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What are the effects of the MyoKinesthetic system on Medial Tibial Stress Syndrome in high school athletes?

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ABSTRACT

Introduction: Medial Tibial Stress Syndrome (MTSS) is a painful overuse stress injury that plagues many athletes in the secondary school population. MTSS affects up to 20 % of runners and females more than their male counterparts. Best practice standards for the treatment of MTSS do not exist in current literature. The MyoKinethetic system (MYK) is a global treatment paradigm that targets the nerve root responsible for compensations. The objective of this study is to evaluate the effect of MYK treatment on pain and function in the high school population with MTSS symptoms.

Method: A multiple-site case series was conducted with a convenient sample of ten patients with MTSS ages 14–18. An MYK postural analysis was performed on high school-aged patients by a clinician trained by the creator of the MYK system. Numerical Pain Rating Scale (NPRS) and Patient Specific Function Scale (PSFS) were collected pretreatment and post-treatment for a maximum of seven treatments.

Results: A repeated measure ANOVA was utilized to assess change. There was a significant main effect for time with the NPRS ($F_{(5,45)} = 7.783$, $p < 0.001$, $\eta^2 p = 0.28$) and the PSFS scores ($F_{(5,45)} = 9.606$, $p < 0.001$, $\eta^2 p = 0.27$).

Conclusion: The MYK treatment was successful in the treatment of MTSS symptoms in the high school population and should be considered a possible treatment option for patients, especially those that participate in sports. More research is needed to assess the effectiveness of the MYK treatment.

1. Introduction

Medial Tibial Stress Syndrome (MTSS) is an overuse or repetitive stress injury of the posteromedial tibial region commonly characterized by exercise-induced pain over the anterior medial tibia (Franklyn and Oakes, 2015; McClure and Oh, 2022; Deshmukh and Phansopkar, 2022; Martinez et al., 2019; Moen et al., 2012; Winters, 2020). Multiple studies have investigated the varying pathological causes for posteromedial tibial pain symptoms of MTSS. The primary symptoms of MTSS result from the muscle fibers pulling on the articular cartilage of the tibia, causing inflammation and pain (Schlereth and Birklein, 2007). MTSS pain is most common in the distal third of the tibial on the medial side (Deshmukh and Phansopkar, 2022). MTSS is often present in individuals who perform continuous impact exercises such as running and jumping. MTSS has a moderate incidence rate in runners of 13.6–20 % (McClure and Oh, 2022). This pathology is more common in females, about 55.3 %, whereas it affects males about 44.7 % of the time (Deshmukh and Phansopkar, 2022). There is a lack of research reporting on the prevalence of MTSS in the high school population; in a cohort study by Yagi et al. (2012), the researchers found that 44 % of high school runners reported MTSS symptoms over eight years.

Efforts to determine possible causes of MTSS examined muscle attachments to the posterior medial tibia found that the soleus and flexor digitorum longus were the primary muscles found along the posteromedial tibia which could indicate could indicate that MTSS symptoms could be due to multiple muscles pulling on the bone compared to a singular muscular attachment (Franklyn and Oakes, 2015; Beck and Osternig, 1994; Saxena et al., 1990). Another possible cause for MTSS is muscle imbalance and inflexibility of the triceps surae. Patients with muscle weakness or imbalances of muscle fiber type in the triceps surae are prone to muscle fatigue, leading to altered running mechanics (Beck BR 1998 Tibial stress injuries) and postural imbalances.

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Postural compensations can result in altered mechanics, leading to increased muscle fatigue (Beck and Osternig, 1994). Muscle fatigue can impact the spinal neuromuscular control mechanisms responsible for regulating muscle movement (Schwellnus, 2009). More specifically, it can interfere with the function of the peripheral muscle receptors by causing a decrease in muscular force, pain, soreness, and cramping (Schwellnus, 2009). When these receptors are disrupted, they can cause an increase in the firing rate of the muscle spindles or decrease the activity of type B afferent nerves from the Golgi tendon organs (Schwellnus, 2009). This can result in various symptoms, including muscle tension, weakness, and an inability to maintain proper posture. As muscle fatigue progresses, it can increase excitatory signals and decrease inhibitory signals to the alpha motor neurons (Schwellnus, 2009). Additionally, muscle fatigue can cause an increase in sympathetic nerve activation and a decrease in parasympathetic nerve activation (Tanaka et al., 2015). Despite these challenges, the body's initial response to muscle fatigue is to compensate and maintain allostasis within the nervous system.

There is minimal published research on a global treatment model for this potentially systemic problem, such as treating the nervous system. The MyoKinthestic System™ (MYK), developed by Dr. Michael Uriarte, is a global assessment and treatment model used to restore the body to allostasis by correcting postural imbalances (Moen et al., 2012; Brody et al. 2017; Brody et al., 2015a,b; Martinez et al., 2020). In the MYK

HEAD			**LUMBAR SPINE**
Extension	_____ (C1–C3)	(L1–L5)	_____ Flexed
Flexion	_____ (C1–T1)	(L1–L2)	_____ Extended
Rotation	_____ (C1–T1)	(L1,L2)	_____ Lateral flexion
Lateral flexion	_____ (C1–T1)	(L1–L5)	_____ Rotation
SCAPULA			**HIP**
Elevated	_____ (C3,4)	(L5,S1)	_____ Anterior rotated (flexion)
Depressed	_____ (C3–C5)	(L1,2,3,4,5)	_____ Posterior rotated (extension)
Protracted (abducted)	_____ (C3–C5)	(L2,L3)	_____ Downslip (abduction)
Retracted (adducted)	_____ (C5–C8)	(L4,L5)	_____ Upslip (adduction)
Upward rotated	_____ (C3–C8)	(L2,3,4,5,S1)	_____ Lateral rotated
Downward rotated	_____ (C3–C7)	(L5,S1)	_____ Medial rotated
SHOULDER			**KNEE**
Flexed	_____ (C5–C8)	(L3,L4)	_____ Flexed
Extended	_____ (C5–C8)	(S1)	_____ Extended
Depressed (abducted)	_____ (C5–C8)	(L2,L3,S1)	_____ Externally rotated
Elevated (adducted)	_____ (C5–C6)	(S1)	_____ Internally rotated
Medial rotated	_____ (C5–C6)		
Lateral rotated	_____ (C5–C8)		
ELBOW			**ANKLE**
Flexed	_____ (C7–C8)	(L4)	_____ Planter flexed
Extended	_____ (C5–C7)	(S1,S2)	_____ Dorsiflexed
		(L4)	_____ Everted
FOREARM		(L4)	_____ Pronated
Supinated	_____ (C6–T1)	(L5,S1)	_____ Inverted
Pronated	_____ (C5–C6)	(L5,S1)	_____ Supinated
WRIST			**BIG TOE**
Flexed	_____ (C6–C8)	(L5)	_____ Flexion
Extended	_____ (C6–T1)	(S1,S2)	_____ Extension
Radial deviated	_____ (C7–C8)	(S1,S2)	_____ Hallux varus/abduction
Ulnar deviated	_____ (C6–C7)	(L5,S1)	_____ Hallux valgus/adduction
THUMB			**TOES**
Flexed	_____ (C7–T1)	(L5)	_____ Flexed
Extended	_____ (C6–T1)	(S1,S2)	_____ Extended
Abducted	_____ (C8–T1)		
Adducted	_____ (C6–T1)		
FINGER			
Flexed	_____ (C6–T1)		
Extended	_____ (C7–T1)		
Abducted	_____ (C8–T1)		
Adducted	_____ (C8–T1)		

Fig. 1. MYK postural assessment chart.

evaluation, postural imbalances are deviations in posture stemming from a specific nerve root(s). When posture imbalances occur, they may result in noticeable and measurable compensations such as navicular drop and hip external rotation, which may be associated with MTSS symptoms (McClure and Oh, 2022). MYK is based on the neuromuscular system and uses a unique postural examination to identify postural abnormalities that may result from deficiencies in the nervous system (Moen et al., 2012; Brody et al. 2017; Brody et al., 2015a,b; Martinez et al., 2020). Clinicians use a postural chart to detect the static postural compensations and determine which nerve root they originate from (Fig. 1). According to the paradigm, the pathway containing the greatest number of imbalances drives pain and dysfunction. Compensations within the human body are common; however, if they result in any noticeable symptoms, they should be appropriately addressed.

The central nervous system functions as a feedback loop; it receives information from all parts of the body and then sends signals to the brain, which ultimately sends signals back down to the problem areas (Uriarte, 2014). Intrinsic and extrinsic factors are thought to play a role in MTSS. Intrinsic factors include sex, history of MTSS, high body mass index (BMI), navicular drop, ankle plantar flexion range of motion, excessive protonation at the talocrural joint, and hip external range of motion. The extrinsic factors include poor footwear, abnormal diffusion of ground reaction forces, changes in running surfaces, hard running surfaces, and poor running fundamentals (McClure and Oh, 2022). These factors start the feedback loop where the sensory neurons indicate a problem and send afferent impulses to the spinal cord and brain. The brain responds and closes the loop by sending efferent impulses to the problem area, causing muscle activation and movement compensations (Uriarte, 2014). Continued compensation may result in the development of the MTSS symptoms identified through the MYK postural analysis. The MYK treatment corrects the feedback loop, resulting in symptom resolution (Uriarte, 2014).

In five articles, Moen et al., 2012, Brody et al., 2015a,b, Brody et al., 2017 and Martinez et al., 2020, found that:

MYK is designed to stimulate all the muscles innervated by a specific nerve root. The clinician stimulates mechano- and sensory receptors

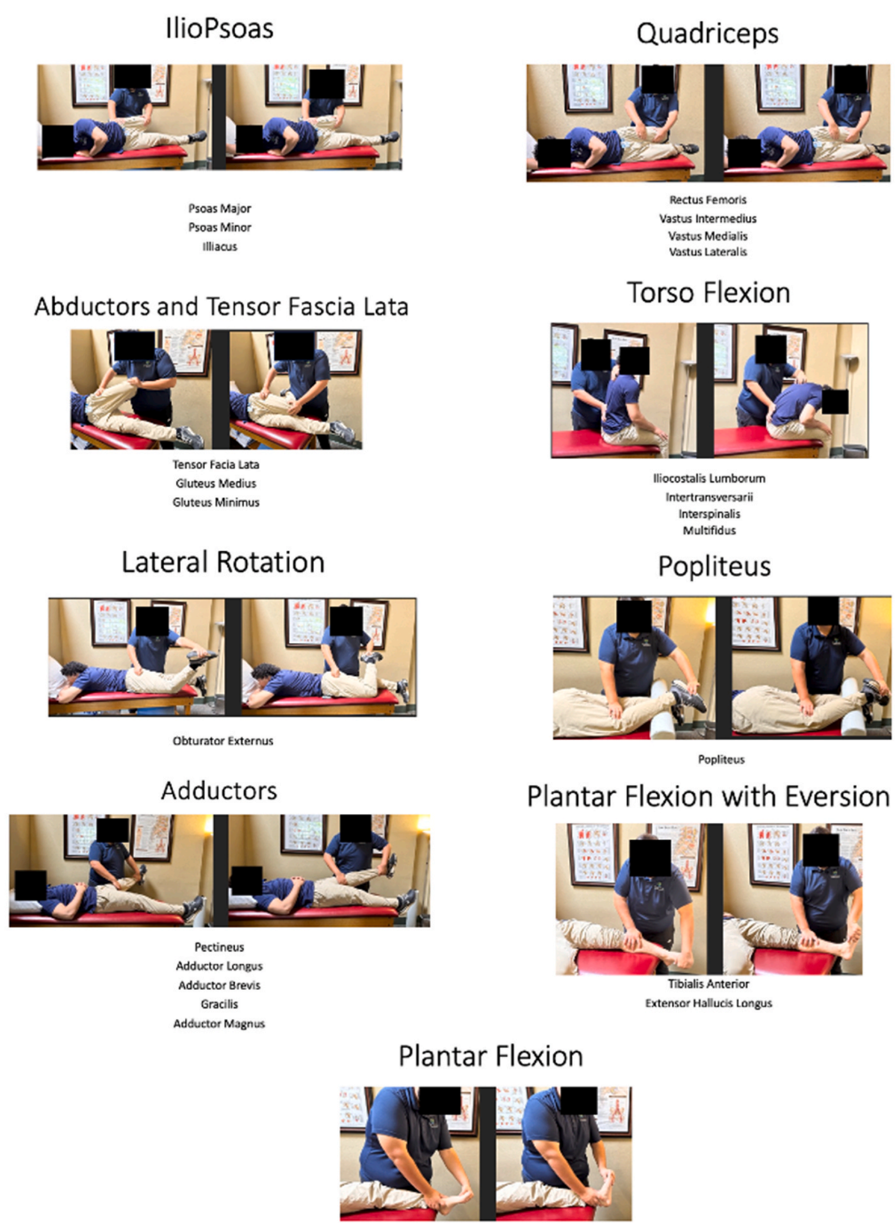

Fig. 2. L4 Treatment stimulated musculature.

through the patient's active and passive functional range of motion and tactile stimulation while simultaneously applying the stimulation to increase the "communication" between that region of the body and the central nervous system. Tactile stimulation provided by the clinician is performed along the muscles of the nerve root pathway. The tactile stimulation was provided through light pressure by not blanching the fingertips. Fig. 2 displays the L4 nerve root treatment. The purpose of the active and passive movements, and the tactile sensation, is to activate the spinothalamic tracts along the spinal cord, which are sensitive to touch. In contrast, the spinocerebellar tracts are stimulated by movement. As communication normalizes between the afferent and efferent pathways, the kinetic chain is restored to allostasis by eliminating postural abnormalities predisposing the body to injury and pain.

To the best of our knowledge, only two studies have investigated MYK as a potential treatment for MTSS. Martinez et al. (2020) investigated MYK in a case study that successfully treated two competitive athletes. Martinez et al. (2019) completed a multi-site study that investigated the effectiveness of MYK on pain and disablement without the cessation of activity. After eight treatments, all the patients met discharge criteria over a roughly 14-day timespan.

The limited data on neurological treatment paradigms for pain modulation in patients with MTSS indicates the need for research to investigate the possibility of MYK as an effective treatment for the cause of MTSS, not just the symptoms. This study examines the effects of the MYK nerve root treatment on pain and function in high school student-athletes experiencing MTSS symptoms.

2. Methods

2.1. Design

This was a multi-site case series conducted at four secondary school athletic training clinics in three states. Treatments were provided by four certified athletic trainers (three male and one female) with a mean of five years of professional experience. All clinicians received 40 h of instruction from Dr. Michael Uriarte, the creator of the MYK System, which included the MYK upper and MYK lower courses. All clinicians are novice MYK practitioners.

2.2. Patients

All patients and their legal guardians completed informed consent. Patients were selected from convenient sampling over a four-month period, of athletes who presented to the clinic with MTSS symptoms from the high school athletic population. All patients that presented to the clinic that met inclusion and did not meet exclusion criteria were asked to participate in the study. Patients ranged from 14 to 18 years of age and were physically active for at least 300 min a week, participating in interscholastic competitions that were repetitive weight-bearing activities. Patient inclusion criteria were based on the orthopedic evaluation for MTSS (Yates and White, 2004). Inclusion criteria were patients who were experiencing $\geq$ two weeks of pain, $\geq$ 5 cm of pain over the posterior medial border of the tibia, an NPRS score $\geq$2, and pain induced by exercise for a period $\geq$ 1 h. Exclusion criteria were concurrent leg pathologies, pregnancy, open skin lesions, paresthesia, and cancer.

2.3. Procedure

A standard orthopedic exam was used to diagnose MTSS. The physical exam included palpation of the posterior medial tibial border. If recognizable pain was absent during palpation for at least five consecutive centimeters, other leg pathologies, including radicular symptoms, were considered, and the patient was excluded from the current study (Winters, 2020). Common differential diagnosis included but not limited to fracture, muscle strain, ligament sprain, and compartment syndrome. Patients performed a single leg hop test and presented negative with Ottawa ankle rules to rule out a fracture. The single leg hop test has a sensitivity of 100 % and a specificity of 45 % to rule out stress fractures when patients presented with pain and tenderness (Milgrom et al., 2021). Once diagnosed, the MYK postural assessment (Fig. 1) was used to identify nerve root dysfunction for each patient. While the patient was standing comfortably, the clinicians identified postural compensations bilaterally by utilizing the MYK postural chart (Fig. 1). Treatments were structured to conclude after 14 days (about two weeks) or until the patient met discharge criteria, in which treatments were stopped. Patients were instructed to continue activity as tolerated and to not change their training schedule or modify their daily life which was monitored through patient reporting.

The MYK treatment includes tactile stimulation with active and passive movements to stimulate the muscles innervated by the specified nerve root (Fig. 1). Dr. Michael Uriarte, the creator of the MYK systems, reports that the pressure and type of tactile stimulation do not affect treatment outcomes (Michael Uriarte, DC, interview March 23, 2023). Inter-rater reliability was established by meeting with Dr. Uriarte and the four clinicians. During the meeting, Dr. Uriarte demonstrated his technique while the four clinicians mirrored his demonstration with synonymy.

If multiple nerve roots are identified with the MYK assessment, the superior nerve is treated following Dr. Uriarte's treatment protocol (Michael Uriarte, DC, interview March 23, 2023). After determining the treatment based on the postural assessment, the clinicians followed a video instruction from the "The MYK Brain". The MYK Brain, developed by Dr. Uriarte, is a website tool designed to assist the clinician with diagnosing and treating a nerve root after performing the postural assessment. The MYK Brain provides video instruction and tutorials that each clinician followed during the treatment session. Each treatment lasted about 15 min and was applied bilaterally despite some patients only having pain unilaterally. Stimulation was provided during passive movements followed by the active motion of the muscle for seven repetitions.

2.4. Measurement methodology

The primary outcome measures, Numerical Pain Rating Scale (NPRS) and the Patient Specific Function Scale (PSFS) were collected at intake, before and after the treatment of each follow-up visit, and at discharge. Patients were discharged when pain was reported to be $\leq$ 1 and a PSFS-reported score of $\geq$7 so that patients could reach the minimally clinically important difference (MCID) (Williamson and Hoggart, 2005; Ferreira-Valente et al., 2011; Hawker et al., 2011; Johnson, 2005 Fairbairn et al., 2012; Horn et al., 2012). Patients were treated every 48 h for seven treatments unless they met discharge standards before the seventh treatment. Dr. Uriarte recommended five to seven treatments as best practice (Michael Uriarte, DC, interview March 23, 2023).

The NPRS is a validated subjective patient-perceived pain scale from zero to ten (Williamson and Hoggart, 2005; Ferreira-Valente et al., 2011). Zero on the scale represents that the patient is not experiencing any pain, while ten represents intense pain that the patient describes as the "worst pain imaginable" (Hawker et al., 2011). The NPRS has a test-retest reliability of 0.79–0.96 with patients with chronic pain (Cheatham et al., 2018). A decrease of two points indicates MCID (Williamson and Hoggart, 2005; Ferreira-Valente et al., 2011; Hawker et al., 2011; Johnson, 2005). Pre- and post-intervention NPRS scores were recorded in a stationary weight-bearing position for every treatment session through the patient's discharge.

The PSFS assesses patients' perceived ability to function on specific, meaningful activities or tasks (Fairbairn et al., 2012; Horn et al., 2012). Patients are asked to identify at least three meaningful tasks they have difficulty performing or completing due to the injury/problem (Fairbairn et al., 2012; Horn et al., 2012). After selecting the meaningful activities, patients used an 11-point scale to rate each activity, where zero indicates the patient is "unable to perform the activity" to ten, which indicates the patient is "able to perform the activity at the same level as before injury or problem" (Horn et al., 2012). The MCID for the PSFS ranges from two to three points and is responsive to specific conditions (Fairbairn et al., 2012; Horn et al., 2012). Within this study, an MCID of three points was valued as a meaningful change based on the findings of Fairbairn et al., (2012); Hefford et al. (2012); Horn et al. (2012). Neurological and musculoskeletal rehabilitation programs similarly benefit from using the PSFS as a patient-centered outcome measure (Horn et al., 2012).

2.5. Statistical analysis

Data was analyzed using R™ statistical software version 4.3.3. Means and Standard Deviations were also calculated for each outcome from intake to discharge. The alpha was set at $\alpha < 0.05$ to indicate statistical significance for all tests. A repeated measures (RM) ANOVA was performed before and after the first three treatments for both the NPRS and PSFS to assess change over multiple time points. The RM ANOVA was only performed before and after the first three treatments because some patients were discharged after the third treatment while others were not, and the RM-ANOVA cannot account for missing data points. Significant main effects were followed up with paired t-tests and Bonferonni corrections. Data was analyzed for normality using the Shapiro-Wilks test and for sphericity using Mauchly's test.

3. Results

A clinically meaningful difference was noted between the intake and discharge of each patient, as determined by MCID for the NPRS and PSFS. The mean difference for the NPRS (Table 1) between pre-treatment one and at discharge was a difference of −5.8 ± 1.95, indicating a 5.8 reduction in pain. The mean difference for the PSFS (Table 1) between pre-treatment one and discharge was 4.6 ± 1.62, indicating a 4.6 increase in function. The average number of treatments from intake to discharge was 3.7 ± 1.1.

At initial evaluation, the postural assessment showed 90 % (N = 9) of patients with S1 nerve root dysfunction and 10 % (N = 1) with a L4 nerve root dysfunction. All patients were treated until they met discharge criteria. 100 % (N = 10) of patients had at least three treatments. 50 % (N = 5) of patients had a fourth treatment. 20 % (N = 2) of patients had a fifth treatment, and 10 % (N = 1) had a sixth treatment. All patients met discharge criteria prior to the seventh treatment.

Shapiro-Wilk tests indicated that the data was normally distributed ($p > 0.05$) for the NPRS and PSFS scores pre and post MYK treatment. Using Mauchly's test of sphericity, the data for NPRS scores were found to have equality of variances and for the PSFS ($p > 0.05$). There was a significant main effect of time for NPRS scores ($F_{(5,45)} = 7.78$, $p < 0.01$, $\eta^2 p = 0.28$) and the PSFS scores ($F_{(5,45)} = 9.61$, $p < 0.01$, $\eta^2 p = 0.27$).

Table 1
NPRS and PSFS descriptive statistics.

Time point	N	NPRS mean	NPRS SD	PSFS mean	PSFS SD
Pre Tx 1	10	5.9	±2.6	4.6	±2.22
Post Tx 1	10	5.9	±2.92	7.3	±1.83
Pre Tx 2	10	5.1	±2.33	5.7	±2.21
Pre Tx 2	10	5.7	±2.98	7.4	±2.41
Pre Tx 3	10	3.5	±2.42	6.8	±2.10
Post Tx 3	10	1.4	±2.01	8.5	±2.17
Pre Tx 4	5	2.8	±2.23	7.2	±2.23
Post Tx 4	5	1.2	±1.47	8.6	±1.74
Pre Tx 5	2	3.5	±.5	7.5	±.5
Post Tx 5	2	1	±1	9	±1
Pre Tx 6	1	1	NA	8	NA
Post Tx 6	1	0	NA	10	NA

N- amount of patients.
Tx- treatment
SD- Standard Deviation.

Follow-up pairwise comparison tests were used to assess the main effect of time for NPRS and PSFS at the $\alpha = 0.05$ level (Table 2). All odd time points (1,3,5) signify pre-treatment time points, and even time points (2,4,6) signify post-treatment for three treatment encounters. NPRS scores showed significant differences at time points 1 and 2 (p = 0.03, d = 1.09), 1 and 4 (p<.01, d = 1.14), 1 and 6 (p<.01, d = 1.94), 3 and 6 (p = 0.03, d = 1.70). PSFS scores showed a significant difference at time points 1 and 2 (p<.01, d = −1.33), 1 and 4 (p<.01, d = −1.21), 1 and 6 (p<.01, d = −1.78), 5 and 6 (p = 0.02, d = −0.80). There was a statistically significant difference between treatments in NPRS and PSFS scores. There were two statistical outliers for the PSFS data, patients 6 and 7, patient 7 was also an outlier for NPRS.

4. Discussion

This study aimed to assess the effectiveness of MYK nerve root treatments on pain and function for patients with MTSS. The changes noted between pre- and post-treatments indicate that each treatment session successfully reduced the patient's pain and improved the patient's function per MCID criteria. Additionally, the RM ANOVA indicated a statistical main effect of time in both NPRS and PSFS scores indicating an improvement over time. At the same time, the patients continued to participate in activity and sports. The continual trend towards pain relief and improved function in patient-reported outcomes suggests that MYK may be an effective treatment for MTSS while patients are participating in sports. Patients continued to participate throughout the MYK treatment which the researchers view as a strength which can be translated into clinical practice.

Treating the patients and seeing positive results while they continued to participate differs from the treatment options established in the current literature. In only three treatment sessions, the MYK treatment showed significant improvements from traditional interventions coupled with the cessation of activities (Deshmukh and Phansopkar, 2022; Martinez et al., 2019; Moen et al., 2012; Winters, 2020). Patients treated in this study showed statistically and clinically significant improvements in their pain and function after three treatments, compared to the current literature, which states that a significantly longer treatment and recovery time for MTSS is 59–117 days (about four months) with discontinued or modified activity (Moen et al., 2012). The results of this study show that MYK can be an effective treatment for MTSS without discontinuing activity during the season. While performing a literature search in preparation for this study, researchers also noted that no other treatments allowed for continued activity while significantly reducing symptoms in six days.

The study encompassed a treatment regimen ranging from one to six sessions over a duration of 14 days, equivalent to approximately two weeks. As evidenced in Tables 1, 3 and 4, following the third treatment, 50 % of the patients in the sample cohort satisfied the discharge criteria, demonstrating a mean NPRS of 1.4 ± 2.01 and a PSFS of 8.5 ± 2.17. Subsequently, all patients met the discharge criteria by the conclusion of the seventh treatment. The average variance between intake and discharge for NPRS was −5.3 ± 1.95, and for PSFS, it was 4.6 ± 1.62, both surpassing the MCID.

Table 2
NPRS and PSFS RM-ANOVA data.

Time point	NPRS P value	NPRS Cohens d	NPRS Δ	PSFS P value	PSFS Cohens d	PSFS Δ
1–2	.03	1.09	−3	.006	1.33	2.7
1–4	.008	1.14	−3.2	.002	−1.21	2.8
1–6	.003	1.94	−4.5	.003	1.78	3.9
3–6	.029	1.7	−3.7	N/A	N/A	N/A
5–6	N/A	N/A	N/A	.018	.80	1.7

The confidence interval was set at 95 %.
p-value significance was set at .05.
N/A-Not Applicable.

Table 3
PSFS Descriptive data.

Pt No.	Tx level	Tx 1		Tx 2		Tx 3		Tx 4		Tx 5		Tx 6		Δ
		Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	
1	L4	4	8[b]	9	10	9	9	–	–	–	–	–	–	5
2	S1	4	6	5	6	7	9	4	6	8	10	–	–	6
3	S1	7	8	8	10	9	10	9	10	–	–	–	–	3
4	S1	5	8[b]	3	8[b]	8	10	–	–	–	–	–	–	5
5	S1	8	10	8	9	7	9	–	–	–	–	–	–	1
6[a]	S1	0	6[b]	3	3	3	4	–	–	–	–	–	–	4
7[a]	S1	5	7	6	7	4	5	5	7	7	8	8	10	5
8	S1	6	10[b]	7	10	6	10	–	–	–	–	–	–	4
9	S1	3	5	4	5	6	9	9	10	–	–	–	–	7
10	S1	4	5	4	6	9	10	9	10	–	–	–	–	6

Abbreviations: Pt No.- Patient Number, Tx-treatment.
Δ = change from initial to discharge.
[a] indicates outlier.
[b] indicates that MCID was met.

Table 4
NPRS Descriptive data.

Pt No.	Tx level	Tx 1		Tx 2		Tx 3		Tx 4		Tx 5		Tx 6		Δ
		Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	
1	L4	3	1[b]	1	0	0	0	–	–	–	–	–	–	−3
2	S1	8	8	7	7	0	0	7	4[b]	4	0[b]	–	–	−8
3	S1	2	1	2	1	2	0[b]	1	0	–	–	–	–	−2
4	S1	7	0[b]	7	0[b]	3	0[b]	–	–	–	–	–	–	−7
5	S1	3	0[b]	4	1[b]	4	2[b]	0	–	–	–	–	–	−3
6	S1	10	6[b]	8	8	6	5	–	–	–	–	–	–	−5
7[a]	S1	7	5[b]	4	2	6	5	3	1[b]	3	2	1	0	−7
8	S1	5	0[b]	5	0	7	0[b]	–	–	–	–	–	–	−5
9	S1	8	3[b]	7	5	3	1[b]	1	1	–	–	–	–	−7
10	S1	6	5	6	5	4	1[b]	2	0[b]	–	–	–	–	−6

Abbreviations: Pt No.- Patient Number, Tx-treatment.
Δ = change from initial to discharge.
[a] indicates outlier.
[b] indicates that MCID was met.

In the given data set, there were two statistical outliers. The findings of statistical outliers was likely due to the small sample size. These participants were kept in the analysis because their removal from the analysis did not change the statistical significance of the main effects, nor the researcher's interpretation of the data. Nevertheless, these patient cases were further examined to determine potential reasons why their data may have deviated from the group. Patient 6 was a football player patient who sought medical attention for a series of treatment sessions. The patient was a statistical outlier for PSFS (Table 3). Significant improvements were seen in the NPRS scores (Table 4) from intake to discharge with a decrease of five points. A potential reason for limited improvement in their function could be the number of days between treatment sessions. Between treatment one and two, there were five days and between treatment two and three there were three days. The patient stopped coming in for treatments due to the conclusion of their season. The patient also sought treatment following their practices which could have impacted their functional improvement. This patient was also an outlier from the treatment protocol compared to the other patients included in this study which could have impacted the patients lack improvement on PSFS as seen in Table 3. While the patient was considered an outlier, improvements were seen within the first three treatments.

Patient 7 was also a statistical outlier as they did not follow the treatment program to the same extent as the other patients in this study. Patient 7 reported an increase in pain (Table 4) and loss of function at time point five. The relapse in pain and function was likely due to a four-day gap in treatment, during which the patient increased training intensity. In traditional treatment methods, continued or unmodified activity may result in relapses in pain and function in clinical practice. After the third treatment session, the patient was treated following their sport practice, and treatment results recorded a decrease of 50 % in NPRS scores; PSFS scores exhibited an upward trend of improved function. By the fifth treatment encounter, the patient had ultimately met the discharge criteria, which supports Dr. Uriarte's treatment prescription of five to seven visits within two weeks. Patient 7 received six treatments demonstrating the effectiveness of MYK as a primary treatment paradigm for MTSS without discontinuing activity during the season.

Franklyn and Oakes (2015) showed in their research that the Soleus, Flexor Digitorum Longus, and Tibialis Posterior are the primary muscles involved with MTSS symptoms and have attachments on the posteromedial tibia. The tibial nerve, originating at the L4-S3 nerve root, innervates the posterior compartment of the lower leg (Franklyn and Oakes, 2015). It is possible that because of intrinsic and extrinsic factors of MTSS, the body creates compensations to deal with the overload of ground reaction forces that manifest as the MTSS pathology. Therefore, MYK could be a successful treatment for MTSS due to the current understanding that MYK works to treat the body's compensations through the kinetic chain.

Unlike the traditional local treatments such as rest, ice, stretching, and other manual therapies commonly used to treat MTSS, MYK uses a global approach, assessing posture to identify imbalances and treating affected nerve roots to correct the imbalances and compensations (Deshmukh and Phansopkar, 2022; Martinez et al., 2019; Moen et al., 2012; Winters, 2020). The MYK treatment system may help resolve pain by addressing dysfunctions for patients with MTSS symptoms. Patients with multiple nerve root dysfunctions may require multiple nerve roots to be corrected before a resolution of symptoms can be observed. In future research, it is necessary to identify patients with multiple nerve root dysfunctions, observe the number of treatments, and MYK treatments required.

LIMITATIONS.

Limitations found in this study include a low number of participants, lack of a control group, the clinicians' limited experience using the MYK system, and long term follow up. This study was designed to be conducted in real-world clinical settings; which can be challenging to follow protocols. However, it is more applicable to treating patients in a clinical setting. The researchers did not perform an intra-rater reliability test for performing the treatment or the evaluation. However, Dr. Uriarte explains that the amount of pressure and the order of muscles stimulated do not affect the outcomes. Due to the lack of a control group, comparing the MYK treatments to conventional treatment options is difficult. Since there is a limited number of published articles about the MYK system, the researchers have very limited articles to examine the effectiveness of MYK. Finally, no study has been conducted with the high school population.

5. Conclusion

The current study assesses the effectiveness of the MYK treatment for high school patients with MTSS. The results illustrate the effectiveness of the MYK treatments without discontinuing or modifying activity during the patients' sports season and decreased pain while increasing functionality. Patients were treated in less time than traditional treatments and did not require the cessation or modification of activity. The changes in the NPRS scores were statistically and clinically significant. The changes in the PSFS scores were clinically meaningful through the continued progression of scores. Further research should include larger sample sizes, control groups, participants from other age groups and activity levels, and should be directly compared to other traditional MTSS treatments to determine if MYK can be included in a standardized MTSS treatment protocol.

CRediT authorship contribution statement

Mikala Palermo: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Data curation, Conceptualization. **Cameron Motz:** Writing – review & editing, Writing – original draft, Visualization, Validation, Resources, Methodology, Investigation, Data curation, Conceptualization. **Jai Jackson:** Writing – review & editing, Writing – original draft, Validation, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Miguel Martinez:** Writing – original draft, Resources, Methodology, Investigation, Conceptualization. **Nickolai Martonick:** Writing – review & editing, Formal analysis, Data curation. **James May:** Writing – review & editing, Supervision.

Clinical relevance

- The findings in this study suggest a treatment for MTSS without the cessation of activity.
- There is currently no gold standard treatment for MTSS, but this study's results provide a step toward finding one.
- A global approach to treating MTSS rather than a treatment that focuses primarily on the lower leg.

Conflicts

This research did not receive any specific grant or outside funding.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Mikala Palermo reports administrative support was provided by The MyoKinesthetic System. Cameron Motz reports administrative support was provided by The MyoKinesthetic System. Jai Jackson reports administrative support was provided by The MyoKinesthetic System. Miguel Martinez reports administrative support was provided by The MyoKinesthetic System. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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