Research Article

KINESIO TAPING AND EXTRACORPOREAL SHOCK WAVE THERAPY IN PLANTAR FASCIITIS: ACUTE EFFECTS ON PAIN, PLANTAR FASCIA FLEXIBILITY, AND LOWER EXTREMITY FUNCTION

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Abstract

Aim: This study aimed to compare the effects of extracorporeal shock wave therapy (ESWT), the combination of ESWT with kinesiology taping (KT), and placebo ESWT on pain intensity, lower extremity function, and plantar fascia flexibility in the acute phase of male patients with plantar fasciitis (PF).

Method: The study included 90 male patients aged 18–50 years with moderate pain intensity (Visual Analog Scale, VAS ≥4) diagnosed with PF. Patients were divided into ESWT, ESWT+KT, and placebo ESWT groups (n=30). Each group received the respective intervention in a single session. Pain intensity was assessed using the VAS, and functionality was evaluated using the Lower Extremity Functional Scale (LEFS). Plantar fascia flexibility was measured during passive dorsiflexion.

Findings: Significant reductions in VAS scores were observed in all groups ($p < 0.05$). LEFS scores increased only in the ESWT (p=0.011) and ESWT+KT (p=0.050) groups. Plantar fascia flexibility increased significantly only in the ESWT+KT group ($p = 0.012$). In a mixed-design ANOVA, a time×group interaction was found to be significant for LEFS (p=0.019) and flexibility (p=0.022); no significant interaction was detected for VAS. In Bonferroni-corrected post-hoc analysis, only the flexibility difference between ESWT+KT and placebo was significant ($p = 0.010$; $p < 0.017$).

Results: The combination of ESWT and KT provided additional benefits compared to ESWT alone in terms of pain control, lower extremity function, and plantar fascia flexibility during the acute phase. The placebo effect was limited to subjective pain reduction. Integration of ESWT+KT in early rehabilitation is recommended.

Keywords: Extracorporeal Shock Wave Therapy; Function; Kinesio Tape; Pain; Plantar Fasciiti

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Plantar Fasititte Kinezyo Bantlama ve Ekstrakorporal Şok Dalga Terapisinin Ağrı, Plantar Fasya Esnekliği ve Alt Ekstremite Fonksiyonuna Akut Etkisi

Öz

Amaç: Bu çalışma, plantar fasiiti (PF) olan erkek hastalarda ekstrakorporeal şok dalga terapisi (ESWT), ESWT ile kinezyo bantlamanın (KT) kombinasyonu ve placebo ESWT'nin akut fazdaki ağrı şiddeti, alt ekstremite fonksiyonelliği ve plantar fasya esnekliği üzerine etkilerini karşılaştırmayı amaçlamıştır.

Yöntem: Çalışmaya, PF tanısı konmuş, orta derecede ağrı şiddeti (Görsel Analog Ölçeği, GAS ≥4) olan 18-50 yaş arası 90 erkek hasta dahil edildi. Hastalar ESWT, ESWT+KT ve plasebo ESWT gruplarına (n=30) ayrıldı. Her grup tek seansta ilgili müdahaleyi aldı. Ağrı şiddeti GAS kullanılarak değerlendirildi ve fonksiyonellik Alt Ekstremite Fonksiyonel Skalası (AEFS) kullanılarak değerlendirildi. Plantar fasya esnekliği pasif dorsifleksiyon sırasında ölçüldü.

Bulgular: Tüm gruplarda GAS skorlarında anlamlı azalmalar gözlendi (p < 0,05). AEFS skorları sadece ESWT (p=0,011) ve ESWT+KT (p=0,050) gruplarında arttı. Plantar fasya esnekliği sadece ESWT+KT grubunda anlamlı olarak arttı (p = 0,012). Karışık tasarımlı ANOVA'da, zaman×grup etkileşiminin LEFS (p=0,019) ve esneklik (p=0,022) için anlamlı olduğu bulunmuştur; GAS için anlamlı bir etkileşim saptanmamıştır. Bonferroni düzeltmeli post-hoc analizinde, sadece ESWT+KT ve plasebo arasındaki esneklik farkı anlamlıdır (p = 0,010; p < 0,017).

Sonuç: ESWT ve KT'nin kombinasyonu, akut fazda ağrı kontrolü, alt ekstremite fonksiyonu ve plantar fasya esnekliği açısından ESWT'nin tek başına kullanımına kıyasla ek faydalar sağlamıştır. Plasebo etkisi, öznel ağrı azalmasıyla sınırlı kalmıştır. Erken rehabilitasyonda ESWT+KT'nin entegrasyonu önerilmektedir.

Anahtar Kelimeler: Ekstrakorporeal Şok Dalga Tedavisi; İşlevsellik; Kinezyolojik Bantlama; Plantar fasiit; Ağrı

1. INTRODUCTION

Plantar fasciitis (PF) is a prevalent etiology of heel pain, distinguished by persistent inflammation and degenerative alterations in the plantar fascia (Rhim et al., 2021). The plantar fascia is a thick band of connective tissue that connects the calcaneus, or heel bone, to the toes. It is responsible for arch support and shock absorption during ambulation (Morrissey et al., 2021). Excessive mechanical stress, which can be caused by factors such as obesity, prolonged standing, improper footwear, or incorrect walking dynamics, can lead to repetitive microtears and an impaired healing process (Hamstra-Wright et al., 2021). During this process, irregularities in collagen fibers, fibrosis, and calcification develop, causing the fascia to thicken (>4 mm). Thickening of the fascia has been shown to reduce its flexibility, intensify pain, and impair walking function. Untreated, such conditions can lead to a considerable decline in quality of life, marked by the presence of chronic pain and impaired mobility (Koc et al., 2023).

Conservative treatment is regarded as the primary phase of PF management, with physiotherapy and rehabilitation interventions serving as pivotal components. These interventions are designed to alleviate pain, restore plantar fascia elasticity, and restore normal walking patterns (Guimarães et al., 2023). Among physiotherapy approaches, extracorporeal shock wave therapy (ESWT) and Kinesio Taping (KT) are prominent methods (Ordahan et al., 2017). ESWT utilizes high-energy acoustic waves to induce microtrauma in the targeted tissue. This microtrauma instigates tissue remodeling, amplifies the secretion of anti-inflammatory cytokines, and modulates pain through the "gate control theory" mechanism. Low-energy radial ESWT (rESWT) is frequently preferred due to its widespread effect and patient comfort (Elgendy et al., 2024). KT, utilizes elastic bands to regulate fascia tension, improve pressure distribution, enhance lymphatic drainage, and support proprioception (Tran et al., 2023). However, the effects of combining ESWT and KT in the acute phase (on pain, flexibility, and functionality) remain to be elucidated.

Placebo-controlled studies are of critical importance in measuring the true effect of treatments (Millum & Grady, 2013). Placebo ESWT emulates the acoustic characteristics and tactile sensations of the active treatment, yet it does not administer therapeutic energy. This approach enables the discernment of improvements attributable to patient expectations or psychological effects. The extant literature suggests that placebo ESWT can provide short-term pain relief (Wang et al., 2019). However, the impact of placebo ESWT on objective parameters such as flexibility or functionality remains to be elucidated. Furthermore, no studies have directly compared the ESWT+KT combination with a placebo.

While extant literature emphasizes the long-term benefits of ESWT and KT in PF, there is a significant paucity of data on the acute phase effects of these methods (Nas Kırdar & Kanyılmaz, 2023). Acute phase outcomes are critical for personalizing early rehabilitation strategies. From a clinical standpoint, these immediate effects are of particular significance. For instance, the rapid enhancement of flexibility may enable patients to mobilize at an earlier stage, while the temporary alleviation of pain may result in a reduction in the utilization of analgesic medications. To address this gap and evaluate the therapeutic potential of acute interventions, a single-blind, randomized controlled trial was conducted. The primary objective of the study was to compare the acute effects of three protocols: (1) ESWT alone, (2) ESWT combined with KT, and (3) placebo ESWT.

2. MATERIALS AND METHODS

The present study was conducted in accordance with the Helsinki Declaration and has been approved by the Ethics Committee of the Faculty of Health Sciences at *** University (Ethics Committee No: 2023/451; Application No: 14478). The study protocol was registered in advance on ClinicalTrials.gov (NCT06055933) to ensure transparency and compliance with international reporting standards. Prior to registration, all volunteers were provided with detailed information about the study procedures, potential risks, and benefits in their native languages. Written informed consent was obtained from each participant. A single-blind, randomized controlled design was employed, entailing a single-session treatment intervention and two standard assessments—baseline (pre-intervention) and post-intervention—with evaluations conducted by a researcher who was blinded to the study's interventions.

2.1. Participants

The present study was conducted on a sample of 93 male patients diagnosed with chronic PF. The inclusion criteria for participation in the study were as follows: subjects had to be between the ages of 18 and 50, have a baseline pain intensity of at least 4 on the Visual Analog Scale (VAS; 0-10), and not have received any physical therapy or corticosteroid injections in the previous two weeks. Exclusion criteria encompassed active infection, systemic inflammatory disease (e.g., rheumatoid arthritis), malignancy, circulatory disorders in the lower extremities, deep vein thrombosis, peripheral neuropathy, previous foot/ankle surgery, structural deformities (severe flat feet/high arches), pregnancy, allergy to KT materials, and inability to comply with the study protocols. Participant eligibility was determined through a comprehensive evaluation that entailed a clinical examination and a thorough review of the subject's medical history. During the screening process, three participants were excluded (Figure 1.). The remaining 90 participants were randomly assigned to three groups using the Research Randomizer software and the block randomization method: ESWT group (n=30), ESWT+KT group (n=30), and placebo ESWT group (n=30). Group assignments were stored in opaque, sealed envelopes prepared by an independent statistician and opened by the physical therapist during the initial treatment session.

Outcome measurements, including VAS, LEFS, and flexibility tests, were conducted by a physical medicine specialist physician who was unaware of the group assignments. The physical therapist who administered the treatment could not be blinded due to the practical nature of the intervention. The participants were informed that they might receive either "active or simulated treatment," yet the specifics of the placebo procedures were not disclosed.

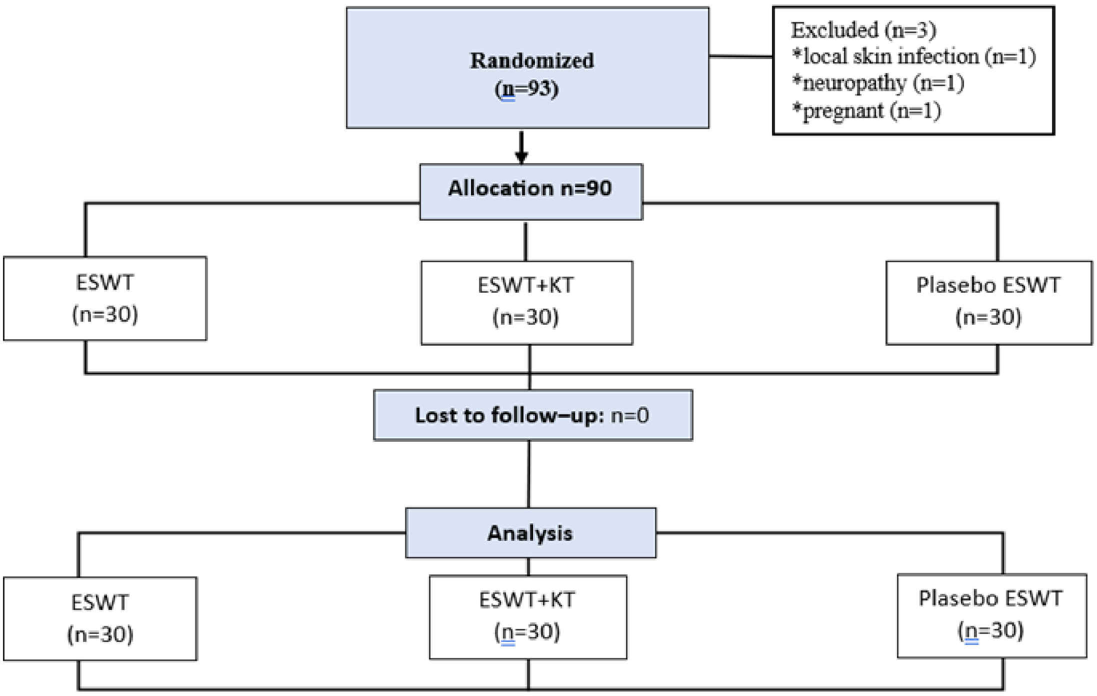

Figure 1. Flow Diagram

2.2. Data Collection

During the data collection process, the BTL-6000 SWT model radial shock wave device (BTL Industries, UK) was utilized in the ESWT group. The treatment parameters were set as follows: energy density of 0.25 mJ/mm² (total of 2.5 mJ/mm²), frequency of 10 Hz, applicator diameter of 15 mm, and 2,000 pulses per session. The selection of these parameters was guided by the moderate energy range that has been widely documented in the literature as a crucial stimulus for tissue repair in PF (International Society for Medical Shockwave Treatment, 2023). Prior to application, the medial calcaneal region was assessed via palpation, and the point reported by the patient as the most painful was targeted (Figure 2.). In the placebo ESWT group, the same device and application protocol as the active treatment were used, but the energy output was disabled. The device's operating sound and vibration were simulated using a pre-recorded audio file, ensuring that participants could not distinguish it from the actual treatment. This deceptive application endeavors to distinguish non-specific effects, such as patient expectations and contact pressure, by reproducing the auditory and tactile stimuli of ESWT without therapeutic energy transmission. The application of KT was performed subsequent to shock wave therapy in the ESWT+KT group. The Kinesio Tex Gold FP (5 cm × 5 m) elastic tapes were applied using the "fascia correction technique," (Figure 3.) and the skin was sterilized with an alcohol-soaked cloth prior to taping (Kase et al., 2013).

Figure 2. Application of Shock Wave Therapy

Figure 3. Application of Kinesio Taping

2.3. Outcome Measure

2.3.1. Visual Analog Scale (VAS)

The assessment of pain intensity was conducted using the VAS, a method that has been demonstrated to be both valid and reliable in the measurement of musculoskeletal pain. Participants were instructed to rate their pain levels on a 10-centimeter line, ranging from 0, indicating "no pain," to 10, indicating "unbearable pain." VAS is a widely utilized method in PF studies due to its sensitivity to acute pain changes (Yaray et al., 2011; Dixon & Bird, 1981).

2.3.2. The Lower Extremity Functional Scale (LEFS)

The lower extremity function of the subjects was measured using the 20-item Lower Extremity Functional Scale (LEFS), which is a well-established tool that assesses daily activities (walking, climbing stairs, squatting, etc.). Each item was evaluated on a scale ranging from 0 (representing a very difficult or unfeasible task) to 4 (indicating no difficulty), with a total score ranging from 0 to 80, where higher scores denote enhanced functional capacity. The LEFS has been validated as a measure in the PF population (Binkley et al., 1999; Citaker et al., 2016).

2.3.3. Plantar Fascia Flexibility

The measurement of plantar fascia flexibility was executed in accordance with a standardized protocol (Akınoğlu, Köse & Soylu, 2018). Participants were instructed to position themselves with their knees slightly flexed and their heels in contact with the wall. The distance (in centimeters) between the tip of the participant's big toe and the wall was then measured during maximum passive dorsiflexion (Figure 4.).

Figure 4. Measurement of Fascia Flexibility

2.4. Sample Size

The G-Power program (Version 3.1.7, Franz Faul, University of Kiel, Germany) was utilized to calculate the sample size for the present study. According to the reference study, the primary outcome measure parameter was the VAS (Şaş & Koçak, 2020). The effect size was calculated using the mean and standard deviation values from the reference article before treatment (8.75 ± 1.06) and after treatment (2.07 ± 1.77), as shown in Table II. The effect size was calculated to be d=0.432, and the power was set to 85% based on the reference article. A total of 90 participants were included in the study, with 30 participants in each group.

2.5. Statistical Analysis

The data analysis was conducted using IBM SPSS Statistics 21.0 (Armonk, NY: IBM Corp) software. The descriptive statistics for numerical data with a normal distribution are presented as the mean ± standard deviation. For those without a normal distribution, the descriptive statistics are presented as the median (25th–75th percentile). For categorical data, the descriptive statistics are presented as frequency (%). For within-group comparisons (pre- and post-treatment), a paired t-test was employed for normally distributed data, and the Wilcoxon signed-rank test was utilized for non-normally distributed data. To assess intergroup differences and time-group interactions, a mixed-design analysis of variance (ANOVA) was employed. Furthermore, the statistical analysis included the calculation of pre- and post-treatment difference scores for each of the outcome variables (VAS, LEFS, flexibility). To ensure the validity of the results, intergroup comparisons were performed using the One-Way ANOVA method if the data were normally distributed and the Kruskal-Wallis test if they were not. Bonferroni correction was applied to control Type I error. The adjusted significance threshold was set at $a = 0.05/3 = 0.017$ for all possible pairwise comparisons (total of 3: ESWT vs. ESWT+KT, ESWT vs. placebo, ESWT+KT vs. placebo). Therefore, post hoc pairwise comparison results were considered statistically significant only when $p < 0.017$.

3. RESULTS

Of the 93 male patients enrolled in the study, three were excluded, and the study was completed with a total of 90 patients divided into three groups (ESWT, ESWT+KT, placebo) of 30 patients each (Figure 1.). A meticulous examination of the data revealed no statistically significant disparities between the groups with respect to age, body mass index (BMI), distribution of affected/dominant extremities, pre-treatment pain intensity (VAS), lower extremity function (LEFS), plantar fascia flexibility, and analgesic use frequency (all $p > 0.05$; Table I).

Table I. Baseline demographic and clinical characteristics of the study groups

		ESWT Groups (n=30)	ESWT+KT Groups (n=30)	ESWT placebo Groups (n=30)	p
Age (year)		47.8±4.8	44.3±9.1	45.5±6.2	0.27 (2.6[b])
BMI (kg/m^2)		31.2±4.8	31.9±3.4	31.7±6.7	0.49 (1.4[b])
Dominant foot Right/Left		29/1	30/0	29/1	0.60 (X^2=1.02)
Affected Extremity Right/Left		11/19	17/13	17/13	0.20 (X^2=3.2)
VAS	Before treatments	8 (7-10)	8 (5-10)	8 (4-10)	0.56 (1.16[a])
	After treatments	6 (3-10)	6 (0-10)	7 (3-10)	0.71 (0.67[a])
LEFS	Before treatments	40.0 (35-45)	40.0 (32-48)	39.0 (30-44)	0.22 (3.0[a])
	After treatments	41.5 (36-47)	41.0 (33-50)	40.0 (31-45)	0.33 (2.2[a])
Flexibility (cm)	Before treatments	4.0 (2.5-5.0)	4.0 (2.4-5.4)	4.0 (2.5-5.0)	0.99 (0.06[a])
	After treatments	4.0 (2.5-5.2)	4.2 (3.0-5.8)	4.0 (2.5-5.0)	0.54 (1.25[a])
Analgesia (n)	Before treatments	0 (0-4)	0 (0-2)	0 (0-2)	0.96 (0.08[a])
	After treatments	0 (0-4)	0 (0-2)	0 (0-2)	0.51 (1.35[a])

$p < 0.05$: significance level, ESWT: Extracorporeal Shockwave Therapy, KT: Kinesio Taping, VAS: Visual Analog Scale, Flexibility: Fascia elasticity level, cm: centimeter, LEFS: Lower Extremities Functional Scale, Analgesia (n): Number of analgesic intakes, a: Kruskal-Wallis test (non-normally distributed data), b: One-way ANOVA (normally distributed data), χ^2: Chi-square test (categorical data).

Subsequent to the administration of treatment, a substantial decrease in pain levels, as measured by the VAS scale, was observed among all three groups. In the ESWT group, the median VAS score demonstrated a statistically significant decrease from 8 (interquartile range [IQR]: 7–10) to 6 (IQR: 3–10; p = 0.010) post-treatment. In a similar vein, the ESWT+KT group exhibited a median VAS score reduction from 8 ([IQR]: 5–10) to 6 (IQR: 0–10; p = 0.010), while the placebo group demonstrated a decrease from 8 (IQR: 4–10) to 7 (IQR: 3–10; p = 0.010). LEFS demonstrated enhancement in the ESWT cohort, exhibiting an increase from a median score of 40 to 41.5 (p = 0.011). A similar trend was observed in the ESWT+KT group, where the median score advanced from 40 to 41 (p = 0.050). A notable enhancement in plantar fascia flexibility was observed exclusively in the ESWT+KT group, with a median increase from 4 centimeters to 4.2 centimeters, yielding a statistically significant result (p = 0.012). The frequency of analgesic use remained consistent across all groups (p > 0.05) (Table II).

Table II. Within-group comparisons of pre- and post-treatment outcome measures

Groups	Outcome	Before Treatment	After Treatment	p/z
ESWT	VAS	8 (7-10)	6 (3-10)	0.010 (z=-4.18)
	LEFS	40.0 (35-45)	41.5 (36-47)	0.011 (z=-2.55)
	Flexibility (cm)	4.0 (2.5-5.0)	4.0 (2.5-5.2)	0.054 (z=-1.93)
	Analgesia (n)	0 (0-4)	0 (0-4)	0.051 (z=-2.12)
ESWT+KT	VAS	8 (5-10)	6 (0-10)	0.010 (z=-4.05)
	LEFS	40.0 (32-48)	41.0 33-50)	0.050 (z=-1.92)
	Flexibility (cm)	4.0 (2.4-5.4)	4.2 (3.0-5.8)	0.012 (z=-2.50)
	Analgesia (n)	0 (0-2)	0 (0-2)	0.102 (z=-1.60)
ESWT placebo	VAS	8 (4-10)	7 (3-10)	0.010 (z=-3.47)
	LEFS	39.0 (30-44)	40.0 (31-45)	0.620 (z=-0.49)
	Flexibility (cm)	4.0 (2.5-5.0)	4.0 (2.5-5.0)	0.320 (z=-1.00)
	Analgesia (n)	0 (0-2)	0 (0-2)	0.320 (z=-1.00)

$p < 0.05$: significance level, ESWT: Extracorporeal Shockwave Therapy, KT: Kinesio Taping, VAS: Visual Analog Scale, Flexibility: Fascia elasticity level, cm: centimeter, LEFS: Lower Extremities Functional Scale, Analgesia (n): Number of analgesic intakes, z: Wilcoxon Signed-Rank Test.

Between-group comparisons using a mixed-design analysis of variance (ANOVA) revealed that the time × group interaction was statistically significant for LEFS (F [2,87] = 4.12; p = 0.019) and plantar fascia flexibility (F [2,87] = 3.98; p = 0.022). However, this interaction was not significant for VAS scores (F [2,87] = 1.45; p = 0.241). Subsequent Bonferroni-corrected post hoc analyses (α = 0.017) revealed that the mean differences in LEFS scores between ESWT vs. ESWT+KT (1.5 vs. 2.3; unadjusted p = 0.120), ESWT vs. placebo (1.5 vs. 0.8; unadjusted p = 0.040), and ESWT+KT vs. placebo (2.3 vs. 0.8; unadjusted p = 0.030) did not meet the p < 0.017 threshold, and thus no statistically significant group differences were found in terms of LEFS. Regarding plantar fascia flexibility, the mean difference between ESWT vs. ESWT+KT comparison showed an average difference of 0.1 cm vs. 0.3 cm (unadjusted p = 0.040), ESWT vs. placebo comparison showed 0.1 cm vs. 0.0 cm (unadjusted p = 0.150), and ESWT+KT vs. placebo comparison showed 0.3 cm vs. 0.0 cm (unadjusted p = 0.010). Only the ESWT+KT vs. placebo comparison met the p = 0.010 < 0.017 threshold and was considered statistically significant. In the pairwise comparisons of VAS scores, all p values were above 0.05, indicating that the differences between groups were not statistically significant (Table III).

Table III. Mixed-design ANOVA and post-hoc analysis results for outcome measures

Outcome Measure	Time × Group Interaction	Group Comparison	Mean Difference (95% CI)	p-value (Uncorrected; Bonferroni-Adjusted)
LEFS	*F* (2,87) = 4.12, *p* = 0.019	ESWT vs ESWT + KT	1.5 vs 2.3 (95% CI – 0.42 – 3.42)	0.120 (uncorrected); 0.360 (adjusted)
		ESWT vs Placebo	1.5 vs 0.8 (95% CI – 0.35 – 2.75)	0.040 (uncorrected); 0.120 (adjusted)
		ESWT + KT vs Placebo	2.3 vs 0.8 (95% CI 0.48 – 4.12)	0.030 (uncorrected); 0.090 (adjusted)
Plantar Fascia Flexibility (cm)	*F* (2,87) = 3.98, *p* = 0.022	ESWT vs ESWT + KT	0.1 cm vs 0.3 cm (95% CI 0.01 – 0.59)	0.040 (uncorrected); 0.120 (adjusted)
		ESWT vs Placebo	0.1 cm vs 0.0 cm (95% CI –0.15 – 0.25)	0.150 (uncorrected); 0.450 (adjusted)
		ESWT + KT vs Placebo	0.3 cm vs 0.0 cm (95% CI 0.07 – 0.53)	0.010 (uncorrected); 0.030 (adjusted) **Yes**
VAS	*F* (2,87) = 1.45, *p* = 0.241	All group comparisons	–	>0.05

LEFS: Lower Extremity Functional Scale; VAS: Visual Analog Scale; ESWT: Extracorporeal Shock Wave Therapy; KT: Kinesio Taping; Mixed-design ANOVA: time (pre-post) × group (ESWT, ESWT + KT, placebo) interaction effects; Uncorrected p-values derive from post hoc one-way ANOVAs; Because all three possible pairwise comparisons were performed, the Bonferroni-corrected alpha level was set at 0.05 / 3 = 0.017; an outcome was deemed statistically significant only if its uncorrected p < 0.017.

4. DISCUSSION

This study is the first randomized controlled trial comparing the acute effects of single-session ESWT, ESWT + KT combination, and placebo ESWT on pain, lower extremity function, and plantar fascia flexibility in patients diagnosed with PF. Our findings confirmed a statistically significant reduction in pain scores in all groups (ESWT: p = 0.010; ESWT+KT: p = 0.010; placebo: p = 0.010), improvements in lower extremity function were observed only in the ESWT (p = 0.011) and ESWT+KT (p = 0.050) groups. An important finding was that a significant increase in plantar fascia flexibility was detected only in the ESWT+KT group (p = 0.012). In the placebo group, there were no significant changes in function (p = 0.620) or flexibility (p = 0.320).

Mixed-design ANOVA analyses revealed a significant time × group interaction for lower extremity function score (LEFS) (F[2,87] = 4.12; p = 0.019) and plantar fascia flexibility (F[2,87] = 3.98; p = 0.022), no similar interaction was observed for pain measured by VAS (F[2,87] = 1.45; p = 0.241).

Bonferroni-corrected ($\alpha = 0.017$) post hoc analyses revealed critical findings: The difference in plantar fascia flexibility was statistically significant only between the ESWT+KT and placebo groups (unadjusted $p = 0.010$; adjusted $p < 0.017$). Improvements in LEFS did not exceed the Bonferroni threshold ($p < 0.017$) in any group pair (ESWT vs ESWT+KT: $p = 0.120$; ESWT vs placebo: $p = 0.040$; ESWT+KT vs placebo: $p = 0.030$). The decrease in VAS scores did not show a significant difference between groups ($p > 0.05$).

In terms of mechanism, the analgesic effect of ESWT is based on the excessive stimulation of peripheral nociceptors, reflex inhibition, and increased release of growth factors and anti-inflammatory cytokines (Ryskalin et al., 2022). KT, on the other hand, improves pressure distribution, accelerates lymphatic flow, and mechanically stimulates mechanoreceptors, leading to temporary increases in fascia flexibility and improvements in proprioception (Wu et al., 2015). Consistent with these mechanisms, the ESWT + KT protocol resulted in a statistically significant improvement in plantar fascia flexibility ($p = 0.010$), whereas functional gains (LEFS) did not meet the Bonferroni-adjusted threshold ($p < 0.017$). Although the ESWT group showed a trend toward improvement in lower extremity function ($p = 0.011$), this difference did not reach statistical significance after Bonferroni correction. Our findings are consistent with the known placebo effect on subjective pain perception. Placebo ESWT significantly reduced pain scores ($p = 0.010$), demonstrating the strong influence of patient expectations and contextual factors on subjective pain reporting in PF. However, it did not produce any meaningful improvement in more objective measures such as lower extremity function ($p = 0.620$) or plantar fascia flexibility ($p = 0.320$). This clear distinction emphasizes that while placebo can modulate pain perception, it does not produce measurable physiological changes in tissue properties or functional capacity during the acute phase.

Two different ESWT methods have been used in the literature for plantar fasciitis: radial ESWT (rESWT) and focused ESWT (fESWT). rESWT reaches approximately 3 cm in depth at low pressure (1–10 MPa), while fESWT can penetrate up to 12 cm at high pressure (10–100 MPa) (Lohrer et al., 2010). We opted for rESWT at medium energy intensity (0.25 mJ/mm^2) due to its broader treatment area, patient comfort, and cost-effectiveness. The single-session design of this study confirmed that moderate-intensity rESWT improves lower extremity function in acute rehabilitation (pre- vs post-LEFS $p = 0.011$); however, the lack of a Bonferroni-adjusted p value < 0.017 suggests that the treatment effect may require a more flexible analysis threshold.

4.1. Clinical Applications and Contributions

This study is the first to evaluate the immediate effects of ESWT, ESWT + KT, and placebo ESWT in PF in terms of both functionality and facial flexibility. The results suggest that combining KT with ESWT may provide synergistic benefits in acute rehabilitation and indicate that this method can be easily integrated into existing shock wave protocols. In particular, while the addition of KT to ESWT offers selective superiority in tissue flexibility, further studies are needed to confirm functional gains. Additionally, the potential of single-session interventions to reduce analgesic dependency and accelerate early rehabilitation emerges as a significant advantage in clinical practice. These findings also emphasize the need for multicenter studies evaluating long-term outcomes.

5. CONCLUSION

In this randomized controlled trial, the addition of KT to ESWT provided a significant acute-phase benefit, particularly for plantar fascia flexibility, compared to ESWT alone and placebo ESWT (ESWT + KT vs. placebo: unadjusted $p = 0.010$; Bonferroni-adjusted $p < 0.017$). Specifically, while the placebo group showed a statistically significant reduction in subjective pain scores ($p = 0.010$), it did not demonstrate any significant improvement in function ($p = 0.620$) or flexibility ($p = 0.320$). Although statistically significant intra-group improvements in lower extremity function (LEFS) were observed in the ESWT ($p = 0.011$) and ESWT + KT ($p = 0.050$) groups before and after intervention, after adjustment for multiple comparisons, the between-group differences in LEFS change scores did not meet the Bonferroni-corrected significance threshold of $p < 0.017$. No significant difference was found between groups in pain reduction measured by VAS. These findings strongly support the integration of ESWT and KT in early PF rehabilitation protocols to acutely increase plantar fascia flexibility. The placebo's selective effect on subjective pain perception further validates the specific biomechanical effects of the ESWT+KT combination on tissue properties.

Supporting Organization

There is no individual or organization providing financial support for this study.

Conflict of interest

The authors have no conflicts of interest.

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