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The Effect of Radial Shockwave Therapy on Iliotibial Band Tendon Thickness, Pain and Knee Function in Runners with Iliotibial Band Syndrome: A Double-blind, Randomized Clinical Trial

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Trial registration

This study was registered in the Iranian Registry of Clinical Trials on 22-01-2024 (IRCT20231217060447N1).

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Abstract

Background: Iliotibial Band Syndrome (ITBS) is a common injury in runners, causing lateral knee pain and functional limitations. Radial Shockwave Therapy (RSWT) is a non-invasive method used to reduce pain and promote tissue healing. However, its effects on iliotibial band (ITB) thickness and knee function in athletes remain unclear.

Objective: To evaluate the effects of RSWT on ITB tendon thickness, pain intensity, and knee function in runners with ITBS.

Design: Double-blind, sham-controlled, parallel-group randomized clinical trial.

Setting: Physiotherapy clinics.

Participants: Thirty-two field and track runners (weekly mileage: 20–40 km) with chronic ITBS (15 females, 17 males; aged 18–35) were randomly assigned using block randomization to either an active RSWT group or a sham control group.

Intervention: The RSWT group received increasing energy pulses to the lateral femoral epicondyle without anesthesia. Both groups underwent a standardized electrotherapy program including infrared, ultrasound, and transcutaneous electrical nerve stimulation, administered three times weekly for four weeks**.**

Main Outcome Measures: Pain was assessed using the Visual Analog Scale (VAS), knee function via the Knee Injury and Osteoarthritis Outcome Score (KOOS), and ITB thickness through ultrasonographic imaging. Assessments were conducted at baseline, post-intervention, and one-month follow-up.

Results: Significant time × group interactions were found for pain (VAS), knee function (KOOS), and ITB tendon thickness. The SWT group showed greater improvements than the sham-group across all outcomes. Pain scores decreased substantially ($F(2,60) = 126.83$, $p < .001$, partial $\eta^2 = 0.81$), indicating a very large effect size. KOOS scores improved significantly ($F(2,60) = 75.59$, $p < .001$, partial $\eta^2 = 0.76$), also reflecting a very large effect. ITB thickness was reduced ($F(2,60) = 54.39$, $p < .001$, partial $\eta^2 = 0.65$), demonstrating a large effect size.

Conclusion: RSWT enhances recovery in ITBS when combined with physiotherapy, offering measurable benefits in pain reduction and knee function.

Keywords: Iliotibial Band Syndrome; Extracorporeal Shockwave Therapy; Pain; Function; Tendon Thickness

Key Points

• Shockwave Therapy (SWT) significantly reduced pain, improved knee function, and decreased iliotibial band (ITB) thickness in athletes with ITBS.

• The study supports SWT as a non-invasive adjunct to physiotherapy, enhancing recovery from overuse injuries.

• Findings highlight the value of integrating targeted mechanical therapy in athletic rehabilitation to optimize functional outcomes and reduce inflammation.

Introduction

Iliotibial Band Syndrome (ITBS) is a prevalent overuse injury characterized by friction between the Iliotibial Band (ITB) and the lateral femoral epicondyle during repetitive activities such as knee flexion and extension under strain, particularly among athletes.[1] Recent studies challenge the traditional friction-based theory, suggesting multifactorial causes including biomechanical abnormalities and tissue compression.[2] Key contributing factors include a tight ITB, muscle weakness, limited flexibility, functional impairments of associated muscles, and shortened ITB length.[1] ITBS is recognized as the leading cause of lateral knee injuries, accounting for approximately 5–14% of cases. Moreover, it ranks as the second most prevalent source of knee pain in runners, contributing to up to 12% of runners' injuries and 22.2% of lower extremity complaints.[3] Routine activities, such as descending stairs or squatting, can exacerbate symptoms, diminishing occupational and physical performance.[4]

The pathophysiology of ITBS involves pain and functional impairment caused by trauma or excessive friction over the lateral femoral epicondyle. Radiological findings suggest that the iliotibial band (ITB) is injured in approximately 57.5% of acute knee trauma cases**,** with damage ranging from minor sprains to complete tears.[5] Although the ITB itself is a non-contractile, fibrous structure with minimal intrinsic extensibility, its tension and apparent flexibility are modulated by the Tensor Fasciae Latae (TFL) and gluteus maximus, which insert into it.[1] Therefore, optimal function and neuromuscular control of the TFL–ITB complex are imperative for maintaining musculoskeletal health and preventing biomechanical abnormalities.[2]

Athletes affected by ITBS frequently report localized pain, often burning in nature, located approximately 2 cm above the lateral joint line. This pain may radiate proximally or distally and reoccur with continued activity, despite subsiding after rest in severe cases.[6,7] Left untreated, ITBS can precipitate structural problems such as tibial internal rotation, hip abductor weakness, foot pronation, genu varum, and ITB shortening, disrupting normal biomechanics.[8] Excessive tension in the ITB and associated muscles can compress underlying tissues, resulting in inflammation, pain, and compromised functionality.[9,10]

Initial management strategies focus on reducing inflammation, increasing the range of motion, and addressing biomechanical deficiencies. Treatment modalities include NSAIDs, corticosteroid injections, gentle stretching, progressive muscle strengthening, and rehabilitation programs, often facilitating recovery within two weeks. Incremental adjustments in running distance and stride length are recommended for avoiding symptom exacerbation.[11,12] Rarely, resistant cases necessitate surgical intervention, aiming at muscle release and ITB fiber tension reduction Adjunctive therapies such as manual therapy, dry needling, electroacupuncture, and tailored training programs may be employed both pre- and post-operatively to optimize outcomes.[12-14]

Shockwave Therapy (SWT) has recently emerged as an innovative treatment for musculoskeletal disorders such as myofascial pain, tendinitis, and fascial inflammation.[15] Using strong acoustic pulses generated by electromagnetic or piezoelectric mechanisms, SWT enhances localized blood flow, accelerating tissue regeneration.[16,17] Recent studies highlight SWT's efficacy in alleviating pain, strengthening muscles, and restoring functional ability in tendinopathies.[18,19]

There are two primary modalities of SWT: Radial ESWT (R-ESWT) and Focused ESWT (F-ESWT). Radial ESWT disperses low-energy waves over a broader area, with an effective penetration depth of approximately 3–4 cm. It is ideal for treating superficial conditions such as lateral epicondylitis, Achilles tendinopathy, and iliotibial band syndrome. Focused ESWT, on the other hand, delivers high-energy waves to a precise focal point, reaching depths up to 12 cm. It is preferred for deep-seated or localized pathologies like calcific tendinitis or nonunion fractures.[20,21] Weckström et al. (2016) emphasized the effectiveness of Extracorporeal Shockwave Therapy in ITBS management, suggesting no superiority over manual therapy programs.[22] Sanchez-Alvarado et al. (2024) demonstrated the benefits of combining SWT with hip abductor strengthening exercises for optimal pain reduction and functional improvement.[23] Ultrasonography, a real-time and non-invasive imaging modality, is widely utilized for evaluating soft tissue structures, assessing viscoelastic changes, and monitoring therapeutic outcomes.[24] While ultrasonography has been used to detect ITB thickening and soft tissue swelling in ITBS, no studies to date have assessed changes in ITB thickness following SWT. Given ITBS's prevalence among athletes and the promising results of SWT, this study investigates the impact of shockwave therapy on pain and lower extremity function in athletes with iliotibial band syndrome. By examining its efficacy, this approach may pave the way for accessible, safe, and performance-enhancing interventions for athletes, ensuring uninterrupted training and optimal recovery.

MATERIALS AND METHODS

Study Design

This study employed a double-blind, randomized controlled trial (RTC) with a parallel-group design. Eligible runners diagnosed with iliotibial band syndrome (ITBS) were randomly allocated to receive either shockwave therapy (SWT) or sham-shockwave therapy (sham-SWT), in combination with a standard electrotherapy-based physiotherapy protocol. Outcome assessments were performed at three time points: baseline (pre-intervention), immediately after the 4-week intervention (post-treatment), and one month after the completion of treatment (follow-up).

The independent variables were group (SWT vs. sham-SWT) and time (baseline, post-treatment, follow-up). The primary dependent variables was pain intensity, assessed using Visual Analogue Scale (VAS). Secondary outcomes included knee function, measured using the Persian version of the Knee Injury and Osteoarthritis Outcome Score (KOOS) questionnaire, and ITB tendon thickness, quantified via ultrasonography. The study was conducted at the Neuromuscular Rehabilitation Research Center, affiliated with XXX.

Ethical Considerations

The study protocol was approved by the Human Ethics Committee of XXX (XXX) and complied with the Declaration of Helsinki. The trial was also registered in the XXX Clinical Trials Registry (XXX). Written informed consent was obtained from all participants after providing a detailed explanation of the study objectives, procedures, procedures, potential risks, and benefits.

Sample Size and Recruitment

The target population consisted of endurance runners aged 18-35 years who met the inclusion criteria. A purposeful, accessible sampling strategy was applied to recruit participants, and randomization was conducted after screening. Based on prior research by Weckström et al. (2016) examining similar interventions in ITBS populations,[22] a sample size of 32 participants (16 per group) was calculated to achieve sufficient statistical power. A total of 40 individuals were screened, of whom 8 were excluded based on eligibility criteria. The final sample comprised 32 participants (17 men, 15 women).

Participants

Participants were track and field athletes presenting with lateral knee pain who were referred to the Physiotherapy Department at the Rehabilitation School, XXX between February 2024 and August 2024. Inclusion criteria were as follows: 1) Aged 18-35 years; 2) at least one year of running experience; 3) participation in regular weekly training sessions; 4) involvement in official track and field competitions; 4) minimum weekly running distance of 20 kilometers; and 5) lateral knee pain for at least four weeks. [22]

Exclusion Criteria

Exclusion criteria included: 1) clinical signs or symptoms of other knee pathologies; 2) history of ITBS treatment within the past six months; 3)use of analgesics or NSAIDs within two weeks prior to enrollment; 4) use of hot/ cold therapy, stretching or resistance training within the previous 48 hours; 5) history of knee surgery or fractures in the affected limb within the past year; 6) previous exposure to SWT; 7) presence of systemic or severe medical conditions (e.g., tumors, diabetes, rheumatologic disorders, cardiovascular disease, psychiatric illness); 8) declining participation or inability to commit the study protocol. [22]

Randomization and Blinding

Participants were randomly allocated to the intervention or control group using a block randomization method (six blocks of four participants each), ensuring balanced group sizes. Randomization was conducted by a third party using sequentially numbered, opaque, sealed envelopes (SNOSE) to preserve allocation concealment.

To maintain double blinding, both the treating physiotherapist and the outcome assessor were blinded to group allocation. Group assignment was revealed only after enrollment via envelope opening. The physiotherapist who administered the treatment did not participate in outcome assessments. The evaluator responsible for VAS, KOOS, and ultrasonographic measurements remained blinded throughout the study. Participants were assigned to one of two groups: Group A (intervention): received 10 sessions of SWT combined with a standard electrotherapy-based physiotherapy protocol, and Group B (control): received 10 sessions of sham-SWT alongside the same physiotherapy protocol. Both groups underwent treatment three times per week for four consecutive weeks, totaling 12 contact sessions.

Study Procedure

Participant Preparation:

Following informed consent, athletes were thoroughly briefed on the study protocol to ensure full understanding and compliance with the intervention and assessment procedures. All participating athletes maintained their usual training and competition routines throughout the study period. No restrictions were placed on physical activity.

Intervention Protocol:

Active SWT: Athletes in the intervention group received Radial SWT using the NP-S20 device (Negarpajoohan Teb, Iran). Painful sites over the lateral femoral epicondyle were identified through precise palpation. Treatment started with 500 pulses at an energy flux density of 0.10 mJ/mm² (2 Bar) and a frequency of 15 Hz, gradually progressing to 2000 pulses at 0.10–0.40 mJ/mm² (2–4 Bar) based on the athlete's pain tolerance. No local anesthesia was used to preserve natural tissue response and neuromuscular feedback. This protocol aligns with current evidence supporting SWT's effectiveness in accelerating recovery and reducing inflammation in athletic soft tissue injuries. [22] SWT was applied to the lateral femoral epicondyle and the distal portion of the iliotibial band, targeting the area of maximal tenderness identified through palpation. The treatment site was reassessed at each session, and adjusted as needed based on symptom localization.

Sham SWT (Control): Control participants received sham treatment where the device was activated without delivering therapeutic shocks. To simulate sensation, a few sub-threshold pulses were initially applied, after which the device was turned off, ensuring participant blinding while eliminating physiological effects.

Standard Electrotherapy-Based Physiotherapy Protocol: All athletes, regardless of group allocation, underwent a Standard electrotherapy-based physiotherapy program including: Infrared (IR) therapy (15 minutes), pulsed ultrasound therapy at 3 MHz (5 minutes), and high-frequency TENS therapy (20 minutes).

Outcome Measures

Pain Assessment: Pain intensity was quantified using the Visual Analog Scale (VAS), a 10 cm line anchored by "no pain" (0) and "worst pain imaginable" (10). This scale offers a sensitive measure of changes in pain perception relevant to athletic populations. [25]

Knee Function Assessment: Knee function was evaluated using the Knee Injury and Osteoarthritis Outcome Score (KOOS) questionnaire, a validated instrument widely employed in sports medicine. [26] The KOOS assesses five domains: pain, symptoms, activities of daily living, sports/recreation function, and knee-related quality of life, scored on a 0–100 scale with higher scores indicating better function. The validated Persian version of KOOS demonstrates a Cronbach's alpha of 0.70, as reported by Salavati et al. [27]

ITB Tendon Thickness Measurement: ITB tendon thickness was assessed using a Sonography unit (HS-2100V, Honda Electronics Co, Toyohashi, Japan), equipped with a 7.5 MHz linear transducer. High-resolution B-mode ultrasonography performed with the athlete in a supine position. The lateral femoral epicondyle was palpated approximately 2 cm above the lateral joint line to locate the scanning site. The transducer was placed perpendicular to the coronal plane of the knee with water-based acoustic gel to optimize image quality. [28] All sonographic assessments were performed by the same blinded sonologist, ensuring consistency in technique and minimizing both intra-rater and inter-rater variability (Figure 2).

Please insert Figure 2 approximately here

Statistical Analysis

All statistical analyses were conducted using SPSS version 24.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics (mean ± standard deviation) were computed for all outcome variables. The normality of data distributions was assessed using the Shapiro–Wilk test. Baseline demographic and clinical characteristics were compared between groups using independent-samples *t* tests for continuous variables and chi-square or Fisher's exact tests for categorical variables, as appropriate. To examine the effects of the intervention over time, a two-way repeated-measures analysis of variance (ANOVA) was performed with group (active shockwave therapy vs. sham) as the between-subjects factor and time (baseline, post-intervention, and one-month follow-up) as the within-subjects factor. When significant main or interaction effects were found, Bonferroni-adjusted pairwise comparisons were conducted. Statistical significance was set at $p < .05$. Effect sizes were reported using partial eta squared (ηp^2) to indicate the magnitude of observed effects.

RESULTS

Baseline Characteristics

All 32 participants (16 per group) completed the study. The flow of participants is presented in Figure 1 (CONSORT diagram). Table 1 summarizes baseline demographic and clinical variables. No significant differences were observed between groups in terms of age (P = .83), gender (P = .73), body mass index (P = .11), side of injury (P = .61), sports experience (P = .13), or occupation (P = .63). Likewise, baseline pain intensity, KOOS score, and ITB tendon thickness were comparable across groups ($P > .05$). All variables met the assumption of normality as assessed by the Shapiro–Wilk test ($P > .05$) (Table 1).

Please insert Figure 1 approximately here

Please insert Table 1 approximately here

Repeated-Measures ANOVA

Pain (VAS)

A significant time × group interaction was observed for VAS scores (F (2,60)= 126.83, $P < .001$, partial $\eta^2 = 0.81$), indicating a very large effect size. Significant main effects for group (F (1,30)= 73.938, $P < .001$, partial $\eta^2 = 0.71$) and time (F(2,60) = 412.39, $P < .001$, partial $\eta^2 = 0.93$), both reflecting very large effects according to conventional thresholds (small = 0.01, medium = 0.06, large ≥ 0.14). Bonferroni-adjusted post hoc analysis revealed a significant reduction in VAS scores from baseline to post-intervention (mean difference = –4.56, 95% CI [–5.25, –3.87], $P < .001$) and from baseline to one-month follow-up (mean difference = –3.75, 95% CI [–4.46, –3.03], $P < .001$). Between-group comparisons indicated significantly greater improvements in the active SWT group compared to the sham group (mean difference = -3.75, 95% CI [–4.46, –3.03], $P < .001$) (Table 2).

Knee Function (KOOS)

A significant time × group interaction was found for KOOS scores (F (2,60)= 75.59, $P < .001$, partial $\eta^2 = 0.76$), indicating a very large effect size**.** Significant main effects of group (F (1,30)= 44.184, $P < .001$, partial $\eta^2 = 0.60$) and time (F (2,60)= 403.016, $P < .001$, partial $\eta^2 = 0.93$), both reflecting very large effects**.** Post hoc analysis showed significant improvements in KOOS scores from baseline to post-intervention (mean difference = –25.43, 95% CI [–30.40, –20.47], $P < .001$) and from baseline to one-month follow-up (mean difference = –33.69, 95% CI [–37.55, –

29.81], $P < .001$). Between-group comparisons confirmed significantly greater functional improvement in the active SWT group (mean difference = -38.93, 95% CI [–45.24, –32.63], $P < .001$) (Tables 2 and 3).

ITB Tendon Thickness (Ultrasonography)

A significant time × group interaction was also observed for ITB tendon thickness ($F_{(2,60)}$= 54.39, $P < .001$, partial $\eta^2 = 0.65$), indicating a very large effect size, based on conventional thresholds for partial η^2. Significant main effects were also found for group ($F_{(1,30)}$= 6.309, $P < .001$, partial $\eta^2 = 0.17$) and time ($F_{(2,60)}$= 228.11, $P < .001$, partial $\eta^2 = 0.88$), both reflecting large to very large effects. Post hoc comparisons revealed significant reductions from baseline to post-treatment (–0.51, 95% CI [–0.75, –0.27], $P < .001$) and to follow-up (–0.56, 95% CI [–0.79, –0.32], $P < .001$). The active SWT group showed greater improvement compared to the sham group (mean difference = –0.78, 95% CI [–1.00, –0.58], $P < .001$) (Table 2).

Please insert Table 2 approximately here

Please insert Table 3 approximately here

DISCUSSION

This study demonstrated that the integration of shockwave therapy (SWT) with standard electrotherapy-based physiotherapy led to meaningful clinical improvement in endurance athletes diagnosed with iliotibial band syndrome (ITBS). These benefits included significant reductions in pain, decreased ITB tendon thickness, and marked improvements in knee function. Importantly, these gains were maintained at a one-month follow-up, underscoring the durability of SWT's therapeutic effects.

Baseline demographic and clinical variables including age, gender, body mass index (BMI), sport experience, and laterality of symptoms did not differ significantly between groups, allowing for unbiased comparison of treatment outcomes. The homogeneity of baseline characteristics reinforces the internal validity of the findings.

Pain Reduction and Mechanistic Underpinnings

SWT produced a 90.3% reduction in VAS pain scores post-treatment, with further improvement to 93.1% at one-month follow-up. These results are consistent with previously published literature demonstrating SWT's strong pain-relieving effects across a range of chronic tendinopathies, [29] such as patellar tendinopathy, [30] greater trochanteric pain syndrome (GTPS), [31] and Achilles tendinopathy. [32] In recent decades, shockwave therapy has emerged as a non-invasive treatment for musculoskeletal disorders affecting the spine, upper limbs, and lower limbs—often serving as an alternative to surgery. [33] Its pain-relieving mechanisms are multifaceted and include enhanced local blood flow; neovascularization and angiogenesis; anti-inflammatory modulation through cytokine regulation. Additionally, SWT may reduce pain perception by calming overactive nerve signals. [17, 34, 35]

On a cellular level, SWT stimulates the release of nitric oxide and influences macrophage infiltration, promoting tissue repair rather than offering only short-term symptom relief. [36] This aligns with our findings, where pain reduction persisted well beyond the active treatment phase, suggesting sustained biological effects. Compared to more invasive methods like platelet-rich plasma injections or surgery, SWT is considered low-risk, with shorter recovery periods that allow athletes to continue training during rehabilitation. [37]

In ITBS, pain typically presents as tenderness over the lateral femoral epicondyle and worsens with activity. External factors such as long-distance or downhill running, and internal factors like genu varum, weak hip abduction, leg length discrepancies, contribute to symptom progression. [6]

Our findings are in line with those of Weckström et al. (2016), [22] and Wheeler et al (2016), [38] who reported sustained pain relief in both ITBS and GTPS populations, following SWT. Interestingly, Weckström et al. also found that manual therapy produced comparable outcomes, suggesting that SWT may be used interchangeably or in combination with other conservative treatments. [22] Maghroori et al. (2021) also reported faster pain reduction with dry needling at four weeks compared to SWT, though both interventions led to improved function. [39]

In contrast to pharmacological or invasive modalities, SWT offers minimal risk and supports continued athletic participation throughout the rehabilitation period

Tendon Remodeling and Sonographic Correlations

Ultrasound imaging revealed a 38.8% reduction in ITB tendon thickness post-treatment and a 41.2% reduction at follow-up, providing objective evidence of structural remodeling. This is clinically important because thickening of the ITB is a hallmark of chronic ITBS and is often associated with lateral knee friction and inflammation. [28]

Overuse of the lateral knee can lead to bursitis and ITB thickening, resulting in irritation between the ITB and lateral femoral epicondyle. [4] Prolonged muscle contraction and repetitive tendon use increase tissue temperature, possibly triggering cellular damage through enzyme activation. [2]

SWT applies controlled mechanical stress to the tissue, which activates repair mechanisms such as increased protein synthesis, collagen production, and the release of growth factors. This biological responses help restore tendon structure and reduce inflammation. [36] Specifically, molecules like TGF-β1 and IGF-I promote fibroblast activity and collagen regeneration, while nitric oxide enhances healing by improving extracellular matrix quality and reducing tendon thickness. [35]

While many previous ITBS studies have focused primarily on pain relief, this study adds a new layer by demonstrating measurable changes in tendon morphology. This highlights the value of ultrasound not only for diagnosis but also for monitoring treatment progress. From a clinical standpoint, these results suggest that tracking tendon thickness could be a useful tool in rehabilitation, especially in high-load sports where recurrence is common.

Functional Restoration and Athlete-Centered Outcomes

Functional improvement was evaluated using the KOOS, a validated tool commonly used in both research and clinical settings. The SWT group exhibited substantial improvements across all five KOOS subscales. These improvements exceed the minimal clinically important differences (MCID) threshold reported in previous KOOS validation studies [40], underscoring the clinical relevance of SWT, especially for athletes who require a fast and complete return to activity. Notably, the near-complete recovery in the sport/recreation subscale (98.6%) suggests that SWT not only reduces symptoms but also restores performance capacity. This supports its role in preparing athletes for return-to-sport and reintegration into high-demand activities.

The control group, which received standard electrotherapy-based physiotherapy protocol, also demonstrated improvement but to a significantly lesser extent. This suggests a synergistic, not merely additive, effect between SWT and therapeutic exercise. These modalities are widely utilized in outpatient rehabilitation settings and have demonstrated clinical efficacy in musculoskeletal pain management, as supported by previous studies. [23, 41]

Clinical Relevance and Athletic Implications

For sports medicine professionals, athletic trainers, and rehabilitation specialists, the integration of SWT presents a non-invasive, low-risk, and highly effective adjunct to traditional therapy. The magnitude and durability of the improvements observed in this study highlight SWT's potential as a first-line conservative treatment for ITBS, particularly in endurance athletes and high-performance populations.

Importantly, the objective sonographic findings combined with validated patient-reported outcome measures (PROMs) provide a robust framework for outcome tracking, goal setting, and return-to-play decision-making. Incorporating SWT into clinical protocols may reduce reliance on pharmacologic treatments or surgical interventions and expedite athletes' return to pre-injury levels of performance. Although symptom improvement in ITBS can occur over time through natural recovery and activity modification, the statistically significant differences observed between the SWT and sham-SWT groups indicate that SWT provides an additive therapeutic benefit. This reinforces its value as a non-invasive and effective adjunct to standard physiotherapy, particularly for endurance athletes and high-performance populations.

Limitations and Directions for Future Research

Despite its strengths, this study has limitations. The sample size was modest and geographically constrained, limiting generalizability. Additionally, the lack of a shockwave-only group makes it difficult to isolate the specific contribution of SWT independent of physiotherapy.

Future research should aim to: include larger, multi-site cohorts, explore isolated effects of SWT in the absence of co-intervention, incorporate advanced sonographic techniques (e.g., elastography) and examine biochemical markers of tendon remodeling (e.g., collagen turnover, cytokine expression). Such investigations could further elucidate the biological underpinnings of SWT and help optimize individualized treatment protocols for overuse injuries in athletic populations.

CONCLUSION

This study evaluated the impact of SWT on pain, ITB thickness, and lower limb function in track and field runners with ITBS. The results showed significant differences between pre- and post-intervention in the SWT group, which received both shockwave and routine physiotherapy. Given the absence of side effects, SWT is recommended to reduce pain, tendon inflammation, and improve lower limb function in athletes with ITBS.

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Table 1. Baseline Characteristics of Participants in the active and Sham SWT

Variable	**Group**		**P-Value**
	Shockwave (n=16)	**Control (n=16)**	
Gender (n, %)			
Female	7 (43.75%)	8 (50.00%)	.732 *
Male	9 (56.25%)	8 (50.00%)	
Dominant Foot (n, %)			
Right	13 (81.25%)	11 (68.75%)	.684 **
Left	3 (18.75%)	5 (31.25%)	
Affected Foot (n, %)			
Right	4 (25.00%)	6 (37.50%)	
Left	5 (31.25%)	3 (18.75%)	.611 £
Both	7 (43.75%)	7 (43.75%)	
Occupation (n, %)			
Employee	7 (43.75%)	4 (25.00%)	
Freelancer	6 (37.50%)	6 (37.50%)	.635 £
Student	2 (12.50%)	3 (18.75%)	
Homemaker	1 (6.25%)	3 (18.75%)	
Sports Experience (years)	7.94 ± 4.60	5.56 ± 3.52	.138 ££
Age (years)	33.06 ± 5.63	30.25 ± 4.77	.830 ££
BMI (kg/m^2)	24.14 ± 3.57	24.37 ± 2.30	.111 ££
Pain,	6.37 ± 0.71	6.00 ± 1.21	.295 ***
KOOS score	88.68 ± 10.60	83.43 ± 6.62	.105 ***
ITB tendon thickness (mm)	2.91 ± 0.32	2.68 ± 0.42	.100 ***

SWT: Shock Wave Therapy; BMI: Body Mass Index; KOOS: Knee Injury and Osteoarthritis Outcome Score; ITB: Iliotibial Band.

*Chi-Square; *Fisher's Exact Test; *** Independent sample t-test; £Fisher-Freeman-Halton Exact; ££T-Test

Table 2. Mean Changes in Physiological and Functional Outcomes Following Active-SWT vs. Sham SWT.

Variable	Time point	Within Group (Mean ± SD)		Between-Group			
		Active-SWT	Sham	Mean difference (95% CI)	F	*t (df)*	*P* value
Pain	Post-Baseline	-5.75 ± 1.00	-1.18 ± 0.91	-4.56 ± 0.33 (-5.25, -3.87)	0.587	*-13.50 (30)*	*P* < .001
	Follow-Up	-5.93 ± 0.85	-2.18 ± 1.10	-3.75 ± 0.34 (-4.46, -3.03)	0.607	*-10.71(30)*	*P* < .001
Knee function	Post-Baseline	-67.18 ± 13.39	-36.50 ± 5.83	-30.68 ± 3.65 (-38.14, -23.22)	9.783	*-8.40 (30)*	*P* < .001
	Follow-Up	-78.68 ± 10.87	-39.75 ± 5.85	-38.93 ± 3.08 (-45.24, -32.63)	4.733	*-12.61 (30)*	*P* < .001
ITB tendon thickness, mm	Post-Baseline	-1.13 ± 0.28	-0.38 ± 0.27	-0.74 ± 0.09 (-0.94, -0.54)	0.825	-7.53 (30)	*P* < .001
	Follow-Up	-1.20 ± 0.33	-0.41 ± 0.25	-0.78 ± 0.10 (-1.00, -0.58)	2.690	*-7.60 (30)*	*P* < .001

SWT: Shock Wave Therapy; KOOS: Knee Injury and Osteoarthritis Outcome Score; ITB: Iliotibial Band.

Mean differences are reported with 95% confidence intervals. Between-group comparisons were analyzed using ANOVA.

Table 3. Comparison of Knee Injury and Osteoarthritis Outcome Score (KOOS) (Mean ± SD) in Participants in SWT and Sham groups

KOOS Subscale	**Group**	**Pre-Intervention**	**Post-Intervention**	**Follow-up**	**Within-Group p-value**	**Between-Group p-value**
Pain	SWT	21.25 ± 3.45	2.81 ± 1.75	1.06 ± 0.92	*P* < .001	*P* < .001
	Control	19.87 ± 3.20	10.68 ± 2.60	9.93 ± 2.56		
Symptoms	SWT	14.62 ± 1.08	7.75 ± 2.84	5.62 ± 2.60	*P* < .001	*P* < .001
	Control	8.62 ± 2.80	8.62 ± 2.80	8.62 ± 2.80		
Activities of daily living	SWT	29.18 ± 5.10	4.56 ± 2.18	2.12 ± 1.74	*P* < .001	*P* < .001
	Control	26.87 ± 3.55	13.25 ± 5.65	11.93 ± 5.77		
Sport and recreation function	SWT	13.25 ± 3.80	1.81 ± 1.42	0.18 ± 0.40	*P* < .001	*P* < .001
	Control	13.25 ± 2.51	8.00 ± 2.52	6.81 ± 1.51		
Knee-related quality of life	SWT	10.37 ± 2.50	4.56 ± 1.99	1.00 ± 0.63	*P* < .001	*P* < .001
	Control	9.06 ± 1.80	6.37 ± 1.58	6.37 ± 1.58		

SWT: Shock Wave Therapy; KOOS: Knee Injury and Osteoarthritis Outcome Score.

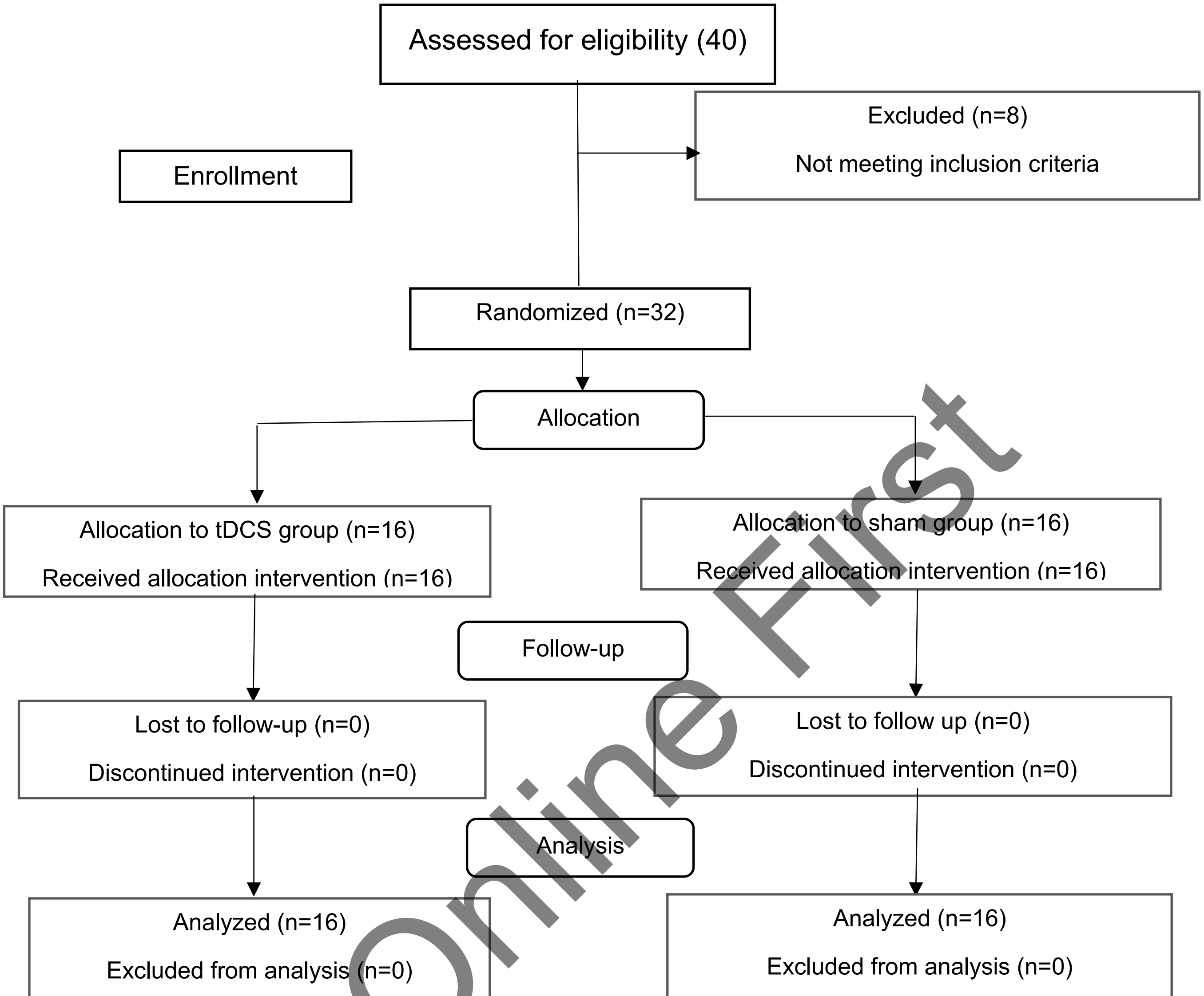

Figure 1. CONSORT flow diagram showing numbers of participants in the eligibility and enrollment, allocation, follow-up, and analysis stages.

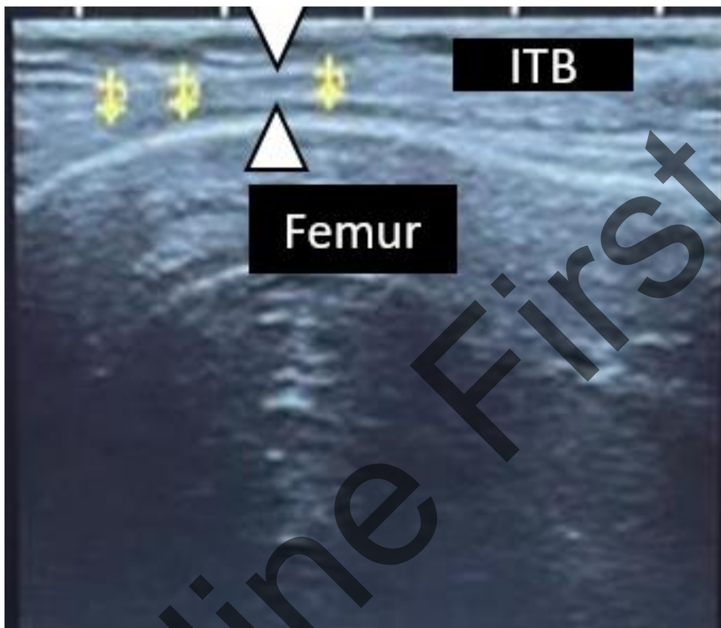

Figure 2. Ultrasonographic illustration of iliotibial band (arrowheads) and the lateral femoral epicondyle