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The impact of shock wave therapy on reducing pain in patients with plantar fasciitis

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A Study Design
B Data Collection
C Statistical Analysis
D Data Interpretation
E Manuscript Preparation
F Literature Search
G Funds Collection

Żaneta Gałecka-Szczerba[1 ABCDEF], Małgorzata Kawa[2 ABCDEF], Magdalena Podczarska-Głowacka[2 ABCDEF]

[1] Department of Physiotherapy and Wellness, Faculty of Physiotherapy and Health Sciences, University School of Health in Gdańsk, Poland

[2] Department of Physiotherapy and Wellness, Chair of Health and Natural Sciences, Faculty of Physical Culture, Gdansk University of Physical Education and Sport in Gdansk, Poland

abstract

Background: Plantar fasciitis, often accompanied by plantar fascia inflammation, is a very troublesome disorder. It causes intense heel and foot pain, disturbs gait, often causing limitation of physical activity. The aim of the work is to evaluate the impact of radial shock therapy on pain and physical activity in patients diagnosed with plantar fasciitis

Material and methods: The study involved 27 patients – 9 men and 18 women – with a diagnosed spur heel; the patient's average age was 56 ±9.5 SD years. To evaluate the effects of the therapy, two testes were used, the VAS analogue pain scale and the Laitinen pain questionnaire.

Results: The analysis of the test results shows a statistically significant reduction in pain ($p<0.001$) and an increase in the subjects' ability to function as a result of shock wave therapy.

Conclusions: The extracorporeal shock wave is an effective method of plantar fasciitis treatment in the studied group of patients. The performed treatments allowed achieving a lasting therapeutic effect and reduced the intensity and frequency of pain, which allowed reducing the use of painkillers and allowed for a return to full physical activity.

Key words: plantar fasciitis, radial shockwave, pain.

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Corresponding author: Dr Magdalena Podczarska-Głowacka, Gdansk University of Physical Education and Sport, 1 Kazimierza Górskiego str., Gdansk 80-336; e-mail: magdalena.podczarska-glowacka@awf.gda.pl

INTRODUCTION

The dynamics of contemporary life requires intensive physical and professional activity. However, pain that is often ignored in its initial stage may lead to development of disorders and result in limitation of such activity in the long run [1,2]. International Association for the Study of Pain defines pain as unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage [3].

Pain in the heel, experienced by many people, is one of the conditions that have a clearly negative impact on physical activity. According to a study of Australian researchers, 3.6% of the population suffers from such pain; researchers from the USA estimate that 7% of population over 65 years of age suffers from pain in the heel [4, 5]. The causes of heel pain include inflammation of the Achilles tendon attachment, with associated inflammation of the Achilles tendon bursa, inflammation of the fat tissue under the calcaneal tuberosity, neuropathies caused by pressure of plantar branch of the tibial nerve by overgrown plantar aponeurosis, fracture of the heel bone, avascular necrosis of bone heel tuberosity– the so called Haglund's syndrome, inflammation of the bones, inflammatory arthropathy, bunion, neuropathy of Baxter nerve, S1 root radiculopathy, tarsal tunnel syndrome and calcaneal spur [6–9].

Calcaneal spur (lat. calcar calcanei) is a degenerative lesion of the heel bone which results in a bony growth. The condition was first described in 1900 by Plettner, who observed it on an X-ray image [10, 11]. Depending on the location of the lesion, the following types are distinguished: interior spur – in the top part of the heel bone, in the direction of the Achilles tendon, and, more frequently, posterior spur, located in the plantar part of the heel – medial tuberosity [12].

The etiopathogenesis of calcaneal spur has not been fully recognized. It is assumed that one of the causes is repeated traction of the attachment of plantar fasciitis from medial heel bone tuberosity, causing inflammation of aponeurosis and reactive calcification of its attachment. Other causes include micro fractures of the heel bone in the course of stress fracture, as a result of vertical compression within the foot. Development of calcaneal spur in such circumstances is a defense mechanism. Continuous irritation of the surrounding structures by pressure results in chronic inflammation of the heel bone area and enthesopathy of plantar fasciitis at its attachment to heel bone tuberosity [10, 13]. Ca. 50% of patients with calcaneal spur also suffer from inflammation of plantar fasciitis. It is considered to be the most popular cause of foot pain in adults, since 10–15% population suffers from the condition, usually between 40–60 years of age [14, 15]. Plantar fasciitis is diagnosed by clinical symptoms of pain, stiffness, edema, positive windlass test, and about 75% have no symptoms in patients with heel spurs.

The first symptom of calcaneal spur and inflammation of plantar aponeurosis is pain in the heel area, occurring after overstraining the heel. The patients describe the pain as burning, scorching, throbbing, blunt or acute. At a later stage, the pain occurs also during rest or when touched. Swelling and redness of the heel area occurs. The patients suffer from pain when taking the first step, which is characteristic of inflammation of plantar aponeurosis, which occurs when taking the first steps in the morning. It is assumed that the pain is caused by the healing process which occurs during sleep. First steps cause breaking of adhesions that had been made during the night rest. Increased pain also occurs

after long inactivity, overstraining the foot or at the end of the day. Walking on hard surface or carrying heavy objects also intensifies pain in patients with this disorder [16–20].

Risk factors increasing the probability of foot pain include: excess weight (high BMI index), standing position at work, age, sex (spur is more frequent in 40–60-year-old women, usually after menopause, practicing sports that burden the feet – sports that include jogging and wearing inadequate footwear. Other reasons include fallen transverse/longitudinal arch [14, 21, 22].

Treatment of plantar fasciitis usually includes medication, applying load-reducing foot beds, kinesiotherapy, massage, manual therapy and physical therapy. The most frequent physical therapy methods include: iontophoresis, ultrasounds, laser therapy, phonophoresis and shock wave therapy [23–27].

Shock wave therapy is a non-invasive treatment method which applies acoustic waves of low frequency and high amplitude. The method of generating shock waves determines their type – waves may be focused (FSWT) or radial (RSWT) [28, 29]. Radial waves (RWST) used in the research described in this article – are generated pneumatically. The air generated in the device is packed under high pressure to the applicator head, where it makes the bullet inside move, then the bullet hits the transmitter located at the end of the applicator and generates radial shock wave [30–32]. The mechanism of anti-pain effect of shock wave therapy has not been fully recognized. It is assumed that its effectiveness is the result of the following: shock waves damage intimal nerve layers, making nerve receptors unable to accumulate the potential and transmit pain; the receptors are hyper-stimulated by shock waves and start sending impulses of high intensity, limiting pain signals, according to pain gate control theory; shock waves trigger free radicals in the area of nerve endings, changing the chemical environment, which reduces pain impulses [33]. Application of shock waves leads to reduction of muscle tone, due to improvement of elasticity and energy of tissue, improvement of blood circulation and distribution of P substance in the cells, which is responsible for pain sensation in a given area, dissolution of fibroblasts and calcium deposits, increase of resorption of milk acid and other metabolites in healthy and affected tissue, stimulation of collagen production [31, 34].

The purpose of this paper is to evaluate the impact of radial shock wave therapy on pain and undertaken physical activity in patients with diagnosed plantar fasciitis.

MATERIAL AND METHODS

The research was performed on an outpatient basis in September 2018 – December 2018. A group of 27 patients were examined – 9 men and 18 women (mean age 56 ±9.5 SD), all diagnosed with calcaneal spur, pain in the heel area. The research included two phases: diagnostic and therapeutic. In the diagnostic phase interviews with patients were conducted in order to exclude potential contraindications. Contraindications included: blood coagulation disorders, thrombosis, pregnancy, cancer, high fever, acute inflammation, polyneuropathy, late stage of osteoporosis. In the diagnostic stage of the research, the pain level was measured using the Laitinen pain scale questionnaire (pain intensity, rate of taking pain killer medication and limitation of physical activity) and the VAS pain scale (where 0 signifies no pain and 10 signifies the strongest pain one can imagine). The patients were asked to assess the pain level when taking the first step, when walking, standing, at the end of a day and during palpation

examination. The distribution of load on legs was assessed with the tandem balance test. The patient was asked to stand on two identical scales, putting one leg on each scales. The weight was taken in an upright posture. The diagnostic test was performed three times: before the first procedure, after the 5th procedure and 8 weeks after completion of the treatment.

BTL 6000 SWT device was used for generating radial shock wave in the therapeutic part. The parameters of the procedures applied to patients were similar to those applied by other authors. Each patient was applied 5 procedures at 7 day intervals. An analysis of research made by other authors showed that 2–6 procedures at 2–7 day intervals were applied, with 7 day interval being the most frequent. Shock wave therapy in treatment of calcaneal spur was applied with 15 mm diameter applicator, 2000 waves of frequency 10Hz and pressure between 2.5 and 3.5 bar – gradually increasing the strength during the therapy depending on the patient's reaction, because pain intensity varies between patients, and strength must be individually adjusted.

During the procedure the patient lied on the stomach on a bed, with a bolster under the ankle. The applicator head was carried with a continuous track, after prior application of contact gel. The patient did not undergo any other procedures as part of this research.

RESULTS

The research was performed on a group of 27 patients – 18 women and 9 men. The patients were rather homogenous in age, BMI (Table 1) and the variation in the burden level of extremities with and without pain, before treatment (as % of body mass).

Table 1. Main statistics of three basic variables – age, BMI and burden on lower extremities

Variable	Women		Men		Total		p(KvsM)
	M ±SD	Min÷Max	M ±SD	Min÷Max	M ±SD	Min÷Max	
Age [years]	54.8 ±8.5	40 ÷ 70	58.4 ±11.6	41 ÷ 74	56 ±9.5	40 ÷ 74	0.357
BMI [kg/m^2]	30.5 ±4	21.9 ÷ 38.3	33 ±3.9	26 ÷ 37.9	31.4 ±4	21.9 ÷ 38.3	0.141
Variation in the burden (as a % of body mass)	8.8 ±7.4	0 ÷ 25	11.6 ±10.9	0 ÷ 34.1	9.8 ±8.6	0 ÷ 34.1	0.437

Additional analyses did not show significant differences between men and women as to the lower limb in pain (left/right), type of performed work (sitting/standing), occurrence of pain (for the first time/repeated) and the duration of pain. Analysis of the difference in burden on the legs was performed before the 1st procedure, after the 5th procedure and 8 weeks after completion of treatment. The results are presented in the table below (Table 2).

Table 2. Leg burden

Variable	Date of examination			effect of repeated measurements
	before the 1st procedure	after the 5th procedure	8 weeks after completion of treatment	
	M ±SD	M ±SD	M ±SD	
Variation in the leg burden level (% of body mass)	9.8 ±8.6	1.8 ±4.8	1.2 ±3.1	< 0.001

The observed effect is statistically significant. It is illustrated in the graph below (Fig. 1).

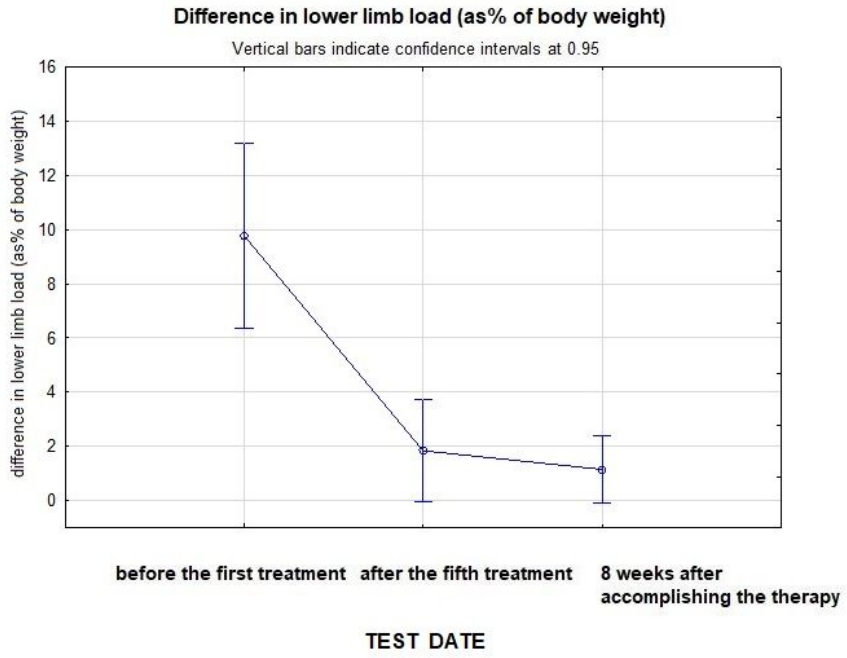

Fig. 1. Variation in the burden level of legs

Post-hoc analysis using the Scheffe test indicates that there are two homogenous groups (Table 3). The variations in the burden level between legs (as % of body mass) after the 5th procedure and 8 weeks after completion of treatment are not significantly different, but they are significantly lower than before the 1st procedure.

Analysis of pain intensity (according to the VAS scale) was performed in patients before the 1st procedure, after the 5th procedure and 8 weeks after completion of treatment. During each examination pain intensity was measured when taking the first step, when walking, when standing, during palpation examination, and at the end of the day. The results are shown in the table below (Table 4).

In the ANOVA test system of repeated measurements, two factors proved to be statistically significant: the time of examination ($p < 0.001$) and the type of examination ($p = 0.027$). Post-hoc analysis using the Scheffe test, regarding the time of examination, indicates that there are three homogenous groups (see Table 5).

Table 3. Analysis of homogenous groups

Time of examination	Avarage	Homogenous groups	
		No. 1	No. 2
8 weeks after completion treatment	1.16	****	
After the 5th procedure	1.84	****	
Before the 1st procedure	9.77		****

Table 4. Analysis of pain intensity according to the VAS scale

Type of examination	Pain intensity according to the VAS scale					
	before the 1st procedure		after the 5th procedure		8 weeks after completion of treatment	
	M ± SD	Min÷Max	M ± SD	Min÷Max	M± SD	Min÷Max
When taking the first step	5.8 ±2.4	0 ÷ 10	2.5 ±1.4	0 ÷ 6	1.4 ±2.1	0 ÷ 8
When walking	4.6 ±1.7	2 ÷ 9	2.1 ±1	1 ÷ 5	1.1 ±2	0 ÷ 9
When standing	4.5 ±1.9	1 ÷ 8	1.8 ±1.2	0 ÷ 5	1.2 ±2.1	0 ÷ 9
During palpation examination	5.9 ±2.1	2 ÷ 10	2 ±1.6	0 ÷ 9	1.1 ±2.1	0 ÷ 9
At the end of the day	5.4 ±2.8	0 ÷ 10	2 ±1.3	0 ÷ 5	1.4 ±2.2	0 ÷ 10

Table 5. Analysis of homogenous groups

Time of examination	Mean	Homogenous groups		
		No. 1	No. 2	No. 3
Before the 1st procedure	1.26	****		
After the 5th procedure	2.15		****	
8 weeks after completion of treatment	5.35			****

The differences in pain intensity are statistically significant for each of the examined times of examination and are significantly reduced along with the progress of therapy. It is illustrated in Fig. 2. Post-hoc analysis using the Scheffe test, regarding the type of examination, using the most conservative Scheffe test did not indicate differences in pain intensity between the analyzed types of examination.

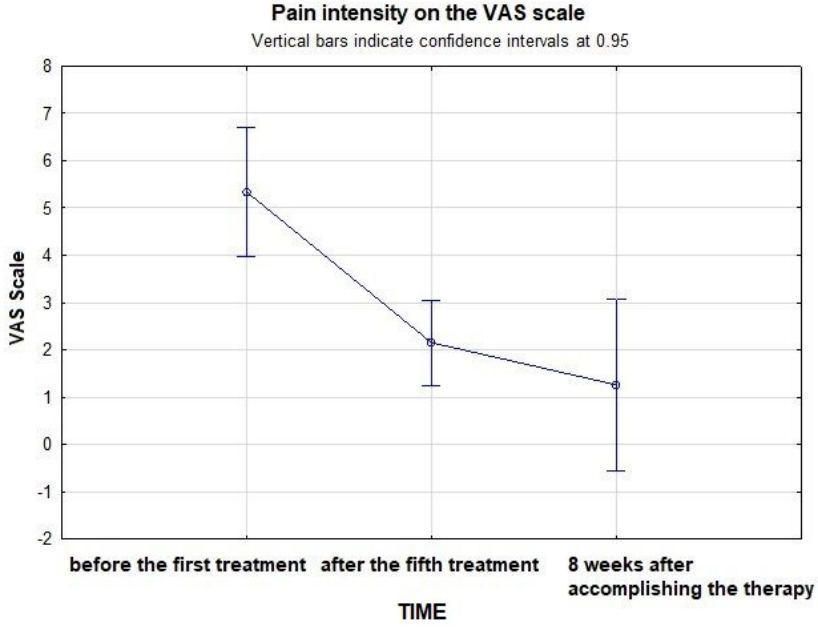

Fig. 2. Pain intensity in the VAS scale

Analysis with the ANOVA Friedman test showed significant differences in limitation of physical activity in subsequent examinations ($p < 0.001$). Before the 1st procedure, less than one in every ten patients claimed no limitation in physical activity. After the 5th procedure, no limitation in physical activity was claimed

by three out of four patients, while after 8 weeks of completion of treatment almost nine in ten patients claimed no limitation in physical activity (Table 6).

Analysis with the Q Cochran test indicated a significant difference in the rate of taking pain killers ($p = 0.005$). Before the 1st procedure, 22% of patients took painkillers on demand. After the 5th procedure the rate dropped to 3.7%, and 8 weeks after completion of treatment none of the examined patients took pain killers any more (Table 7).

Table 6. Limitation of physical activity

Limitation of physical activity	Time of examination					
	before the 1st procedure		after the 5th procedure		8 weeks after completion of treatment	
	number of patients	% of patients	number of patients	% of patients	number of patients	% of patients
None	2	7.4	20	74.1	24	88.9
Partial	15	55.6	7	25.9	3	11.1
Making it difficult to work	10	37.0	0	0.0	0	0.0

Table 7. Rate of taking pain killers

Rate of using pain-killers	Time of examination					
	before the 1st procedure		after the 5th procedure		8 weeks after completion of treatment	
	number of patients	% of patients	number of patients	% of patients	number of patients	% of patients
No pain killers used	21	77.8	26	96.3	27	100.0
Pain killers used on demand	6	22.2	1	3.7	0	0.0

DISCUSSION

Plantar fasciitis is a burdensome ailment to patients. Its treatment is time-consuming and complicated. The main problem related to plantar fasciitis is pain, which is a subjective sensation, hard to measure. In order to measure the pain level, various questionnaires are used allowing one to assess its intensity. One of the most frequently used methods is VAS (Visual Analogue Scale), among others, applied by Drużbicka [35] or Mróz [36].

In this research, a statistically significant drop in the pain level intensity was observed based on the VAS scale. Pain intensity was measured before the 1st procedure, after the 5th procedure and 8 weeks after completion of the therapy. The following results were obtained: when taking the first step, pain intensity dropped on average from 5.8 to 1.4; when walking – from 4.6 to 1.1; when standing – from 4.5 to 1.2; in palpation examination – from 5.9 to 1.1; at the end of the day – from 5.4 to 1.4. A similar trend was observed by Mróz et al. [36], Drużbicka et al. [35], Krzentowska et al. [10], or Hołubowicz [37], who also observed a significant relief of pain measured with the VAS scale in their research. A significant relief of pain after the shock wave therapy was also observed by Yalcin et al. [38], Gerdesmeyer et al. [39], Bicer et al. [40], Purcell et al. [41] or Hocaoglu et al. [42].

Rompe et al. [43] present another opinion on the effects of shock wave therapy in the short term. They examined two groups of patients – the first group was treated with shock wave therapy, and the second one – with stretching. According to the authors, after 2 and 4 months of assessment carried out before the therapy, significantly better effects were observed in the group of patients practicing stretching. Despite the fact that the results obtained by Rompe et al. [43] do not fully confirm the effectiveness of shock wave therapy, most researchers seem to be of an opinion that the therapy has a positive effect on relieving pain. Akinoglu and Kose [44] in their works compared the effectiveness of therapies with shock waves, ultrasounds and exercise in treating plantar fasciitis. The results show that the best anti-pain effect was observed when using shock wave therapy. It was also indicated that the effects of therapy may be strengthened by applying a combination of shock wave therapy and exercise. The effectiveness of shock wave therapy in treatment of plantar fasciitis was also confirmed by Scheuer et al. [45].

The Laitinen pain scale was also used in this research before the 1st procedure, after 5th procedure and 8 weeks after completion of therapy to assess pain intensity, the frequency and rate of using painkillers, the degree of limitation of physical activity. Similarly to the research performed by Koch et al. [46], this examination showed a significant improvement in all indicators in patients after the therapy. Krukowska et al. [47] conducted research on a group of 47 patients with diagnosed calcaneal spur. The group was divided into two subgroups. Patients in the first subgroup underwent a series of 10 ultrasound procedures, while patients in the second subgroup were applied 4 procedures of shock wave therapy. The patients then assessed the pain level by using the VAS scale and the Laitinen questionnaire. Relief of pain was observed in both subgroups. Therefore, the research made by Krukowska provides support to the postulate that shock wave therapy is effective.

In order to relieve pain, patients use painkillers and anti-inflammatory medication. The performed research showed that shock wave therapy of calcaneal spur leads to significant limitation in the use of painkillers. Eight weeks after completion of shock wave therapy none of the examined patients took medication in order to relieve pain. As observed by Sieroń [48], the above provides hope that pharmacological treatment may be replaced with physical therapy, which will lower the risk of dependence on medication that is not neutral to human health.

Application of shock wave therapy resulted in relief of pain and limitation of motor disorders in patients diagnosed with plantar fasciitis. Before the 1st procedure only ca. 8% of patients did not claim any limitation in physical activity, while 8 weeks after completion of treatment the patients without limitation in physical activity constituted almost 89% of the group. Apart from the effect of relief of pain and improvement in motor functions of the foot, Krzentowska et al. [10] observed higher resistance to loads. Leg loads was measured using the test of two scales. The results of the performed examination indicate that the load ability of the affected leg significantly improved.

CONCLUSIONS

Extracorporeal shock wave proved to be an efficient method of treatment of plantar fasciitis in the examined group of patients. The results of the research showed that the patients experienced statistically significant relief of pain. The therapy gave lasting therapeutic effects and limited the intensity and frequency

of pain, which then allowed the patients to reduce the use of painkiller and to return to full physical ability.

Physical therapy is unquestionably a very useful tool in treatment of plantar fasciitis. However, it must be remembered that there is not one established pattern of treatment, since physical stimuli, due to the complexity of human organism, may give different effects in different persons.

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