pain ACT (0-10)	-0.33 (1.86)	-4.50 (1.99)*	<.001	0.48	0.10, 0.67
PPT (kg)	-0.03 (0.70)	2.41 (1.36)*	.001	0.44	0.07, 0.66
FAAM (%)	4.67 (12.96)	16.86 (12.88)*	.06	0.12	-0.05, 0.39
FAAM Function (%)	-0.33 (7.12)	8.93 (10.01)	.06	0.14	-0.05, 0.41
FAAM Sport (%)	6.50 (15.42)	40 (18.93)*	.001	0.40	0.04, 0.63
FAAM Sport Function (%)	10 (18.71)	16.57 (11.84)	.35	-0.004	-0.05, 0.25
EILPQ	12.50 (18.39)*	31.07 (20.11)*	.07	0.12	-0.05, 0.39

Abbreviations: SD, standard deviation; ADL, activities of daily living; Pain ACT, pain during activity; PPT, pressure-pain threshold; FAAM, Foot and Ankle Ability Measure; FAAM Sport, Sport Sub-scale; EILPQ, Exercise-Induced Leg Pain Questionnaire
*Exceeds Minimal Clinically Important Difference for this measure

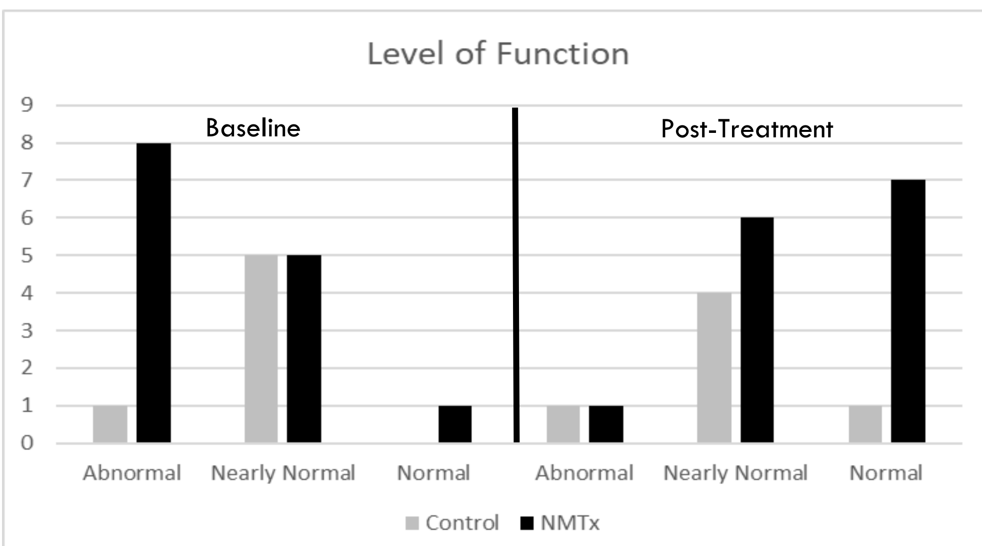

Figure 3. Level of Function. Comparison of the frequency of patient-reported level of function pre- and post-intervention. Wilcoxon signed-ranks CON *P*=.32; NMTx *P*=.004

The minimal clinically important difference (MCID) was calculated by comparing the difference in mean change scores for participants reporting they were at least "a little better" after the 2-week intervention.[30] For pain during ADLs, MCID was 1.2; for pain during activity, it was 2.5; and for pressure-pain threshold, it was 2.0 kg. For patient-reported outcomes, MCID was 10 points for FAAM; 15 points for FAAM Sports Subscale, and 12 points for EILPQ. NMTx exceeded MCID for each of these measures; CON did not meet MCID for any measure other than EILPQ (**Table 4**).

DISCUSSION

This study describes outcomes after a 2-week neuromuscular-based intervention designed to alleviate MTSS by relieving trigger points and improving IFM function among intercollegiate athletes. Releasing trigger points in the deep compartment may be central to reducing pain in sport activity. However, this effect may have been limited without efforts to prevent recurrence of the development of trigger points. The toe extension exercises as described can induce reciprocal inhibition of the toe flexors to prevent recurrence of trigger points while also engaging the IFM.[31] The SFE requires increased activation of the IFM and executing SFE in a standing position is a standard progression for increased load and IFM activation.[31,32]

While all participants reported some improvement after 2-weeks of treatment, those in the NMTx group demonstrated greater reduction in self-reported pain during activity and increased perceived sport function. They also rated their overall condition as being improved more than the CON group at the end of two weeks and had minimal recurrence of MTSS symptoms over the 90-day follow-up program.

The groups were similar relative to pain and function at baseline, though the average duration of symptoms for the CON group was approximately 10 days greater than the NMTx group. The clinical importance of this difference is not clear. Intuitively, one might expect a longer duration of symptoms to lead to a longer recovery period. Yet, multiple studies of MTSS interventions have found no relationship between duration of symptoms and time to recovery, functional outcomes, or numeric pain scales.[12,21,22]

At the conclusion of a 2-week intervention, all participants in the NMTx group reported improvement ("a little" to "a great deal") on the GROC, while only half of the CON group did. Further, the NMTx group reported an 80% reduction in pain during ADLs and a 62% reduction in pain during sport activity after the 2-week neuromuscular intervention. The CON group reported minimal reductions in pain during ADLs and sport activity (0.5% and 2%, respectively). An earlier study, also focused on restoring IFM function in patients with MTSS, reported a 50% reduction in pain during sport activity after a 14-day intervention.[16] In contrast, a study utilizing extrinsic muscle stretching and strengthening program resulted in only a 14% reduction in pain at 4 weeks and fewer than half of participants returning to preferred sport activity at 15 months.[13]

The NMTx group participants were never removed from activity and were encouraged to participate in activity as tolerated. This is contrary to traditional interventions that call for a 7-10-day rest period with a 50% reduction in physical training intensity in the sub-acute phase.[4,33,34] In this study, no NMTx participants refrained from training or competitions. Conversely, all CON group participants reported a period of rest, though all had resumed sport activity to some degree before the end of the 2-week intervention. The potential for patients with MTSS to realize a significant reduction in pain without being prohibited from training may result in better reporting and better compliance with the intervention.

Participant perception of function was captured with the FAAM, FAAM Sports Subscale, and EILPQ. All participants perceived some limitation in ADLs (FAAM) and sport activity (FAAM Sport and EILPQ) secondary to leg pain. Sport activity was, predictably, more limited than ADLs. The NMTx group realized a 40-point gain in FAAM Sports Subscale and a 32-point gain in EILPQ after intervention. The FAAM Sports Subscale and EILPQ have very similar questions with EILPQ adding items regarding exercise of increasing duration, but omitting items related to activities outside of sport. Scores increased on each patient-reported outcome between time points with increases well beyond MCID.

The degree of recovery in the NMTx group observed at 2 weeks represents a substantially shorter recovery period than one might expect. Prospective studies of novice runners have established recovery times of approximately 10 weeks, while military recruits demonstrated recovery at 8-11 weeks.[22-24,35] Studies of graduated running programs with or without ESWT demonstrated recovery at 2-14 weeks.[11,12,21] Sharma et al, pointing to the burden of MTSS, urged re-examination of current approaches to management of this condition.[35] The current study describes a different approach that may result in shorter recovery time.

IFM exercise may be an important addition to MTSS rehabilitation. Training the IFM may provide the dynamic support individuals with MTSS are lacking.[36,37] With 2 weeks of training, it is not likely that muscle hypertrophy has occurred; rather, we suggest a neuromuscular adaptation leading to improved muscle recruitment. IFM training has been found to decrease navicular drop and improve foot posture in uninjured subjects.[36] We did not measure foot posture or navicular drop in this study; however, we observed IFM dysfunction in approximately 80% of patients with MTSS. Bandholm et al, reported increased navicular drop and medial longitudinal arch deformation during quiet standing and during gait in subjects with MTSS compared to controls.[38] This may be related to inversion strength deficits associated with MTSS.[39] Given the role of inverters in providing dynamic support for the medial longitudinal arch, it is logical that extrinsic muscle strengthening would be beneficial for individuals with MTSS; however, results of extrinsic strengthening are unimpressive.[11-13,22,34] Restoring IFM function can provide sensory and motor input that is integrated into dynamic control.[40]

The results of our study support a more comprehensive approach with resolving the trigger points in the deep compartment, restoring IFM function, and strengthening the extrinsic muscles. The persistence of the effect of this intervention suggests the intervention goes beyond temporary pain relief to realize resolution of IFM dysfunction and restoration of muscle balance. IFM exercises have not previously been reported as an intervention for MTSS.

Limitations

This study was limited by a small sample size and unequal groups. Further, 7 participants (26%) did not complete the study. Two contributing factors were an unexpected reduction in patients presenting with MTSS during the 18-month study period and changes in professional healthcare staff, limiting the availability of personnel trained in the intervention and/or willing to adopt this approach to treatment. However, we feel the magnitude of improvement and persistence of effect allow these findings to contribute to clinical practice. The difference in duration of symptoms cannot be ignored, but it is difficult to know the accuracy of reporting and the effect a 10-day difference might have. An additional limitation was the representation of females in the NMTx (35%) and CON (100%) groups. Female sex has been identified as a risk factor in some studies and some literature has reported a longer recovery time for females.[2,12,41,42] The small sample size limited gender comparisons in this study. It is possible that allowing a longer treatment period may have benefited female participants.

CLINICAL APPLICATION

The intervention used in this study provided significant improvement in pain and functional measures in athletes with MTSS within 2 weeks that persisted for more than 90 days. These improvements were well beyond MCID with large effect sizes observed for measures associated with physical activity. The approach, focused on relieving trigger points in the deep compartment and improving IFM function, required no elaborate equipment, allowing application in a variety of settings. The persistence of effect is of consequence to clinicians and patients who can be frustrated by the recurrent nature of this condition.

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