




Comparison of the effectiveness of medium-and low-intensity ESWT in patients with plantar fasciitis

 Nazlı Kılıç¹,  Besna İrem Şekerci^{*2},  Tamer Çankaya³

¹Department of Physiotherapy and Rehabilitation, Dr. Nafiz Körez Sincan State Hospital, Ankara, Türkiye

²Department of Physiotherapy and Rehabilitation, Institute of Postgraduate Education, Bolu Abant İzzet Baysal University, Bolu, Türkiye

³Department of Physiotherapy and Rehabilitation, Faculty of Health Sciences, Bolu Abant İzzet Baysal University, Bolu, Türkiye

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ABSTRACT

Aims: Plantar fasciitis (PF) is caused by inflammation or microtrauma of the plantar fascia, leading to heel pain. Extracorporeal shock wave therapy (ESWT) is a non-invasive method that reduces pain via acoustic waves. This study compared medium- and low-intensity ESWT effects on pain and quality of life in PF patients.

Methods: Forty-two PF patients without recent conservative treatment were randomized into low-intensity ESWT (L-ESWT), medium-intensity ESWT (M-ESWT), and placebo groups. All received cold packs and a standardized exercise program. Outcomes included Visual Analog Scale (VAS), algometry, Roles and Maudsley (RM) score, joint range of motion, Foot Function Index (FFI), and Nottingham Health Profile (NHP), assessed at baseline, post-treatment, and six weeks.

Results: L-ESWT and M-ESWT groups showed significant pain reduction and improved joint mobility and function after treatment and at six weeks ($p<0.05$). NHP subdomains of pain, energy, and sleep also improved ($p<0.05$). L-ESWT yielded greater RM score improvement ($p=0.01$). No significant differences were found between ESWT groups in overall effectiveness ($p>0.05$).

Conclusion: The positive effects of ESWT persisted at six weeks, supporting its short-to mid-term benefit in managing PF-related symptoms.

Keywords: Extracorporeal shockwave therapy, pain, plantar fasciitis, rehabilitation

INTRODUCTION

The plantar fascia is a fibrous layer in the subcutaneous tissue, extending from the calcaneus to the forefoot's deep soft tissues, including proximal phalanges and superficial dermis.¹ It maintains the medial longitudinal arch during weight-bearing, absorbs shock, and aids the windlass mechanism in gait's push-off phase.^{2,3} PF is a degenerative and inflammatory condition at the fascia's attachment on the inferomedial calcaneus due to repetitive microtrauma. It is a leading cause of adult heel pain.^{4,5} Pain worsens with passive toe dorsiflexion, peaks during the first morning steps after rest, may lessen with movement, but often persists and worsens with prolonged walking or activity.⁶ When conservative treatments fail and surgery outcomes are inconsistent, ESWT offers a non-invasive alternative for PF management.⁷

ESWT uses electrohydraulic shock waves-high-energy acoustic waves generated by high-voltage spark discharge between electrodes. The device works on the principle that the body's acoustic impedance is similar to water's, so shock waves are produced in water and transmitted via a coupling medium, focusing energy at the therapeutic point (F2) while reducing reflection losses.^{8,9} ESWT's effect depends

on cavitation, where microbubbles form and move in fluid, causing microtrauma. This triggers healing, promoting neovascularization and pain reduction. Pain relief results from enzyme release and new vessel formation.³

ESWT is a proven effective and safe conservative treatment for PF and ranks among the most successful compared to other methods.¹⁰ A 2024 meta-analysis found ESWT improved pain and FFI scores more than placebo, but showed no superiority over other treatments.¹¹

A study with gradually increased ESWT intensity showed greater pain and biomechanical improvements than controls.¹² While the optimal ESWT energy level is debated, medium-energy ESWT consistently reduces PF pain; low- and high-energy effects versus control are unclear.¹³ A 5-session ESWT protocol also improved quality of life.¹⁴

Although numerous studies have investigated the use of ESWT in the treatment of PF, uncertainty remains regarding the effectiveness of different energy levels. This study aims to evaluate and compare the effects of medium- and L-ESWT on pain and quality of life in patients with PF.

*Corresponding Author: Besna İrem Şekerci, besnairemsekerci@gmail.com



METHODS

This study has been approved by the Clinical Researches Ethics Committee of Abant İzzet Baysal University (Date: 17.06.2014, Decision No: 2014/45). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki. A total of 42 participants presenting with heel pain, diagnosed with PF by a physical medicine and rehabilitation specialist, and who voluntarily signed informed consent forms were included in the study. Inclusion criteria were: a confirmed PF diagnosis by a specialist physician, no history of conservative treatment for PF within the last six months, and voluntary participation. Exclusion criteria included the use of non-steroidal anti-inflammatory drugs or conservative treatments for PF within the past six months, presence of inflammatory arthropathies, pregnancy, pacemaker implantation, skin ulcerations, or coagulation disorders.

Participants were assigned into three groups: L-ESWT (n=20), M-ESWT (n=20) and placebo ESWT (n=20)-using a stratified random sampling method that considered age, sex, and sociodemographic characteristics. The allocation was performed by an independent researcher who was not involved in the intervention. Group 1 received L-ESWT, Group 2 received M-ESWT, and Group 3 received placebo ESWT. During the intervention phase, a total of 17 participants discontinued the study: six from the L-ESWT group, three from the medium-intensity group, and nine from the placebo group. Withdrawals were mainly due to mild discomfort during treatment sessions and logistical challenges, such as scheduling conflicts or difficulty attending follow-ups. The final analyses were conducted on the 42 participants who completed the study. All groups also received a 15-minute cold pack application and a standardized exercise program. The ESWT intervention was administered once a week for a total of three sessions.

Measurements

Demographic data of patients with PF were recorded. Assessments were performed at three time points: before treatment, immediately after treatment, and six weeks post-treatment.

Pain Assessment

Pain intensity was evaluated using the VAS, a 10-cm line with endpoints labeled '0' (no pain) and '10' (worst possible pain).¹⁵ Patients were asked to mark their pain level at rest, in the morning, at night, during palpation, and in daily activities. The distance from the line's start to the mark was measured in centimeters and recorded.

Pressure algometry quantitatively measures pressure pain thresholds, providing an objective assessment of tenderness typically evaluated by palpation. Fischer et al.¹⁶ noted that algometry can aid in diagnosing trigger and hypersensitive points. In this study, a Baseline mechanical pressure algometer with a spring-loaded, rubber-tipped cylindrical probe of 1 cm² area was used. Before measurement, pressure was gradually applied by the examiner's thumb to the pain site until blanching of the nail bed (approximately 4 kg). Subsequently, increasing pressure was applied until the participant reported pain, distinguishing it from pressure

sensation. This procedure was repeated three times per site, and the average value was recorded. A 10-15 second interval was maintained between measurements.

Assessment of Normal Joint Range of Motion (ROM)

Ankle dorsiflexion, plantarflexion, eversion, and inversion ROM values were measured using a goniometer at baseline, post-treatment, and at 6 weeks follow-up.

Foot Function Assessment

The FFI was used to evaluate functional status. The FFI is a widely used self-reported questionnaire designed to assess the impact of foot pathologies like PF on pain, disability, and activity limitation. It consists of 23 items grouped into three subscales: pain, functional limitation, and activity restriction. Each item is scored from 0 (no problem) to 10 (severe problem). Subscale means are calculated, and the total score ranges from 0 to 100, with higher scores indicating worse function.¹⁷

Roles and Maudsley Score

The RM score is a four-grade subjective scale assessing pain level and treatment response. Scores are classified as: 1-no pain (excellent), 2-marked improvement (good), 3-partial improvement (acceptable), and 4-persistent or worsening symptoms (poor). Patients with scores of 1 or 2 are considered treatment successes.⁸

Quality of Life Assessment

The NHP was used to assess quality of life. The NHP evaluates patient-perceived emotional, social, and physical health problems. Each section is scored from 0 to 100, with questions answered as "yes" or "no." The best possible total score is 0, indicating no problems, while the worst is 100. The questionnaire consists of 38 items across six categories: energy, pain, physical mobility, sleep, emotional reactions, and social isolation.¹⁹

In this study, various assessment tools were applied at three time points: before treatment, immediately after treatment, and six weeks post-treatment. Before treatment, VAS, pressure algometry, ROM, NHP, FFI, and RM scales were used. Post-treatment assessments included VAS, pressure algometry, ROM, FFI, and RM. At six weeks, all scales-VAS, pressure algometry, ROM, NHP, FFI, and RM-were administered.

Treatment Procedure

In the current literature, it is generally observed that ESWT is effective when administered two or three times at intervals of one week (or longer).²⁰ Participants received a total of three ESWT sessions once weekly using the Roland Serie-ESWT device. The low-intensity group was treated with 1.8 bar (0.05 mJ/mm²), the medium-intensity group with 2.1 bar, and the placebo group with a minimal dose of 0.5 bar to simulate the treatment without delivering a therapeutic effect. All groups received 1,000 pulses per session at a frequency of 5 Hz. Following each treatment, a 10-minute ice application was administered, and patients were instructed on an exercise program. Exercises included rolling a cold bottle under the foot, towel gathering with toes, and gastrocnemius-soleus stretching against a wall and with a sheet. Patients were advised to perform the exercises three times daily with 10 repetitions each.

Statistical Analysis

Data were analyzed using SPSS 24.0. Normality of continuous variables was assessed with the Shapiro-Wilk test. For normally distributed repeated measures, Repeated Measures ANOVA was used; for non-normal data, the Friedman test was applied. Post-hoc pairwise comparisons after Friedman were conducted using the Wilcoxon Signed-Rank test. For significant Repeated Measures ANOVA results, paired t-tests were performed. Between-group comparisons for continuous variables used One-Way ANOVA (parametric) or Kruskal-Wallis H test (non-parametric). Significant Kruskal-Wallis results were further examined with Mann-Whitney U tests; significant ANOVA results with Tukey HSD post-hoc tests. A p-value <0.05 was considered statistically significant. Post-hoc power analysis was conducted using G*Power (v3.1) with an ANOVA repeated measures, within-between interaction model. Parameters included effect size=0.25, alpha=0.05, sample size=42, correlation among repeated measures=0.66, and sphericity correction epsilon=1.0. The calculated statistical power was 57.91%.

RESULTS

A total of 42 participants were included: 14 in the L-ESWT group, 17 in the M-ESWT group, and 11 in the placebo ESWT group. No statistically significant differences were found among the groups regarding age (p=0.492), gender (p=0.444), body mass index (BMI) (p=0.773), or dominant side (p=0.340). The flow diagram is presented in **Figure**.

Table 1 presents the analyses conducted for pain assessment.

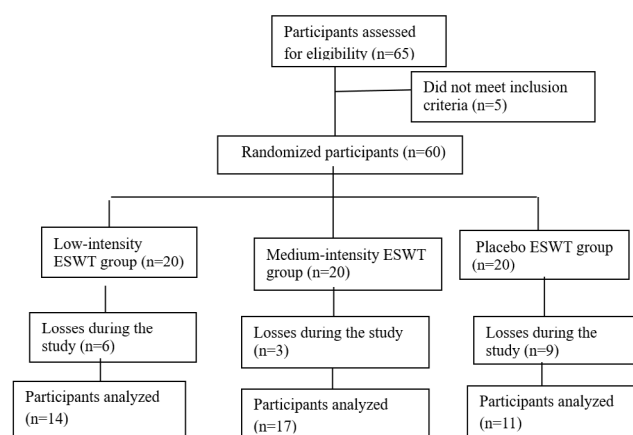


Figure. Flow diagram

The comparison of normal joint range of motion is presented in **Table 2**.

When examining the subcomponents of the FFI, significant improvements were observed in pain and disability scores in all groups at 6 weeks compared to baseline (p<0.01). Although a decreasing trend was noted in activity levels across all three groups, this change was not statistically significant (p>0.05) (**Table 3**).

According to the RM functional assessment results, significant improvement was observed at 6 weeks post-treatment in the low-intensity and placebo groups (p=0.002 and p=0.021, respectively), while the change in the medium-intensity group approached significance (p=0.056) (**Table 4**).

Table 1. Comparison of pain assessments					
		Pre-treatment	Post-treatment	6 Weeks post-treatment	p-value
VAS at rest	Low-intensity	4.3 (0-10)	3.09±2.77	1.15 (0-7.7)	0.377‡
	Medium-intensity	4.5 (0-10) ^a	4.91±3.11 ^a	0 (0-6.7) ^b	0.02‡
	Placebo	6.1 (0-10) ^a	4.89±2.98 ^a	0.9 (0-3.6) ^b	0.01‡
	p-value	0.338*	0.261†	0.757*	
VAS in the morning	Low-intensity	10 (0-10) ^a	7.35 (0-10) ^b	3.4 (0-10) ^c	0.00‡
	Medium-intensity	7.8 (2.5-10) ^a	8.6 (5-10)	1.5 (0-9.2) ^b	0.00‡
	Placebo	8.3 (1.6-10) ^a	6 (1.5 - 10)	1.5 (0-7.7) ^b	0.01‡
	p-value	0.611*	0.360*	0.466*	
VAS at night	Low-intensity	4.3 (0-10) ^a	2.35 (0-8.5)	0 (0-7.6) ^b	0.045‡
	Medium-intensity	2 (0-10) ^a	4.6 (0-10) ^a	0 (0-7.9) ^b	0.001‡
	Placebo	5.8 (0-10)	5.4 (0-8.2)	0 (0-7.7)	0.105‡
	p-value	0.770†	0.298†	0.99*	
VAS during palpation	Low-intensity	5.65 (0-10) ^a	5.67±2.98 ^b	2.15 (0-9) ^c	0.022‡
	Medium-intensity	9 (4.7-10) ^a	7.01±2.49 ^b	2.1 (0-10) ^c	0.00‡
	Placebo	10 (2.5-10) ^a	6.92±2.00 ^a	3.9 (0-10) ^b	0.001‡
	p-value	0.238*	0.371†	0.853†	
VAS during daily activities	Low-intensity	8.2 (0-10) ^a	4.9 (2.4-10) ^b	3.15 (0-10) ^b	0.002‡
	Medium-intensity	9 (1.7-10) ^a	7.8 (0-10) ^b	3 (0-10) ^c	0.00‡
	Placebo	8.5 (5-10) ^a	7.2 (1.3-10) ^a	4 (1.5-10) ^b	0.007‡
	p-value	0.686*	0.377*	0.627*	
Algometer	Low-intensity	8.46±1.86 ^a	9.39±2.10	10.36±2.81 ^b	0.03†
	Medium-intensity	10.04±2.60	10.42±1.81	11.9±3.68	0.067†
	Placebo	8.80±2.73 ^a	10.27±2.47 ^b	11.13±2.85 ^c	0.00†
	p-value	0.172†	0.369†	0.418†	

Data are presented as mean±standard deviation (x̄±SD) and median (min–max). Median: Median value, Min: Minimum value, Max: Maximum value, x̄: Mean; SD: Standard deviation; p: Repeated Measures ANOVA, One-Way ANOVA†, Friedman test, Wilcoxon Signed-Rank test‡, Kruskal-Wallis test#. Small letters a, b, and c indicate post-hoc test results, representing significant differences between groups. VAS: Visual Analog Scale

Table 2. Comparison of normal joint range of motion

		Pre-treatment	Post-treatment	6 Weeks post-treatment	p-value
Ankle dorsiflexion	Low-intensity	8 (0-20) ^a	7 (-5,20)	20 (-5-20) ^b	0.005‡
	Medium-intensity	8 (0-20)	8 (0-20)	20 (0-20)	0.05‡
	Placebo	8 (0-20) ^a	20 (0-20)	20 (5-20) ^b	0.009‡
	p-value	0.884 [‡]	0.487 [‡]	0.724 [‡]	
Ankle plantarflexion	Low-intensity	45 (10-45)	45 (18-45)	45 (30-45)	0.06‡
	Medium-intensity	45 (20-45)	45 (25-45)	45 (25-45)	0.368‡
	Placebo	35 (20-45) ^a	45 (25-45)	45 (35-45) ^b	0.008‡
	p-value	0.388 [‡]	0.484 [‡]	0.720 [‡]	
Ankle inversion	Low-intensity	18.5 (10-35) ^a	20 (2-35) ^x	20 (15-35) ^b	0.019‡
	Medium-intensity	15 (8-30) ^a	20 (11-35) ^x	20 (2-35) ^b	0.003‡
	Placebo	20 (12-25) ^a	25 (20-35) ^{b,y}	30 (20-35) ^c	0.00‡
	p-value	0.176 [‡]	0.010 [‡]	0.063 [‡]	
Ankle eversion	Low-intensity	12 (9-20) ^x	15 (9-20) ^x	17.5 (10-20)	0.018‡
	Medium-intensity	12 (10-20) ^{a,x}	5 (11-20) ^{b,x}	17 (13-22) ^b	0.00‡
	Placebo	20 (13-25) ^y	20 (15-20) ^y	20 (15-20)	0.717‡
	p-value	0.002 [‡]	0.001 [‡]	0.075 [‡]	

Data are presented as median (min-max). Median: Median value, Min: Minimum value, Max: Maximum value. p: Friedman test, post-hoc: Wilcoxon Signed-Rank test‡. For Kruskal-Wallis test#, post-hoc analysis was performed using the Mann-Whitney U test. Small letters a, b, c, x, and y indicate post-hoc test results, showing significant differences between groups

Table 3. Comparison of the foot function index

		Post-treatment	6 Weeks post-treatment	p-value
Foot function index-pain	Low-intensity	83.85 (11.1-100)	42.78±20.14	0.001‡
	Medium-intensity	81.4 (46.6 -94.2)	45.23±26.06	0.00‡
	Placebo	82.8 (43.30-100)	49.27±25.53	0.006‡
	p-value	0.712 [‡]	0.800 [†]	
Foot function index-disability	Low-intensity	82.15 (0-95.5)	33.85 (13.30-90)	0.008‡
	Medium-intensity	78.84 (32.20-100)	37.7 (0-93.3)	0.002‡
	Placebo	91.1 (31.1-100)	26.6 (8.8-83.3)	0.003‡
	p-value	0.615 [‡]	0.845 [‡]	
Foot function index-activity	Low-intensity	22 (0-40)	9 (0-36)	0.169‡
	Medium-intensity	20 (0-60)	0 (0-60)	0.060‡
	Placebo	21 (0-42)	6 (0-32)	0.050‡
	p-value	0.854 [‡]	0.446 [‡]	

Data are presented as median (min-max). Median: Median value, Min: Minimum value, Max: Maximum value. p: One-Way Anova†, Wilcoxon Signed-Rank test‡. Kruskal-Wallis test#

Table 4. Roles and maudslley scores by group

		1 and 2 (%) excellent and good	3 and 4 (%) acceptable and poor	p-value
L-ESWT	Post-treatment	2 (14.3)	12 (85.7)	0.031
	6 Weeks post-treatment	8 (57.1)	6 (42.9)	
M-ESWT	Post-treatment	6 (35.3)	11 (64.7)	0.125
	6 Weeks post-treatment	11 (64.7)	6 (35.3)	
Plasebo	Post-treatment	1 (9.1)	10 (90.9)	0.070
	6 Weeks post-treatment	7 (63.6)	4 (36.4)	
Between-group difference over time, p				
Post-treatment			0.186	
Post-treatment			0.903	

Data are presented as n (%), where n represents frequency and % represents percentage. p-values were calculated using McNemar and Chi-square tests. L-ESWT: Low-intensity extracorporeal shock wave therapy, M-ESWT: Medium-intensity extracorporeal shock wave therapy

In the NHP assessments, significant improvements were observed in the pain subscale across all groups, and in the energy and sleep subscales in the low-and medium-intensity groups ($p < 0.05$). Total NHP scores decreased post-treatment in all groups ($p < 0.05$) (Table 5).

DISCUSSION

The aim of this study was to evaluate and compare the effectiveness of L-ESWT and M-ESWT on pain and quality of life in PF treatment. Significant reductions in morning, night, rest, and palpation pain, alongside notable improvements in FFI scores, were observed in both ESWT groups. The M-ESWT group particularly stood out with improvements in physical activity levels and quality of life. Although some improvements in joint range of motion parameters were noted across all groups, only eversion and inversion angles showed significant differences between groups post-treatment. These findings suggest that ESWT provides therapeutic benefits for pain and functional disability in PF and may be an effective intervention for improving the physical components of quality of life.

Meta-analyses have shown that ESWT is effective in improving pain and functional outcomes, particularly in individuals with chronic PF.²⁰⁻²² It has been reported that

moderate and high-intensity exercise is more effective in reducing overall pain and activity-related pain, and also provides significant improvement in functional outcomes.²⁰ It has also been emphasized that ESWT is superior to placebo in short- and medium-term follow-ups in terms of pain control and may be one of the most suitable options among various conservative treatment options.^{21,22} Our study also found that low- and M-ESWT applications had positive effects on pain and quality of life and provided functional improvement. The M-ESWT group, in particular, stood out with increases in physical activity levels and quality of life. These findings support that ESWT offers therapeutic effects on pain and functional impairment in PF and may be an effective intervention for improving the physical components of quality of life.

L-ESWT and M-ESWT have been reported as effective treatments for PF.^{23,24} Use of L-ESWT has been associated with reductions in morning VAS scores²⁵ and 1,000 pulses have led to improvements in VAS scores at rest, during palpation, and walking, with effects lasting up to five years and reducing the need for surgery.²⁴ After three sessions of M-ESWT, improvements in morning, activity, and rest VAS scores were observed at three months, with continued improvement in VAS scores from 1 to 12 months.^{26,23} In our

Table 5. Comparison of nottingham health profile scores

		Pre-treatment	6 Weeks post-treatment	p-value
NHP-pain	Low-intensity	97.08 (8.96-100)	42.75 (0-100)	0.004‡
	Medium-intensity	87.09 (36.5-100)	53.22 (0-87.09)	0.001‡
	Placebo	76.6 (38.92-100)	18.95 (0-70.27)	0.009‡
	p-value	0.552 [§]	0.553 [§]	
NHP-energy and sleep	Low-intensity	69.6 (0-100)	50 (0-100)	0.017‡
	Medium-intensity	100 (0-10)	60.8 (0-100)	0.008‡
	Placebo	63.2 (0-100)	63.2 (24-100)	0.623‡
	p-value	0.249 [§]	0.632 [§]	
NHP-emotional reactions	Low-intensity	30.09 (0-69.62)	13.95 (0-100)	0.594‡
	Medium-intensity	30.93 (0-100)	16.98 (0-100)	0.224‡
	Placebo	29.54 (0-59.15)	7.22 (0-31.68)	0.008‡
	p-value	0.529 [§]	0.246 [§]	
NHP-sleep	Low-intensity	19.24 (0-72.74)	12.57 (0-100)	0.964‡
	Medium-Intensity	27.16 (0-100)	16.1 (0-100)	0.722‡
	Placebo	55.93 (0-100)	12.57 (0-56.64)	0.012‡
	p-value	0.572 [§]	0.426 [§]	
NHP-physical mobility	Low-intensity	32.83 (11.2-54.55)	21.99 (11.2-63.16)	0.119‡
	Medium-intensity	52.59 (11.2 -100)	34.6 (0-82.26)	0.012‡
	Placebo	20.5 (10.79 -100)	11.2 (0-32.56)	0.123‡
	p-value	0.040 [§]	0.143 [§]	
NHP-social isolation	Low-intensity	20.13 (0-80.64)	0 (0-100)	0.168‡
	Medium-intensity	0 (0-100)	0 (0-100)	0.446‡
	Placebo	0 (84.03)	0 (0-84.03)	0.066‡
	p-value	0.908 [§]	0.426 [§]	
NHP-total score	Low-intensity	256.01±108.88	180.44 (11.2-514.86)	0.022‡
	Medium-intensity	330.89±148.36	196.77 (0-553.1)	0.010‡
	Placebo	266.67±119.66	131.22 (52.25-372.49)	0.008‡
	p-value	0.232†	0.347 [§]	

Data are presented as mean±standard deviation ($\bar{x} \pm SD$) and median (min-max). \bar{x} : mean; SD: Standard deviation, Median: Median value, Min: Minimum value, Max: Maximum value. p-values were calculated using One-Way ANOVA†, Wilcoxon Signed-Rank test‡, and Kruskal-Wallis test# NHP: Nottingham Health Profile

study, improvements in morning, night, palpation, and daily activity VAS scores were seen in both L-ESWT and M-ESWT groups, with the M-ESWT group also showing improvement in rest VAS scores. These improvements were maintained at six weeks follow-up across all groups. The observed reductions in VAS scores in both ESWT groups support the effectiveness of ESWT in pain management for PF.

In individuals with PF, normal range of motion (ROM) in the ankle and foot complex decreases, along with a decline in the quality of lower extremity movements.²⁷ It has been suggested that combining PF stretching and Achilles-gastrocnemius exercises with ESWT may enhance treatment effectiveness.²⁸ In our study, although dorsiflexion showed limited significance only in the M-ESWT group, improvements in dorsiflexion and inversion were observed across all groups; plantar flexion improved in the placebo group, while eversion improved in both L-ESWT and M-ESWT groups. The fact that significant differences between groups were observed only in eversion and inversion angles suggests that ESWT may have an exercise-independent effect on these parameters. Conversely, changes in dorsiflexion and plantar flexion appear to be primarily influenced by the stretching exercises applied.

After three sessions of M-ESWT treatment, improvements in foot function were observed in all groups²³ and ESWT was shown to have positive effects on foot function regardless of energy level.²⁹ ESWT has been suggested as a promising intervention to aid in improving foot function in individuals with PF.³⁰ In our study, functional disability improvements were seen in both ESWT and placebo groups; however, activity level improvements were limited to the placebo group. These results support the positive effects of ESWT on function, while also highlighting the importance of considering the placebo effect.

Improvements in RM scores have been reported in patients treated with L-ESWT and M-ESWT,^{25,31,32} with faster and more sustained recovery compared to the placebo group (33). In our study, the improvements observed in RM scores in the ESWT groups suggest that ESWT may be effective in functional recovery. The sustained improvement at 6 weeks in L-ESWT group indicates that treatment efficacy may increase over time and highlights the importance of long-term follow-up. These results support the therapeutic effect of ESWT on functional outcomes.

M-ESWT significantly improved quality of life, enhancing general health perception and physical functionality.³¹ High-dose and long-duration ESWT protocols have been shown to produce positive changes in physical function, general health, and daily living activities.³⁴ While improvements in pain and foot function following ESWT contributed to increased physical components of quality of life, no significant changes were observed in psychological dimensions.³⁵ In our study, persistent improvements in pain, energy/sleep, and physical activity were seen in the ESWT groups, with the M-ESWT group standing out in physical activity and overall NHP scores. However, no changes were detected in psychological subdomains such as emotional reactions and social isolation within the ESWT groups. This situation may be due to the 6-week follow-up period being insufficient to reflect

psychosocial improvements. In the placebo group, only limited and short-term improvements in pain and sleep quality were observed. These findings demonstrate that ESWT is an effective and durable treatment for physical functionality and pain management.

There remains uncertainty in the literature regarding the dose-dependent effects of ESWT.^{31,33,36} M-ESWT has been reported to provide significant early and long-term improvements in pain and function compared to sham treatment,³³ while L-ESWT demonstrated higher treatment success than placebo in morning first-step pain, daily pain, total pain, and quality of life in both short- and long-term follow-ups.^{31,36} Conversely, no significant differences were found among low-, medium-, and high-intensity ESWT groups regarding pain and foot function.²⁹ It has also been suggested that although L-ESWT initially showed greater improvement, this difference diminished with additional sessions in the low-intensity group.³² In our study, both medium- and L-ESWT produced significant improvements in pain and function, with no significant difference observed between the two intensities overall. Post-treatment, significant differences between groups were observed only in eversion and inversion angles, with similar results obtained in other range of motion parameters. These findings suggest that the clinical efficacy of ESWT may be closely related to the applied dose and number of sessions. Although the rate of functional improvement was slightly higher in the low-intensity group according to the RM scores, this difference did not reach a statistically significant level.

Limitations

The main limitation of this study is the relatively small sample size, which reduced the statistical power and may have hindered the detection of small to moderate effects. Additionally, conducting the study at a single center and the short follow-up period limit the generalizability of the results and the evaluation of long-term effects. Variations in participants' adherence to the exercise program may also have influenced treatment outcomes. Future studies with larger sample sizes, multicenter designs, and longer follow-up periods are recommended.

CONCLUSION

This study demonstrates that ESWT is an effective method for reducing pain, improving foot function, and enhancing the physical dimensions of quality of life in individuals with PF. M-ESWT produced particularly notable results. However, no significant changes were observed in the psychological aspects of quality of life. The findings suggest that ESWT may be a beneficial intervention for symptom management in PF, including pain control, improvement of functional capacity, and support of joint range of motion.

ETHICAL DECLARATIONS

Ethics Committee Approval

This study has been approved by the Clinical Researches Ethics Committee of Abant İzzet Baysal University (Date: 17.06.2014, Decision No: 2014/45).

Informed Consent

Written informed consent was obtained from all individual participants prior to their inclusion in the study. Participants were fully informed about the study's aims, procedures, potential risks and benefits, and their rights-including the right to withdraw at any time without consequence. All participants voluntarily signed a written informed consent form.

Peer Review Process

This manuscript was subject to external peer review.

Conflict of Interest

The authors declare no conflicts of interest related to this study.

Financial Disclosure

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Author Contributions

Concept: N.K., T.Ç.; Design: N.K., T.Ç.; Control: N.K., T.Ç.; Data collection and/or processing: N.K.; Analysis and/or interpretation: B.İ.Ş.; Literature review: B.İ.Ş., N.K.; Article writing: B.İ.Ş., N.K., T.Ç.; Critical review: All authors.

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