Original paper

Effect of focused shock wave therapy on functional efficiency and stabilometric parameters in patients with chronic low back pain: a randomised clinical trial

Wpływ terapii zogniskowaną falą uderzeniową na sprawność funkcjonalną i parametry stabilometryczne u pacjentów z przewlekłym bólem krzyża – randomizowane badanie kliniczne

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Słowa kluczowe: ból krzyża, kontrola postawy, stan funkcjonalny, pozaustrojowa terapia falą uderzeniową.

Abstract

Introduction: Shock wave is a promising and alternative physical method used in the treatment of low back pain (LBP). Most of the effects of this therapy are related to mechanotransduction, which can lead to tissue healing by reducing pain and regulating inflammation.
Aim of the research: Assessment of the effect of a focused shock wave on the level of pain, functional performance, and stabilometric parameters in patients with chronic LBP.
Material and methods: The study involved 36 patients with LBP assigned to the experimental (n = 18, fESWT + rehabilitation) or control (n = 18, sham fESWT + rehabilitation) group. Posturography was used as an objective measurement tool to control posture and balance. Subjective tools were used: Roland-Morris Questionnaire (RMQ), Schober test (OST), and Laseque test. Measurements were taken before and immediately after the intervention and at 1- and 3-month follow-ups.
Results: The procedures undertaken in both groups led to short-term improvement in postural stability in patients. When comparing evaluation results functional efficiency (RMQ) and spine mobility (OST), positive changes in the results of intergroup comparisons were observed. There were statistically significant differences in the fESWT and control groups (main effect: $p < 0.05$). In measuring the range of hip motion for both lower limbs, beneficial effects were obtained in all measured time intervals. Intergroup comparisons showed statistically significant differences ($p < 0.05$).
Conclusions: The use of fESWT with a specific exercise program may be an effective therapy for LBP, and it influence functional improvement in patients with LBP.

Streszczenie

Wprowadzenie: Fala uderzeniowa jest obiecującą i alternatywną metodą fizykalną stosowaną w leczeniu bólów krzyża (LBP). Większość efektów tej terapii wiąże się z mechanotransdukcją, która może prowadzić do terapii tkanek poprzez redukcję bólu i regulację stanu zapalnego.
Cel pracy: Ocena wpływu zogniskowanej fali uderzeniowej na poziom bólu, sprawność funkcjonalną i parametry stabilometryczne u pacjentów z przewlekłym bólem krzyża.
Materiał i metody: W badaniu wzięło udział 36 pacjentów z LBP przydzielonych do grupy eksperymentalnej (n = 18, fESWT + rehabilitacja) lub kontrolnej (n = 18, pozorowana fESWT + rehabilitacja). Jako obiektywne narzędzie pomiarowe wykorzystano metodę posturografii do kontroli postawy i równowagi. Jako subiektywne narzędzia zastosowano Kwestionariusz Rolanda-Morrisa (RMQ), test Schobera (OST) i test Laseque'a. Pomiarów dokonano przed interwencją i bezpośrednio po interwencji oraz podczas obserwacji 1 i 3 miesięcy.
Wyniki: Procedury podejmowane w obu grupach doprowadziły do krótkotrwałej poprawy stabilności postawy u pacjentów. W przypadku porównania wyników oceny sprawności funkcjonalnej (RMQ) i ruchomości kręgosłupa (OST) zaobserwowano pozytywne zmiany w wynikach porównań wewnątrzgrupowych. W grupach fESWT oraz kontrolnej wystąpiły statystycznie istotne różnice (efekt główny: $p < 0,05$). W pomiarach zakresu ruchu bioder dla obu kończyn dolnych korzystne efekty uzyskano we wszystkich mierzonych przedziałach czasowych. W porównaniach międzygrupowych stwierdzono różnice statystycznie istotne ($p < 0.05$).
Wnioski: Zastosowanie fESWT z określonym programem ćwiczeń może stanowić skuteczną terapię w LBP i wpływać na poprawę funkcjonalną u pacjentów z bólami krzyża.

Introduction

Low back pain (LBP) affects people of all ages and is a dominant contributor to the increasing burden of disease worldwide. Conservative treatment is common for functional improvement, including frequently used pharmacotherapy and various methods of kinesiotherapy and physical therapy [1–3]. Surgical treatment is also used, which may cause side effects and prolong the patient's recovery [4]. Focused shock wave therapy (fESWT) is increasingly used to treat the musculoskeletal system because it has been found that most of the effects of this therapy are related to mechanotransduction, which can lead to tissue healing by reducing pain, regulating inflammation and stem cell activity [5, 6]. Available publications show that the effectiveness of therapy is most often assessed using surveys and questionnaires that indicate the patient's subjective pain sensations or functional assessment. To be able to verify the suitability fESWT in the treatment of LBP, it is advisable to use an objective tool to reliably determine the clinical effectiveness of the treatments used. Scientific studies suggest that LBP affects the change in postural control, which is related to the intensity of pain. Chronic pain causes dysfunction in neuromuscular control, which may lead to increased postural sway [7].

Aim of the research

The aim of this study was to evaluate the effect of fESWT on functional efficiency, sense of balance, and postural stability in patients with chronic LBP.

Material and methods

The research project was approved by the Bioethics Committee of the Public Higher Professional Medical School in Opole, Poland (no. KB/90/FI/2018). The study was registered at the International Standard Randomised Controlled Trial Number (ISRCTN) registry database (No. ISRCTN13785224).

This study was designed as a single-blind randomised clinical trial. Participants were grouped as follows: experimental group (n = 18, fESWT + rehabilitation) or control (n = 18, rehabilitation + sham fESWT). In both groups, patients performed basic stabilisation exercises according to the same methodology. The assignment to a given group was independent of the person performing the therapy and analysing the results. All tests and surveys were conducted by one physiotherapist who also conducted the therapy. The researcher had no contact with the people analysing the obtained results. Patients with discopathy at the L5-S1 level, chronic radiating pain, pseudoradicular syndrome, and who had not undergone surgical procedures in the spine were qualified. Patients were over 18 years of age and had current NMR tests confirming the diagnosis of LBP syndrome. The exclusion criteria were as follows: other diseases of the spine (spondylolisthesis, fractures, tumours, rheumatic diseases, cauda equina syndrome), pregnancy or ovulation, loss symptoms, implanted pacemaker, metal implants in the application area, blood clotting disorders, sensory disorders, cancer, skin lesions in the treatment area, ailments causing balance disorders, and patients taking painkillers and anti-inflammatory drugs.

The study included 36 patients with discopathy of the L5-S1 spine, who were randomly assigned to 2 comparison groups: experimental (n = 18) and control (n = 18). Patients in both groups were homogeneous in terms of initial measurements of pain, functional status, and body posture. In both groups, all patients completed treatment. One person from the experimental group and one person from the control group were excluded from the statistical analysis; in both cases, the use of painkillers was recorded.

Patient flow throughout the study period is presented in accordance with the Consolidated Standards of Reporting Trials (CONSORT) in Figure 1.

Interventions

Experimental group-focused shock wave fESWT was used for the therapy using a Duolith SD1 Tower device (Storz Medical, Switzerland). The treatments were performed using the contact, static method, in the area of greatest pain indicated by the patient, at the level of the lumbar and sacral spine, using the following parameters: energy flux density 0.15 mJ/mm^2 (1000 pulses), frequency 4 Hz, and treatment time 7 min.

For the control group, a sham fESWT was used in which the stimulation was deprived of biologically active ingredients by using a polyethylene applicator that absorbed energy, limiting its penetration into human tissues. The methodology and parameters of the treatments were the same as in the experimental group with identical sound signals. To estimate the placebo effect, this group was individually blinded.

Both groups underwent 10 treatments, performed twice a week (Monday and Thursday) for 5 weeks. To reduce tissue resistance, ultrasound gel was used as a coupling substance between the applicator and the patient's skin.

In patients in both groups, the therapy was supplemented with identical stabilisation training (45 min, once a day, 5 days a week from Monday to Friday). The exercise protocol included the following: myofascial relaxation techniques of the spinal extensors, activation of the lumbar-pelvic-iliac complex and deep muscles (so-called core stability exercises focused on transverse abdominis muscle, internal oblique abdominal muscle, multifidus muscle, and pelvic floor muscles), stimulation of proper breathing, and dynamic postural exercises.

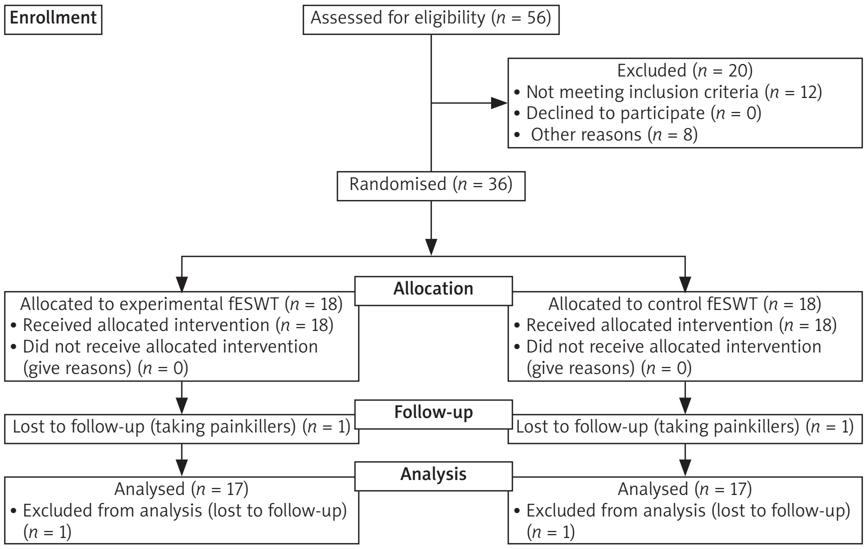

Figure 1. CONSORT flow chart of study participants

fESWT – focused extracorporeal shock wave.

For objective measurements, an AMTI AccuGait strain gauge platform (Advanced Mechanical Technology Inc., USA) with Balance Clinic computer software was used. Parameters assessing postural stability were analysed.

In their studies, scientists most often indicate increased postural sway in LBP in the sagittal plane (AP), without noting significant changes in the frontal plane in the medial-lateral direction (ML) [7–9]. We assessed the deviations of the centre of pressure (COP) in the frontal plane (ML) [mm/s] to see whether the results of our study would show larger deviations in people with LBP than in healthy individuals.

A single measurement lasted 30 s and was performed in 2 trials (with eyes open and closed) in both groups. During the examination, the patient assumed a casual standing position without shoes, feet hip-width apart, arms along the body, head straight.

To assess functional ability and degree of disability, the Roland-Morris Questionnaire (RMQ) was used, which assesses the degree of disability in people with low back pain [10]. Also the Schober test (OST) [11] was performed to measure the range of motion of the lower spine, and to measure the range of motion of both limbs the Laseque test was implemented [12].

In both groups, tests measurements were performed before the start of therapy and after its completion. The procedures were then repeated one and 3 months after the end of treatment. During this time, participants did not use any treatments that could affect the results. Each measurement was performed by the same therapist (the arithmetic mean was taken from 3 measurement attempts), which allowed for the elimination of possible errors while performing the measurements.

Statistical analysis

Statistical analysis was performed using Statistica 13 (TIBCO, Inc., USA). For measurable variables, arithmetic means, medians, standard deviations, quartiles, and the range of variability (extreme values) were calculated. Frequencies were calculated for qualitative variables (results are given in percentages). Quantitative variables were checked with the Shapiro-Wilk test to determine the type of distribution. Comparison of qualitative variables between groups was made using the chi-square test (χ^2). Intergroup comparison between the results obtained in measurements 1, 2, 3, and 4 was performed using Friedman's analysis of variance and post-hoc test (Dunn's test). The comparison of results between groups was assessed using the Mann-Whitney U-test. The level of $\alpha = 0.05$ was used for all comparisons.

Results

Patients in both groups were homogeneous in terms of anthropometric characteristics (Table 1). The results were presented in the study and control groups in 4 subsequent measurements: before therapy, after therapy, and one and 3 months after the end of therapy.

The procedures undertaken in both groups led to short-term improvement in postural stability in patients, for which the AMTI AccuGait strain gauge platform was used. In Table 2 a comparison of changes in the average COP deviation area in the frontal plane (ML) is presented from the centre of the platform with eyes open in the treated fESWT group and in the control group in 4 subsequent measurements. Positive changes were observed immediately after comple-

Table 1. Characteristics of the participants

Variable	Experimental fESWT group							Control fESWT group							*P*-value
	x̄	Me	Min.	Max.	Q1	Q3	SD	x̄	Me	Min.	Max.	Q1	Q3	SD	
Age [years]	41.7	41.0	18.0	64.0	33.0	48.8	13.7	45.5	49.0	22.0	76.0	36.0	55.5	14.6	0.476*
Body weight [kg]	73.1	73.0	57.0	90.0	62.8	83.0	11.3	74.8	77.0	55.0	87.0	72.0	81.5	9.4	0.937*
Body height [cm]	173.1	174.0	156.0	186.0	166.0	178.0	8.1	167.8	170.0	150.0	182.0	163.3	172.0	9.3	0.055*
BMI [kg/m^2]	24.2	23.6	18.3	30.5	22.4	27.1	3.9	26.7	27.4	22.0	32.0	24.8	27.8	2,9	0.064*
Disease duration [months]	56.5	30.0	18.0	204.0	24.0	84.0	53.7	64.0	60.0	3.0	180.0	24.0	72.0	55.3	0.836*
Sex	F – *n* = 9; 50.0%							*F* – *n* = 9; 50.0%							1.000**
	M – *n* = 9; 50.0%							*M* – *n* = 9; 50.0%							

*fESWT – focused extracorporeal shock wave, n – number of individuals, x̄ – mean, Me – median, Min. – minimum value, Max. – maximum value, Q1 – lower quartile, Q3 – upper quartile, SD – standard deviation, F – female; M – male. *U-Mann-Whitney; **c2 test.*

Table 2. Comparison of changes in the mean COP deviation area of the ML [mm/s] parameter in both groups (with open eyes)

Variable	Measure	Experimental fESWT group							Control fESWT group						
		x̄	Me	Min.	Max.	Q1	Q3	SD	x̄	Me	Min.	Max.	Q1	Q3	SD
ML [mm/s] parameter	Before	0.49	0.44	0.06	1.25	0.24	0.63	0.4	0.47	0.39	0.01	1.40	0.20	0.67	0.3
	After	0.33	0.24	0.03	1.00	0.11	0.48	0.3	0.37	0.29	0.00	1.33	0.13	0.49	0.3
	1 month FU	0.30	0.15	0.00	2.33	0.07	0.27	0.5	0.33	0.17	0.00	1.10	0.08	0.58	0.3
	3 months FU	0.48	0.36	0.02	1.97	0.14	0.57	0.5	0.32	0.23	0.01	1.03	0.11	0.48	0.3
P-value (main effect*)		0.009							0.655						
P-value (multiple comparisons**)		Before vs. after: *p* = 0.668 Before vs. 1 month: *p* = 0.006 Before vs. 3 months: *p* = 1.000 After vs. 1 month: *p* = 0.518 After vs. 3 months: *p* = 1.000 1 month vs. 3 months: *p* = 0.120							–						

**Friedman's ANOVA; **Dunn's test. FU – follow-up.*

tion of treatment (although they were not statistically significant). In the follow-up 1 month after the end of therapy, statistically significant results were demonstrated (main effect; $p < 0.05$) in the fESWT group. In the 3-month analysis, the effects turned out to be unstable. No intergroup differences were observed in the analysed results ($p > 0.05$).

In Table 3 a comparison of changes in the average COP deviation area in the frontal plane (ML) is presented from the centre of the platform with eyes closed in the treated fESWT group and in the control group in 4 subsequent measurements. In both groups, improvement in balance and postural stability was noted immediately after therapy, but no improvement was observed with statistically significant differences ($p > 0.05$). In long-term follow-up, the effects turned out to be unstable. No intergroup differences were observed in the analysed results ($p > 0.05$).

In the case of functional efficiency assessment, analysed using the Roland-Morris Questionnaire (RMQ), in the group undergoing therapy fESWT and in the control group, 4 subsequent measurements showed statistically significant differences (main effect: $p < 0.05$). Immediately after completing treatment, in the fESWT group a significant decrease was shown by 8.7 pt, after one month by 8.8 pt, and after 3 months by 9.3 pt. However, in the control group there was a decrease after therapy by 8.1 pt, after 1 month after by 8.8 pt, and after 3 months by 7.8 pt (Table 4). No intergroup differences were observed in the analysed results ($p > 0.05$).

The Schober (OST) test was used for the comparison of 4 measurements between the treatment fESWT group and the control group. Baseline scores in the fESWT group were lower than those in the control group, and both groups showed a beneficial clini-

Table 3. Comparison of changes in the mean COP deviation area of the ML [mm/s] parameter in both groups (with closed eyes)

Variable	Measure	Experimental fESWT group							Control fESWT group						
		x̄	Me	Min.	Max.	Q1	Q3	SD	x̄	Me	Min.	Max.	Q1	Q3	SD
ML [mm/s] parameter	Before	0.45	0.38	0.05	1.34	0.18	0.53	0.4	0.49	0.42	0.01	1.25	0.30	0.66	0.3
	After	0.31	0.28	0.01	0.86	0.09	0.49	0.2	0.40	0.25	0.04	1.34	0.14	0.54	0.4
	1 month FU	0.35	0.24	0.01	2.29	0.13	0.42	0.5	0.43	0.32	0.01	1.10	0.19	0.60	0.3
	3 months FU	0.48	0.27	0.10	1.93	0.15	0.57	0.5	0.25	0.22	0.01	0.73	0.10	0.39	0.2
P-value (main effect*)		0.552							0.365						
P-value (multiple comparisons**)		–							–						

**Friedman's ANOVA; **Dunn's test.*

Table 4. Roland-Morris Questionnaire (RMQ) scores in both groups

Variable	Measure	Experimental fESWT group							Control fESWT group						
		x̄	Me	Min.	Max.	Q1	Q3	SD	x̄	Me	Min.	Max.	Q1	Q3	SD
RMQ score	Before	14.3	15.0	4.0	23.0	11.5	19.0	5.3	13.9	13.5	8.0	22.0	9.5	16.0	4.4
	After	5.6	5.0	0.0	13.0	1.0	10.0	5.0	5.8	3.0	1.0	16.0	2.0	10.0	4.7
	1 month FU	5.5	4.0	0.0	14.0	1.0	9.5	5.2	5.1	3.0	0.0	17.0	1.0	9.5	4.9
	3 months FU	5.0	3.0	0.0	14.0	1.0	9.5	5.0	6.1	5.0	0.0	15.0	1.5	11.5	5.3
P-value (main effect*)		< 0.001							< 0.001						
P-value (multiple comparisons**)		Before vs. after: $p < 0.001$ Before vs. 1 month: $p < 0.001$ Before vs. 3 months: $p < 0.001$ After vs. 1 month: $p = 1.000$ After vs. 3 months: $p = 1.000$ 1 month vs. 3 months: $p = 1.000$							Before vs. after: $p < 0.001$ Before vs. 1 month: $p < 0.001$ Before vs. 3 months: $p = 0.001$ After vs. 1 month: $p = 1.000$ After vs. 3 months: $p = 1.000$ 1 month vs. 3 months: $p = 1.000$						

**Friedman's ANOVA; **Dunn's test.*

cal effect. The differences are not statistically significant, but positive changes in the results of intergroup comparisons were observed. In the group undergoing fESWT therapy and in the control group there were statistically significant differences (main effect: $p < 0.05$). A significant increase in the result in the study group was demonstrated immediately after therapy by 1.7 pt, after 1 month by 1.6 pt, and after 3 months by 1.4 pt. In the case of the control group, by 1.1 pt after therapy, 1 month after by 0.9 pt, and 3 months after by 0.6 pt (Table 5).

Table 6 shows a comparison of the changes in results of left limb Laseque test in the fESWT treatment group and the control group. There were statistically significant differences in both groups (main effect: $p < 0.05$). A beneficial effect was demonstrated in the fESWT group, achieving a final improvement of 10 points. In the case of the control group, there was a final improvement of 8.7 pt. In intergroup comparisons, statistically significant differences ($p < 0.05$) were observed in all measurements.

Table 7 shows a comparison of the changes in results of right limb Laseque test in the treatment fESWT group and the control group. There were statistically significant differences in both groups (main effect: $p < 0.05$). A beneficial effect was demonstrated in the fESWT group, achieving a final improvement of 11.7 pt. In the case of the control group there was a final improvement of 9.7 pt. In intergroup comparisons, statistically significant differences ($p < 0.05$) were observed in all measurements.

To sum up, the results obtained from an objective measurement tool (stabilometric platform) indicated only a short-term improvement in postural stability in patients, while in the 3-month follow-up the effects turned out to be unstable. Beneficial effects were obtained in the assessment of subjective feelings and measurements of the range of motion of the spine and hip joints. No significant improvement in functional status was demonstrated compared to the control group.

Discussion

In our previous report published in 2022, we assessed the impact fESWT on LBP on pain using a Vi-

Table 5. Schober Test (OST) scores in both groups

Variable	Measure	Experimental fESWT group							Control fESWT group						
		x̄	Me	Min.	Max.	Q1	Q3	SD	x̄	Me	Min.	Max.	Q1	Q3	SD
OST score	Before	3.1	3.0	2.0	4.0	3.0	3.0	0.6	3.9	4.0	2.0	5.0	3.0	5.0	1.0
	After	4.8	5.0	3.0	6.0	4.0	5.0	0.7	5.0	5.0	4.0	6.0	4.0	5.5	0.8
	1 month FU	4.7	5.0	3.0	6.0	4.0	5.0	0.7	4.8	5.0	4.0	6.0	4.0	5.0	0.8
	3 months FU	4.5	4.0	3.0	6.0	4.0	5.0	0.8	4.5	4.0	3.0	6.0	4.0	5.0	0.8
P-value (main effect*)		< 0.001							< 0.001						
P-value (multiple comparisons**)		Before vs. after: $p < 0.001$ Before vs. 1 month: $p < 0.001$ Before vs. 3 months: $p < 0.001$ After vs. 1 month: $p = 1.000$ After vs. 3 months: $p = 1.000$ 1 month vs. 3 months: $p = 1.000$							Before vs. after: $p < 0.001$ Before vs. 1 month: $p = 0.004$ Before vs. 3 months: $p = 0.397$ After vs. 1 month: $p = 1.000$ After vs. 3 months: $p = 0.165$ 1 month vs. 3 months: $p = 1.000$						

**Friedman's ANOVA; **Dunn's test.*

Table 6. Laseque test (left side) scores in both groups

Variable	Measure	Experimental fESWT group							Control fESWT group						
		x̄	Me	Min.	Max.	Q1	Q3	SD	x̄	Me	Min.	Max.	Q1	Q3	SD
Laseque Test (left side) score	Before	61.3	60.0	25.0	85.0	55.0	72.5	17.0	54.3	55.0	30.0	75.0	45.0	65.0	13.5
	After	74.3	80.0	30.0	90.0	72.5	80.0	16.3	65.3	67.5	45.0	85.0	55.0	75.0	12.0
	1 month FU	72.8	75.0	30.0	90.0	72.5	80.0	16.2	64.0	65.0	45.0	80.0	55.0	75.0	11.3
	3 months FU	71.3	75.0	30.0	90.0	67.5	80.0	16.5	63.0	65.0	45.0	80.0	52.5	75.0	11.4
P-value (main effect*)		< 0.001							< 0.001						
P-value (multiple comparisons**)		Before vs. after: $p < 0.001$ Before vs. 1 month: $p < 0.001$ Before vs. 3 months: $p = 0.001$ After vs. 1 month: $p = 1.000$ After vs. 3 months: $p = 0.300$ 1 month vs. 3 months: $p = 1.000$							Before vs. after: $p < 0.001$ Before vs. 1 month: $p < 0.001$ Before vs. 3 months: $p < 0.001$ After vs. 1 month: $p = 1.000$ After vs. 3 months: $p = 0.755$ 1 month vs. 3 months: $p = 1.000$						

**Friedman's ANOVA; **Dunn's test.*

sual Analogue Scale (VAS) and Laitinen Pain Scale (LPS), to assess functional status Oswestry Disability Index (ODI) [13].

In the presented study, we performed posturographic tests, which allowed for an objective assessment of balance control and body posture. The procedures undertaken in both groups led to short-term improvement in postural stability in patients. In the 3-month analysis, the effects turned out to be unstable. Interestingly, patients reported an improvement in functional ability, which we assessed using the Roland-Morris Questionnaire (RMQ), demonstrating significant improvement in the fESWT group (main effect: $p < 0.05$). We noted an improvement in the mobility of the spine measured in the lumbosacral section Schober test (OST) in both groups.

The studies from our project correspond to the results of Polish authors, in which clinically significant results were demonstrated in the rESWT group in efficiency assessment of functional (RMQ) and spine mobility (ROM) [14]. In our studies, we achieved functional improvement with an advantage for the group implementing fESWT. The element connecting both projects was the assessment of postural stability. In our study, statistically significant results were demonstrated in the fESWT group in the follow-up one month after the end of therapy (main effect: $p < 0.05$), after the 3-month evaluation the effects were unstable. The studies by Walewicz *et al.* showed a positive impact of the rESWT treatments on body posture control also in 3-month analyses.

The effectiveness of shock wave therapy in patients with LBP is confirmed by reports of other research teams, indicating a significant improvement in pain parameters, disability, and quality of life in patients with LBP [15, 16].

Table 7. Laseque test (right side) scores in both groups

Variable	Measure	Experimental fESWT group							Control fESWT group						
		x̄	Me	Min.	Max.	Q1	Q3	SD	x̄	Me	Min.	Max.	Q1	Q3	SD
Laseque Test score	Before	61.8	60.0	40.0	80.0	55.0	67.5	12.1	56.3	62.5	30.0	75.0	50.0	65.0	14.0
	After	76.0	75.0	50.0	90.0	72.5	85.0	11.9	68.0	70.0	45.0	85.0	65.0	75.0	11.1
	1 month FU	75.0	75.0	50.0	90.0	70.0	80.0	11.7	67.5	70.0	45.0	80.0	62.5	75.0	10.8
	3 months FU	73.5	75.0	50.0	90.0	70.0	80.0	11.0	66.0	67.5	45.0	80.0	60.0	75.0	11.3
P-value (main effect*)		< 0.001							< 0.001						
P-value (multiple comparisons**)		Before vs. after: $p < 0.001$ Before vs. 1 month: $p < 0.001$ Before vs. 3 months: $p < 0.001$ After vs. 1 month: $p = 1.000$ After vs. 3 months: $p = 0.668$ 1 month vs. 3 months: $p = 1.000$							Before vs. after: $p < 0.001$ Before vs. 1 month: $p < 0.001$ Before vs. 3 months: $p = 0.002$ After vs. 1 month: $p = 1.000$ After vs. 3 months: $p = 0.850$ 1 month vs. 3 months: $p = 1.000$						

**Friedman's ANOVA; **Dunn's test.*

The added value of our project is the assessment of the range of motion of both limbs, measured with the Laseque test.

As Lee *et al.* indicate in their study, the range of hip motion in patients with chronic low back pain may affect the occurrence of pain and functional efficiency. Sixty-nine participants with LBP were qualified for the project. The ranges of hip motion were compared in the group of patients with lumbar instability (n = 30) and with lumbar stability (n = 39). Patients with lumbar instability had higher levels of limitation than those with lumbar stability [17]. Prather *et al.* in their study compared pain and function in 101 patients with LBP. The tested hip movements included hip flexion, similar to our study, indicating decreased flexion movement in patients with LBP (p = 0.008) compared to asymptomatic subjects. The implications suggest that hip movement and pain associated with a hip disorder may influence LBP [18]. Reports by other authors suggest that the occurrence of a reduced range of hip flexion motion is associated with increased pain and reduced functional efficiency [19, 20]. Based on the analysed literature, it can be concluded that reduced hip range of motion may be one of the factors contributing to the development of low back pain.

In our project, in both groups statistically significant differences ($p < 0.05$) were observed in measurements of hip range of motion in all measured time intervals for both lower limbs.

In summary, our study noted improvements in lumbar spine range of motion, hip joints, and functional ability at each time point in both groups. Although the results of our study did not demonstrate a clear therapeutic advantage over sham therapy, the use of fESWT for LBP may contribute to an increase in overall functional ability. Unfortunately, the objective data recorded from the stabilographic platform turned out to be insufficient for long-term evaluation.

The limitation of this study is the small number of patients. It would be useful to design a study with more participants as a multicentre clinical trial to verify the results obtained in our project. It also seems justified to use other, precise measurement tools and compare the methods fESWT with other commonly used therapies in LBP.

It is worth continuing research on the effectiveness of this therapy based on other indicators and measurement tools, to comprehensively assess the usefulness and effectiveness of this method. An important aspect is to establish uniform treatment protocols that could be verified by other researchers.

Conclusions

Our findings suggest that fESWT application with a specific exercise program may be a promising alternative in the treatment of LBP. Although objective assessment using a stabilometric platform showed beneficial effects only in the short term, subjective assessment of patients and measurements of the range of motion of the spine and hip joints showed positive effects both in the short and long term. Further studies are warranted to determine the effectiveness of fESWT in patients with LBP.

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Ethical approval

Bioethics Committee of the Public Higher Professional Medical School in Opole, Poland (no. KB/90/FI/2018).

Conflict of interest

The authors declare no conflict of interest.

References

1. Finco G, Mura P, Musu M, Deidda C, Saba M, Demelas I, Evangelista M, Sardo S. Long-term, prolonged-release oral tapentadol for the treatment of refractory chronic low back pain: a single-center, observational study. Minerva Med. 2018; 109: 259-265.
2. Alvani E, Shirvani H, Shamsoddini A. Neuromuscular exercises on pain intensity, functional disability, proprioception, and balance of military personnel with chronic low back pain. J Can Chiropr Assoc. 2021; 65: 193-206.
3. Rajfur J, Pasternok M, Rajfur K, Walewicz K, Fras B, Bolach B, Dymarek R, Rosińczuk J, Halski T, Taradaj J. Efficacy of selected electrical therapies on chronic low back pain: a comparative clinical pilot study. Med Sci Monit. 2017; 23: 85-100.
4. Todd NV. The surgical treatment of non-specific low back pain. Bone Joint J. 2017; 99-B: 1003-1005.
5. d'Agostino MC, Craig K, Tibalt E, Respizzi S. Shock wave as biological therapeutic tool: from mechanical stimulation to recovery and healing, through mechanotransduction. Int J Surg. 2015; 24: 147-153.
6. Crevenna, R, Mickel, M, Schuhfried O, Gesslbauer K, Zdravkovic A, Keilani M. Focused extracorporeal shockwave therapy in physical medicine and rehabilitation. Curr Phys Med Rehabil Rep. 2021; 9: 1-10.
7. Park J, Nguyen VQ, Ho RLM, Coombes SA. The effect of chronic low back pain on postural control during quiet standing: a meta-analysis. Sci Rep. 2023; 13: 7928.
8. Azadinia F, Ebrahimi-Takamjani I, Kamyab M, Asgari M, Parnianpour M. Immediate effects of lumbosacral orthosis on postural stability in patients with low back pain: a preliminary study. Arch Bone Jt Surg. 2019; 7(4): 360-366.
9. Cha E, Park JH. Spinopelvic alignment as a risk factor for poor balance function in low back pain patients. Global Spine J. 2023; 13(8): 2193-2200.
10. Jenks A, Hoekstra T, van Tulder M, Ostelo RW, Rubinstein SM, Chiarotto A. Roland-Morris Disability Questionnaire, Oswestry Disability Index, and Quebec Back Pain Disability Scale: which has superior measurement properties in older adults with low back pain?. J Orthop Sports Phys Ther. 2022; 52: 457-469.
11. Sturion LA, Nowotny AH, Barillec F, Barette G, Santos GK, Teixeira FA, Fernandes KP, da Silva R. Comparison between high-velocity low-amplitude manipulation and muscle energy technique on pain and trunk neuromuscular postural control in male workers with chronic low back pain: a randomised crossover trial. S Afr J Physiother. 2020; 76: 1420.
12. Kamath SU, Kamath SS. Lasègue's sign. J Clin Diagn Res. 2017; 11: RG01-RG02.
13. Rajfur K, Rajfur J, Matusz T, Walewicz K, Dymarek R, Ptaszkowski K, Taradaj J. Efficacy of focused extracorporeal shock wave therapy in chronic low back pain: a prospective randomized 3-month follow-up study. Med Sci Monit. 2022; 28: e936614.
14. Walewicz K, Taradaj J, Dobrzyński M, Sopel M, Kowal M, Ptaszkowski K, Dymarek R. Effect of radial extracorporeal shock wave therapy on pain intensity, functional efficiency, and postural control parameters in patients with chronic low back pain: a randomized clinical trial. J Clin Med. 2020; 9: 568.
15. Elgendy MH, Mohamed MH, Hussein HM. Effect of extracorporeal shock wave on electromyographic activity of trunk muscles in non- specific chronic low back pain: a randomized controlled trial. Eurasian J Biosci. 2020; 14: 6955-6962.
16. Çelik A, Altan L, Ökmen BM. The effects of extracorporeal shock wave therapy on pain, disability and life quality of chronic low back pain patients. Altern Ther Health Med. 2020; 26: 54-60.
17. Lee SW, Kim SY. Comparison of chronic low-back pain patients hip range of motion with lumbar instability. J Phys Ther Sci. 2015; 27: 349-351.
18. Prather H, van Dillen L. Links between the hip and the lumbar spine (hip spine syndrome) as they relate to clinical decision making for patients with lumbopelvic pain. PM R. 2019; 11 Suppl 1: S64-S72.
19. Shin D. Correlation between non-specific chronic low back pain and physical factors of lumbar and hip joint in office workers. Med Hypotheses. 2020; 144: 110304.
20. Sánchez-Zuriaga D, López-Pascual J, Garrido-Jaén D, García-Mas MA. A comparison of lumbopelvic motion patterns and erector spinae behavior between asymptomatic subjects and patients with recurrent low back pain during pain-free periods. J Manipulative Physiol Ther. 2015; 38: 130-137.

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