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A Comparative Study of Plyometric Training on Sand Versus Wobble Board Exercises on Pain Management and Performance Enhancement in Athletes with Medial Tibial Stress Syndrome

Mahisree Bharathi. U. V[1], Sheela Angel. I[2], Soundarya. M[3], R. Mukesh Kumar[4*], Dr. Sandhiya. M[5], Dr. P. Senthil Selvam[6]

[1] Assistant Professor, School of Physiotherapy, Vels Institute of Science Technology and Advanced Studies (VISTAS), Chennai, India
[2] Associate Professor, College of Physiotherapy, Sri Venkateswaraa University, Chennai, India.
[3] Research Scholar, School of Physiotherapy, Vels Institute of Science Technology and Advanced Studies (VISTAS), Chennai, India
[4*] Assistant Professor, College of Physiotherapy, School of Health Science, Dayananda Sagar University, Bangalore, India.
[5] Assistant Professor, School of Physiotherapy, Vels Institute of Science Technology and Advanced Studies (VISTAS), Chennai, India.
[6] Professor & HOD, School of Physiotherapy, Vels Institute of Science Technology and Advanced Studies (VISTAS), Chennai, India.
Corresponding Author: R Mukesh Kumar, Assistant Professor, College of Physiotherapy, School of Health Science, Dayananda Sagar University, Bangalore, India

ABSTRACT:

Background: Medial Tibial Stress Syndrome (MTSS) is a common overuse injury among athletes, characterized by exercise-induced pain along the posteromedial aspect of the tibia. It can significantly affect athletic performance, particularly during running, jumping and other high-impact activities. Various rehabilitation approaches are used to manage MTSS, including strengthening, stretching, proprioceptive training and plyometric exercises.

Objective: To compare the effectiveness of plyometric training on sand versus wobble board exercises in reducing pain and improving athletic performance among athletes with Medial Tibial Stress Syndrome.

Methods: An experimental comparative study was conducted involving 30 participants aged 18–25 years with Medial Tibial Stress Syndrome. Participants were recruited using a random sampling technique and divided into two groups. Group A received cryotherapy, stretching and strengthening exercises followed by 20 minutes of plyometric training on sand. Group B received the same conventional treatment followed by 20 minutes of wobble board exercises. Pain intensity and athletic performance were assessed using the Numerical Pain Rating Scale (NPRS) and 20-Yard Shuttle Test, respectively. Statistical analysis was performed using SPSS version 24.0. Paired t-tests and independent t-tests were used for within-group and between-group comparisons, respectively.

Results: Both intervention groups demonstrated improvements in pain intensity and athletic performance following treatment. The post-intervention NPRS mean score was 1.67 ± 0.72 in Group A and 2.73 ± 1.16 in Group B ($t = 3.016$, $p < 0.001$). Similarly, the post-intervention 20-Yard Shuttle Test mean score was 4.85 ± 0.62 in Group A and 5.96

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± 0.95 in Group B (t = 3.760, p < 0.001). Between-group comparisons demonstrated statistically significant differences in both outcome measures, favouring Group A.

Conclusion: Both plyometric training on sand and wobble board exercises were effective in reducing pain and improving athletic performance among athletes with Medial Tibial Stress Syndrome. However, plyometric training on sand demonstrated superior outcomes compared with wobble board exercises. Therefore, plyometric training on sand may be considered an effective rehabilitation approach for managing MTSS and enhancing athletic performance.

INTRODUCTION

Medial tibial stress syndrome (MTSS) is one of the most common lower-leg injuries among athletes and service members. It is an overuse injury characterized by pain along the tibia's distal medial border, which is thought to be caused by excessive bone loading. [1] The term "shin splints" is commonly used to describe exercise-induced leg pain. There are two types: (a) anterior shin splints, which involve dysfunction of the anterior leg compartment or surrounding structures, and (b) medial tibial stress syndrome, which is characterized by exercise-induced pain along the distal two-thirds of the leg. [6,7] In runners, improper foot biomechanics, such as a statically pronated foot, a lower standing foot angle, rearfoot or forefoot varus, and excessive pronation, have been linked to MTSS. [8] Intrinsic risk factors include female sex, a history of MTSS, high BMI, increased navicular drop (a measure of arch height and foot pronation), greater ankle plantar-flexion and hip external rotation ranges of motion, and vitamin D deficiency, which may increase the risk of stress injury. [14,16] MTSS is considered a distinct clinical condition that differs from chronic exertional compartment syndrome, stress fracture, popliteal artery entrapment syndrome, and a variety of neuropathies. [10]





The pathophysiology of MTSS is linked to the accumulation of unrepaired microdamage in the cortical bone of the distal tibia. Periostitis usually appears at the site of bone injury, which also corresponds to the tendinous attachments of the soleus, flexor digitorum longus, and posterior tibialis. Sharpey's fibers, which are connective tissue fibers that penetrate bone and connect it to the periosteum, serve as a mechanical link between these structures. This has led to the theory that repeated muscle traction can result in periostitis and cortical microtrauma. [12] Overuse accounts for approximately 50% of all sports injuries. Overuse injuries are said to be evaluated twice as frequently as acute injuries in primary care sports medicine clinics. The majority of injuries seen in running injury clinics are also caused by overuse, with roughly half involving the lower leg (20%), ankle (15%), or foot. Shin splints, also known as MTSS, cause diffuse tenderness over the posteromedial aspect of the distal third of the tibia. In mild cases, pain occurs only during exercise; in more severe cases, it can occur at rest. Shin splints

are responsible for an estimated 12% to 18% of running injuries and affect about 4% of military recruits during basic training. Women seem to be affected more frequently than men. Increased rearfoot valgus and excessive pronation can cause MTSS by increasing eccentric contraction of the soleus and posterior tibial muscles. Intrinsic factors that can increase valgus forces and pronation include femoral anteversion, genu varum, tibial or forefoot varus, and an abnormal Q angle. Other intrinsic factors linked to MTSS include excessive pes planus or pes cavus, tarsal coalition, leg-length inequality, and muscle imbalances. Extrinsic risk factors include poor footwear, abrupt changes in training, insufficient warm-ups, running on uneven or hard surfaces, running in cold weather, and a lack of calcium intake. Treatment for MTSS consists of relative rest and addressing any recent changes in training. Running on hills or uneven surfaces is not recommended. Proper footwear is essential for reducing rearfoot valgus and correcting overpronation, pes planus, or pes cavus. Orthotics may be useful when footwear alone is insufficient to address these issues. [20]Many believe the main cause of medial tibial stress syndrome involves underlying periostitis of the tibia due to tibial strain when under a load. However, new evidence indicates that a spectrum of tibial stress injuries is likely involved in medial tibial stress syndrome, including tendinopathy, periostitis, periosteal remodelling, and stress reaction of the tibia. Dysfunction of the tibialis posterior, tibialis anterior, and soleus muscles are also commonly implicated. These various tibial stress injuries appear to be caused by alterations in tibial loading, as chronic, repetitive loads cause abnormal strain and bending of the tibia. Although sometimes composed of different etiologies, Medial tibial stress syndrome and tibial stress fractures may be considered on a continuum of bone–stress reactions [13]

The management of medial tibial stress syndrome (MTSS) is conservative, with a focus on rest and activity modification to reduce repetitive, weight-bearing exercise. Other treatments that may be beneficial, but have low-quality evidence, include iontophoresis, phonophoresis, ice massage, ultrasound therapy, periosteal pecking, and extracorporeal shockwave therapy. [17,18] Plyometric training typically consists of stretch-shortening cycle exercises with multi-joint movements, rapid eccentric phases, and explosive concentric muscle contractions facilitated by the stretch reflex. [2,3] Rapid eccentric muscle actions can lead to muscle damage, soreness, and a temporary loss of strength. Plyometric exercises are typically performed on firm surfaces like grass or wood. However, a recent study found that drop jumps on sand caused less muscle damage than jumps on a firm surface [4,5]. Plyometric training has also been shown to improve sprinting and jumping ability, running economy, and joint stability, as well as reduce the severity of knee injuries. [3] Plyometric exercises improve the stretch-shortening cycle (SSC) and can assist athletes in achieving high movement speeds. They are used to improve lower-body power and explosiveness by teaching muscles to do more work in less time. [31] Sand may cause less muscle soreness and damage than firm surfaces during plyometric training. However, training on sand requires less elastic energy reuse, in part because the feet may slip during the concentric phase. As a result, some of the muscle's energy may be absorbed rather than returned, potentially reducing muscular performance when compared to hard surface training. [31] A wobble board, also known as a multidirectional balance board, consists of a round, disk-shaped platform with a partial or half-ball base in the center. It enables movement in multiple planes and is intended to retrain the proprioceptive system by improving mechanoreceptor function and restoring normal neuromuscular communication. [11] Proprioceptive rehabilitation programs frequently employ balance-training devices, such as unstable platforms, to address proprioceptive deficits and restore functional ankle stability. Because balance training is done while weight bearing, it may aid in regaining neuromuscular control and improving functional stability. [19] Tropp found that wobble-board training had a significant preventive effect in soccer players, reducing subsequent ankle sprains. [21] Clark and Burden discovered that wobble-board training improved static and dynamic balance in athletes with functional ankle instability. The wobble-board training protocol was based on previous research showing that four weeks of training resulted in significant improvements. These findings indicate that wobble-board training may improve people's perceptions of functional stability and reduce the risk of further sprains in those with functional ankle instability. [22]

METHODOLOGY

This study was conducted using an experimental study design with a comparative study approach. A total of 30 participants were recruited using a random sampling technique based on inclusion and exclusion criteria. Informed consent form were collected from the participants. Both male and female aged between 18 to 25 years with shin bone pain and reduced ankle dorsiflexion ROM were included whereas subjects with recent fracture, recent surgeries, metal implant in affected lower limb were excluded. NPRS and 20 Yard shuttle test were used to measure Pain and Performance.

GROUP A (PLYOMETRIC TRAINING ON SAND)

The subject were in supine position, cryo pack was applied for 5 minutes around shin bone covering superior to inferior aspect. Treatment was given for 45 minutes following which stretching and strengthening exercise were given for 10 minutes each on 10 repetitions followed by plyometric training on sand for 20 minutes.

Stretching exercise: Seated shin stretch, Gastrocnemius calf stretch, Tibialis anterior muscle stretch, Achilles tendon standing stretch.

Strengthening exercises: Soleus squat, single leg soleus bridge, Side lying leg lift, Calf strengthening.

Plyometric training programme: Vertical Jumping, Bounding, Broad Jumping, Drop Jumping



Fig 3. Vertical Jumping



Fig 4. Bounding



Fig 5. Broad Jumping



Fig 6. Drop Jumping

GROUP B (WOBBLE BOARD EXERCISE)

The subject were given with cryo application, followed by stretching and strengthening exercise as of Group A followed by Wobble Board exercise for 20 minutes.

WOBBLE BOARD EXERCISE: Forward position, Backward position, Right Lateral position, Left Lateral position.

WOBBLE BOARD TRAINING INSTRUCTIONS (adapted from Wester et al.,)

1. Stand with feet parallel on the board, rock the board forward and back (Fig 6.)
2. Stand with feet parallel on the board rock the board from side to side (Fig 7.)

3. Stand with feet wide apart on the board rock the front of the board from side to side in a circulating movement (Fig 8)

4. Repeat exercises 1-3 but with your knees slightly bent and your hands on your buttocks (Fig 9.)

Continue exercises 1–4 for 30 s, rest for 10 s and repeat



Fig 7



Fig 8



Fig 9.



Fig 10.

DATA ANALYSIS

The collected data were tabulated and analyzed using both descriptive and inferential statistics. All the parameters were assessed using statistical package for social science (SPSS) version 24.0. Paired t-test was adopted to find the statistical difference within the groups & Independent t-test was adopted to find the statistical difference between the groups

TABLE – 1: COMPARISON OF NUMERICAL PAIN RATING SCALESCORE BETWEEN GROUP – A AND GROUP – B IN PRE TEST AND POST TEST

NPRS	GROUP A		GROUP B		t-TEST	SIGNIFICANCE
	MEAN	SD	MEAN	SD		
PRE TEST	4.20	1.37	4.07	1.38	0.265	.793*
POST TEST	1.67	0.72	2.73	1.16	3.016	.000**

GRAPH – 1: COMPARISON OF NUMERICAL PAIN RATING SCALESCORE BETWEEN GROUP – A AND GROUP – B IN PRE TEST AND POST TEST

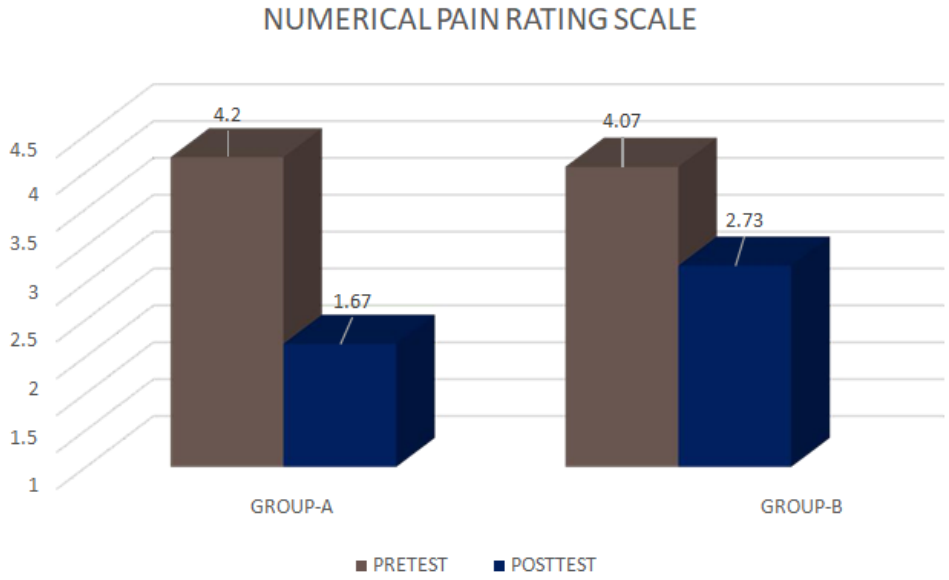
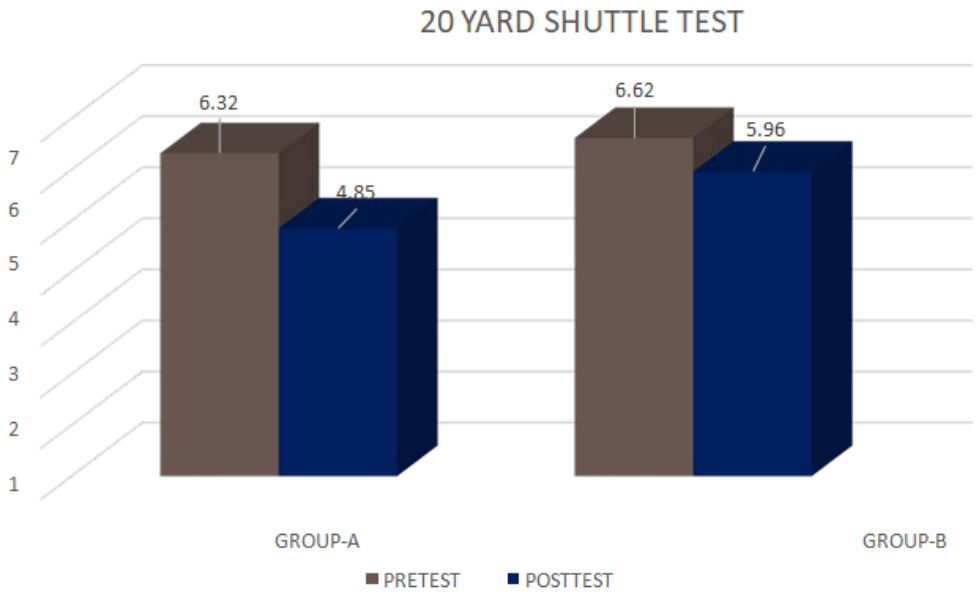


TABLE 2: COMPARISON OF 20 YARD SHUTTLE TEST SCOREBETWEEN GROUP – A AND GROUP – B IN PRE TEST AND POST TEST

20 YARD SHUTTLE TEST	GROUP A		GROUP B		t-TEST	SIGNIFICANCE
	MEAN	SD	MEAN	SD		
PRE TEST	6.32	0.52	6.62	0.67	1.383	.178*
POST TEST	4.85	0.62	5.96	0.95	3.760	.000**

GRAPH – 2: COMPARISON OF 20 YARD SHUTTLE TEST SCOREBETWEEN GROUP – A AND GROUP – B IN PRE TEST AND POST TEST



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TABLE – 3: COMPARISON OF NUMERICAL PAIN RATING SCALE AND 20 YARD SHUTTLE TEST BETWEEN PRE TEST AND POST TEST WITHIN GROUP – A

GROUP–A	PRE TEST		POST TEST		t-TEST	SIGNIFICANCE
	MEAN	SD	MEAN	SD		
NPRS	4.20	1.37	1.67	0.72	8.264	.000*
20 YARD SHUTTLE TEST	6.32	0.52	4.85	0.62	10.276	.000*

GRAPH – 3: COMPARISON OF NUMERICAL PAIN RATING SCALE AND 20 YARD SHUTTLE TEST BETWEEN PRE TEST AND POST TEST WITHN GROUP – A

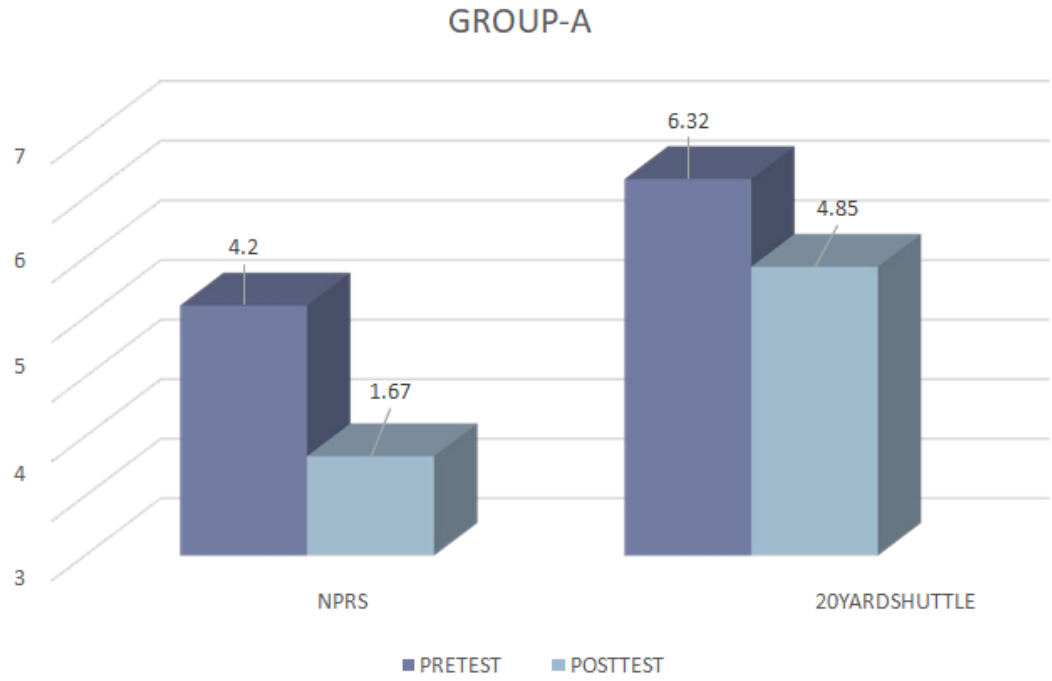
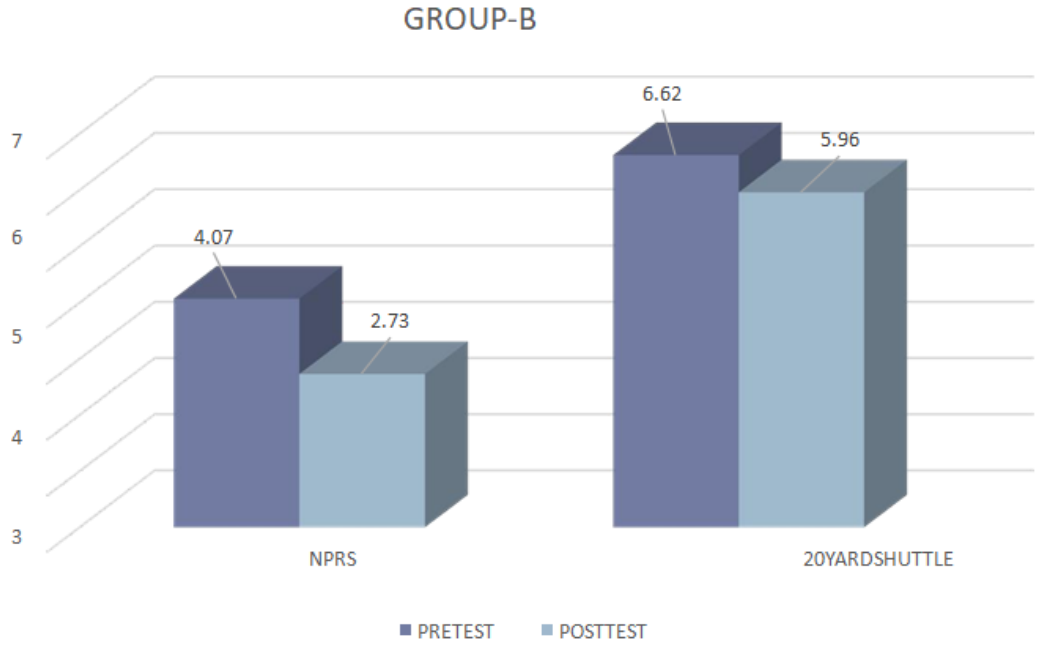


TABLE – 4: COMPARISON OF NUMERICAL PAIN RATING SCALE AND 20 YARD SHUTTLE TEST BETWEEN PRE TEST AND POST TEST WITHIN GROUP – B

GROUP–B	PRE TEST		POST TEST		t-TEST	SIGNIFICANCE
	MEAN	SD	MEAN	SD		
NPRS	4.07	1.38	2.73	1.16	8.367	.000*
20 YARD SHUTTLE TEST	6.62	0.67	5.96	0.95	4.991	.000*

GRAPH – 4: COMPARISON OF NUMERICAL PAIN RATING SCALE AND 20 YARD SHUTTLE TEST BETWEEN PRE TEST AND POST TEST WITHIN GROUP – B



RESULT

In Table 1, On comparing mean values of GROUP-A and GROUP-B on Numerical Pain Rating Scale shows highly significant improvement in the posttest mean but GROUP-A shows (1.67) lesser mean value is more effective than GROUPB (2.73) at P≤0.001, Hence the null hypothesis is rejected.

In Table 2, On comparing mean values of GROUP-A and GROUP-B on 20 Yard Shuttle test score shows highly significant improvement in the posttest mean but GROUP-A shows (4.85) lesser mean value is more effective than GROUP-B (5.96) at P≤0.001, Hence the null hypothesis is rejected.

In Table 3 & 4, On comparing Mean Values of Numerical Pain Rating Scale and 20 Yard Shuttle Test scores between pre test and post test within the Group-A and Group-B shows highly significant difference at p≤ 0.001.Hence the null hypothesis is rejected.

DISCUSSION

The present study was conducted to compare the effectiveness of plyometric training on sand versus wobble board exercises in reducing pain and improving athletic performance among athletes with Medial Tibial Stress Syndrome (MTSS). The study included 30 participants aged between 18 and 25 years who were divided into two intervention groups. Group A received plyometric training on sand along with conventional physiotherapy, whereas Group B received wobble board exercises along with the same conventional physiotherapy. The outcomes were assessed using the Numerical Pain Rating Scale (NPRS) and 20-Yard Shuttle Test.

The findings of the present study demonstrated that both intervention groups showed improvement in pain intensity and athletic performance following the treatment programme. However, the comparative analysis revealed that Group A (plyometric training on sand) demonstrated significantly greater improvement than Group B (wobble board exercises) in both outcome measures.

Effect of Plyometric Training on Sand on Pain Reduction

In the present study, Group A demonstrated a reduction in the mean NPRS score from 4.20 ± 1.37 in the pre-test to 1.67 ± 0.72 in the post-test. This indicates a considerable reduction in pain intensity following plyometric training on sand.

Plyometric exercises involve rapid eccentric muscle contraction followed by an explosive concentric contraction, facilitating the stretch-shortening cycle. These exercises improve neuromuscular coordination, muscular power and functional performance. Performing plyometric exercises on sand provides a relatively compliant training surface that may attenuate impact forces and reduce mechanical loading compared with harder surfaces.

According to Miyama and Nosaka (2004), the surface on which drop jumps are performed influences exercise-induced muscle damage and muscle soreness. Their findings support the potential advantage of sand surfaces in reducing the physiological stress associated with plyometric activities.

Furthermore, Arazi et al. (2014) investigated muscular adaptations following depth-jump plyometric training on sand and land surfaces, highlighting the relevance of surface selection in plyometric rehabilitation and athletic conditioning.

The improvement observed in Group A may therefore be attributed to the combined effects of progressive plyometric loading, neuromuscular adaptations and the cushioning characteristics of the sand surface.

Effect of Wobble Board Exercises on Pain Reduction

Group B demonstrated a reduction in the mean NPRS score from 4.07 ± 1.38 in the pre-test to 2.73 ± 1.16 in the post-test. This indicates that wobble board exercises were also beneficial in reducing pain among athletes with MTSS.

Wobble board exercises primarily focus on proprioceptive stimulation, balance training and neuromuscular control. Training on an unstable surface activates the sensory receptors around the ankle joint and facilitates coordinated muscular responses to maintain postural stability.

Rozzi et al. (1999) reported that balance training using unstable surfaces could improve functional ankle stability and proprioceptive control. Similarly, wobble board exercises may contribute to improved ankle neuromuscular function and lower-limb stability.

The improvement observed in Group B may be associated with enhanced proprioceptive awareness, improved muscular coordination and better control of lower-limb movements during functional activities.

Effect of Plyometric Training on Sand on Athletic Performance

The 20-Yard Shuttle Test was used to evaluate athletic performance involving acceleration, deceleration and change-of-direction ability.

In Group A, the mean test score improved from 6.32 ± 0.52 in the pre-test to 4.85 ± 0.62 in the post-test. This indicates improved performance following the intervention, assuming the recorded values represent completion time in seconds.

Plyometric training improves the efficiency of the stretch-shortening cycle by enhancing the ability of muscles to generate force rapidly. It also contributes to improvements in lower-limb power, reactive strength and neuromuscular coordination.

Impellizzeri et al. (2008) investigated the effects of plyometric training performed on sand and grass surfaces on muscle soreness, jumping and sprinting ability in soccer players. Their findings provide supporting evidence for the application of sand-based plyometric training in athletic conditioning.

The improvement in shuttle test performance observed in Group A may be explained by improved lower-limb muscular power, acceleration capacity and neuromuscular coordination.

Effect of Wobble Board Exercises on Athletic Performance

Group B demonstrated an improvement in the mean 20-Yard Shuttle Test score from 6.62 ± 0.67 in the pre-test to 5.96 ± 0.95 in the post-test.

Wobble board exercises promote dynamic balance, proprioception and functional ankle stability. The multidirectional movements performed on an unstable surface challenge the postural control system and facilitate coordinated activation of the lower-limb musculature.

Improved proprioceptive function and ankle stability may contribute to better movement control during acceleration, deceleration and directional changes.

The findings of Rozzi et al. (1999) support the role of balance training in improving functional ankle stability. This may partly explain the improvement in athletic performance observed in Group B.

Comparison Between the Two Intervention Groups

The between-group analysis revealed a statistically significant difference in post-intervention NPRS scores, with Group A demonstrating a lower mean score (1.67 ± 0.72) compared with Group B (2.73 ± 1.16), with $p < 0.001$.

Similarly, the post-intervention 20-Yard Shuttle Test score was lower in Group A (4.85 ± 0.62) compared with Group B (5.96 ± 0.95), with $p < 0.001$.

These findings indicate that although both interventions produced improvements, plyometric training on sand demonstrated superior post-intervention outcomes compared with wobble board exercises.

The greater improvement observed in Group A may be associated with the specific training adaptations produced by plyometric exercises, including enhanced muscular power, stretch-shortening cycle efficiency and functional neuromuscular performance. In contrast, wobble board exercises primarily emphasize proprioception and postural stability.

Therefore, the differences in the primary training mechanisms of the two interventions may explain the comparatively better outcomes observed in the sand-based plyometric training group.

Overall, the findings suggest that plyometric training on sand may be a promising rehabilitation approach for reducing pain and improving athletic performance among athletes with MTSS.

However, further studies involving larger sample sizes, longer follow-up periods and additional functional outcome measures are required to establish the long-term effectiveness of these interventions.

CONCLUSION

The present study concludes that both plyometric training on sand and wobble board exercise programmes are effective in reducing pain intensity and improving athletic performance among athletes with Medial Tibial Stress Syndrome (MTSS).

The findings demonstrated improvements in both intervention groups following the treatment programme. However, the comparative analysis revealed that Group A, which received plyometric training on sand along with conventional physiotherapy, showed superior post-intervention outcomes compared with Group B, which received wobble board exercises along with conventional physiotherapy.

The reduction in Numerical Pain Rating Scale scores indicates an improvement in pain intensity, while the improvement in 20-Yard Shuttle Test performance suggests enhanced functional athletic ability, particularly in activities involving acceleration, deceleration and changes in direction.

The superior outcomes observed in the sand-based plyometric training group may be attributed to improved lower-limb muscular power, neuromuscular coordination and stretch-shortening cycle efficiency. Additionally, the compliant nature of the sand surface may provide a relatively lower-impact training environment during plyometric activities. In comparison, wobble board exercises primarily facilitate proprioceptive stimulation, postural control and functional ankle stability, contributing to improvements in pain and athletic performance.

Therefore, the study suggests that plyometric training on sand, when incorporated into a structured physiotherapy rehabilitation programme, may be a more effective intervention than wobble board exercises for improving the measured outcomes in athletes with MTSS.

Overall, plyometric training on sand can be considered a promising rehabilitation strategy for pain management and enhancement of athletic performance among athletes with Medial Tibial Stress Syndrome. However, further research involving larger sample sizes, standardized intervention protocols, additional functional outcome measures and long-term follow-up is recommended to establish its effectiveness and sustainability in athletic rehabilitation.

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