Effect of multidimensional physiotherapy on non-specific chronic low back pain: a randomized controlled trial

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Abstract

Background Many people with non-specific chronic low back pain (NSCLBP) do not recover with current conventional management. Systematic reviews show multidimensional treatment improves pain better than usual active interventions. It is unclear whether multidimensional physiotherapy improves pain better than usual physiotherapy. This study determines the effectiveness of this treatment to reduce pain and disability and improve quality of life, pain cognitions, and electroencephalographic pattern in individuals with NSCLBP.

Methods 70 eligible participants aged 18 to 50 years with NSCLBP were randomized into either the experimental group (multidimensional physiotherapy) or the active control group (usual physiotherapy). Pain intensity was measured as the primary outcome. Disability, quality of life, pain Catastrophizing, kinesiophobia, fear Avoidance Beliefs, active lumbar range of motion, and brain function were measured as secondary outcomes. The outcomes were measured at pre-treatment, post-treatment, 10, and 22 weeks. Data were analyzed using intention-to-treat approaches.

Results There were 17 men and 18 women in the experimental group (mean [SD] age, 34.57 [6.98] years) and 18 men and 17 women in the active control group (mean [SD] age, 35.94 [7.51] years). Multidimensional physiotherapy was not more effective than usual physiotherapy at reducing pain intensity at the end of treatment. At the 10 weeks and 22 weeks follow-up, there were statistically significant differences between multidimensional physiotherapy and usual physiotherapy (mean difference at 10 weeks, -1.54; 95% CI, -2.59 to -0.49 and mean difference at 22 weeks, -2.20; 95% CI, − 3.25 to − 1.15). The standardized mean difference and their 95% confidence intervals (Cohen's d) revealed a large effect of pain at 22 weeks: (Cohen's d, -0.89; 95% CI (-1.38 to-0.39)). There were no statistically significant differences in secondary outcomes.

Conclusions In this randomized controlled trial, multidimensional physiotherapy resulted in statistically and clinically significant improvements in pain compared to usual physiotherapy in individuals with NSCLBP at 10 and 22 weeks.

Trial Registration ClinicalTrials.gov NCT04270422; IRCT IRCT20140810018754N11.

Keywords Biopsychosocial, Chronic low back pain, Electroencephalography, Pain intensity

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Bemani *et al. Advances in Rheumatology*   (2023) 63:57

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Introduction

Non-specific chronic low back pain (NSCLBP) is a common musculoskeletal disorder, leading to a considerable personal, social, and economic burden [1–5]. The effective management of NSCLBP is a major concern for individuals, the economy, and society [6]. While there is a wide range of guideline-based management for NSCLBP, disability and burden have been increasing, leading to persistent, worsening, and recurrent pain [3, 7–10]. Despite the large volume of clinical research focused on identifying effective treatments for NSCLBP, optimal management remains a point of contention [11]. In recent decades, NSCLBP has been considered a multidimensional experience characterized by physical, psychological, behavioral, lifestyle, and social factors, and effective treatment requires intervention that specifically addresses these factors [11, 12]. This has led to the evolution of multidisciplinary biopsychosocial rehabilitation (MBR) programs [11, 12]. These programs typically involve a combination of physical, psychological, educational, lifestyle, and work-related components delivered by a team of health care professionals from different disciplines [3, 11–14]. Systematic reviews indicate that MBR programs are more effective than usual care or active physical interventions for reducing pain and disability in people with chronic low back pain[11]. Nevertheless, there is no evidence to guide the decision-making about the most optimal way, dose, and content to deliver MBR programs for patients with chronic low back pain. Also, given the moderate size of MBR effects and the potentially high monetary and time of intensive intervention, the decision to refer to MBR requires some consideration [11, 12, 15–17]. Furthermore, psychological factors involved in NSCLBP are not necessarily mental health disorders that require assessment and management by a mental health provider. For instance, kinesiophobia or catastrophizing are pain-related disorders. They can be within the scope of musculoskeletal clinicians [18]. Hence, we designed a physiotherapy-led intervention called multidimensional physiotherapy that targets physical, psychological, and lifestyle factors.

Up to this point, little is known about the precise central mechanisms of chronic low back pain. Various researchers have identified a relationship between chronic pain and functional changes in electroencephalography (EEG) activity at different frequency bands [19–30]. Most studies on the power spectrum of EEG activity at rest have demonstrated that chronic pain displays increased power in frontal and parieto-occipital regions in the theta and alpha frequency bands [31–36]. Importantly, these EEG activity changes are suggested to be reversible with successful treatment. Therefore, a treatment addressing both functional changes and inappropriate pain cognitions might result in larger effect sizes and clinically relevant changes [37, 38]. Therefore, brain function analysis for studying central mechanisms involved in chronic low back pain and investigating the central effect of multidimensional physiotherapy could be of great value [29, 30].

Based on the above-described voids, this randomized controlled trial investigated whether multidimensional physiotherapy is superior to usual physiotherapy in reducing pain and improving functionality, and pain cognitions in people with NSCLBP. Also, we are assessing changes in EEG patterns following multidimensional physiotherapy.

Methods

Study design and setting

This study was a 22-week, outcome assessor-blind, randomized, controlled, parallel trial from April 2020 to February 2022. The study protocol has been published previously [39] (Additional file 1). The ethical committee of the Iran University of Medical Sciences (IUMS) approved this study (IR.IUMS.REC.1398.1041). Participants signed a reviewed and approved informed consent document. We followed the Consolidated Standards of Reporting Trials (CONSORT) reporting guidelines.

Participants

We sought to recruit participants from hospitals, advertisements, and social media in Tehran, Iran. All participants were examined by a specialist for eligibility. Inclusion criteria were as follows: 18–50 years old; having permanent or intermittent local pain between L1 and gluteal fold for three months or more and a Numeric Rating Scale (NRS) score of 3–7/10 in the last week; the Oswestry Disability Index (ODI) score of 20–60; the Tampa Scale for Kinesiophobia (TSK) score > 37; elementary level of education and native Persian speaking. The exclusion criteria were having a specific medical diagnosis (such as fracture, canal stenosis), rheumatoid disease, fibromyalgia, neuropathy, progressive neurological disease, headache, dizziness, nausea, epilepsy, migraines, and mental disorders; having a history of lumbar surgery in the past three years; Beck's Anxiety Inventory score > 26; Beck's Depression Inventory-II score > 29; participating in other therapies during the present research and pregnancy. Then they participated in an initial screening interview to provide an overview of the study. Informed written consent was obtained from all participants before the baseline examination. After completing baseline examinations, individuals who agreed to participate in the study were assigned to either the experimental or active control group. A total of 246 patients with NSCLBP presented to participate in the present study, and researchers excluded 176 participants based on exclusion criteria.

Randomization and blinding

After performing a baseline assessment, participants were randomly assigned (1:1) to an experimental or active control group. A computer-generated randomization sequence was performed using a stratified permuted block allocation (block size of 4). The stratification factor was gender. The outcome assessor who evaluated the outcome of the study was blind to the allocation of the groups. An analyzer independent of the research team and blinded to participant assignment monitored and analyzed the study data. In addition, the person who assigned participants was instructed not to disclose the status of the assignment to patients at any time. Details of the study protocols have been previously published.

Outcome measures

The primary outcome was pain, assessed by NRS at baseline, after six weeks of treatment, and after 10 and 22 weeks of follow-up. The NRS uses an 11-point scale to measure pain intensity [40].

The secondary outcomes included pain cognitions, disability, quality of life, active lumbar forward flexion, and brain function. Brain function was measured using the EEG power spectra analysis. EEG was recorded (bandwidth is 0-0.70 Hz, the pass filter is 0.05–60 Hz, and the sampling rate is 512 Hz) with a 64-channel amplifier (EB Neuro, Italy). The cap with 19 Ag–AgCl electrodes (impedance below 20 KOhm) was positioned according to the international 10–20 system at Fp1, Fp2, F7, F3, Fz, F4, F8, T3, C3, Cz, C4, T4, T5, P3, Pz, P4, T6, O1, O2. We placed references and ground electrodes on the mastoid processes (A1 and A2) and the Fpz region. EEG signals were recorded under two conditions: three minutes of an eyes-open resting state and 20 s of active lumbar forward flexion. The absolute and relative (percentage of total EEG power) EEG power spectra analyses of the following frequency domains were calculated: delta (1–3.8 Hz), theta (4.0–7.8 Hz), alpha (8.0–13.8 Hz), beta (14.0–34.8 Hz), and gamma (35–50 Hz).

The following questionnaires were used to assess pain cognitions: The Pain Catastrophizing Scale [41]; the Tampa Scale for Kinesiophobia [42]; and the Fear Avoidance Beliefs Questionnaire [43]; Quality of life and disability were measured using the 36 Health Status Survey (SF-36) [44] and the Oswestry Disability Index Questionnaire [45].

Study group interventions

Participants in each group received 12 treatment sessions delivered twice weekly for 6 weeks from their trained independent physiotherapists. The treatment in each session lasted equally long in the two groups.

Experimental group intervention

Participants in the experimental group received multidimensional physiotherapy. This treatment included psychoeducation, graded exposure, postural correction and electrotherapy as a passive warm-up. In this study, we performed twelve 30-minute psychoeducation sessions based on cognitive behavioral therapy (CBT). Each session was conducted using the question-and-answer method. The physiotherapist first provided the desired content, then posed a question regarding the covered topic to ensure the patients' attendance and active involvement in each session. At the end of each session, the patient was given a task to do at home and present in the next session. Out of the 12 sessions, three were dedicated to educating the patient on pain neurophysiology and achieving therapeutic goals. The contents of these sections were designed based on a summary of the book *Explain Pain* [46]. The other sessions consisted of anxiety management, interpersonal conflict management, problem-solving training, coping strategy training, pain flare-ups management, medication abuse management, enhancing the ability to cope with labeling and stigma, empowering one to create a daily sleep routine, and training relaxation techniques [47]. Each topic is discussed in one session. Table 1 shows the details of psychoeducation treatment in the experimental group. Participants also received recommendations for postural correction, and gradual initiation of movements and activities that are feared. We asked participants to repeat the practice of each session at home once a day. Electrotherapy, including 20 min of transcutaneous electrical nerve stimulation (TENS) at 100 Hz frequency in the lumbar region with a hot pack and ultrasound with a frequency of 1 MHz and intensity of 1.2 W/cm2, was performed on the paravertebral muscle for 5 min.

Active control group intervention

Participants in the active control group received usual physiotherapy including traditional back school education (three sessions), general trunk exercises, and electrotherapy as a passive warm-up. Back school education covered basic anatomy and biomechanics of the spine, common causes of spinal pain, nociceptive pain processing, and ergonomic counseling based on the inherent postural strain associated with various postures and daily activities (including standing, sitting, and lifting). As such, the education sessions prepared the patients for a symptom-contingent, biomedical approach to daily activity and exercise therapy. In session four, general exercise therapy was started with a specific emphasis on treating dysfunctional muscles and joints. Different therapeutic goals were pursued (microcirculation, mobility, endurance, strength of the abdominal and paraspinal muscles) depending on what emerges from the clinical reasoning

Table 1 Description of psychoeducation sessions

Session	Description
Pain neurophysiology	The content, format, and pictures were based on the Explain Pain book. We presented the educational information verbally (explanation by the physiotherapist) and visually (summaries, pictures, metaphors, and diagrams on computer and paper). The education covered the physiology of the nervous system in general and the pain system in particular. Topics addressed during the educational sessions included the characteristics of acute versus chronic pain; how pain becomes chronic; potential sustaining factors of central sensitization like emotions, stress, pain cognitions, and pain behavior.
Anxiety management	• The goal of this session o Identify signs and symptoms of anxiety o Learn coping skills to improve the individual's functioning in the area of anxiety • What to discuss o Rates of anxiety in the chronic pain population o Defining anxiety disorders and common signs and symptoms • Skills to teach o Distracting the mind, imagery, soothing through the senses
Interpersonal conflict management	• The goal of this session o Have individuals learn how to manage conflict more effectively o Increase effective skill use in relationships • What to discuss o Conflict resolution o Positive consequences of conflict o Negative consequences of conflict • Skills to teach o Determination and assertiveness training
Problem-solving training	• The goal of this session o Increase the individual's problem-solving strategies and their effectiveness o Individuals will learn skills to cope more effectively in complex situations and with others • What to discuss o General problem-solving strategies • Skills to teach o Individual-based problem-solving model
Coping strategy training	• The goal of this session o Gain insight and information about common defense mechanisms and coping strategies applied to pain management o Learn coping skills to improve patient functioning in the areas of common defense mechanisms • What to discuss o Healthy behavior o Unhealthy behavior • Skills to teach o Choose healthy behavior
Pain flare-ups management	• The goal of this session o Identify triggering events and typical reactions o Learn coping skills to improve the individual's functioning in the areas of fear and avoidance • What to discuss o Coping with pain o Fears of reinjury o Negative feedback loop • Skills to teach o Creating a skills implementation plan
Medication abuse management	• The goal of this session o Learn coping skills to improve the individual's functioning in the area of accepting reality o Learn coping skills to improve the individual's functioning in the area of chemical abuse • What to discuss o Motivation to reject reality o Ways to escape from reality o Ways to avoid reality o Ways to alter reality • Skills to teach o Turning the Mind o Distracting the mind, imagery, soothing through senses

Table 1 (continued)

Session	Description
Cope with labeling and stigma	• The goal of this session
	o Gain insight and understanding into the effects of stigma
	o Learn coping skills to improve the individual's ability to cope effectively with stigma
	• What to discuss:
	o Stigma
	o Stigma and chronic pain
	o Impact of stigma on the individual
	o Negative associations
	• Skills to teach
	o Turning the mind
	o Thought-stopping and positive self-talk
Create a daily sleep routine	• The goal of this session
	o Learn coping skills to improve the individual's functioning in the areas of building and maintaining healthy sleep patterns
	• What to discuss
	o How sleep patterns affect functioning
	o What are habits and routines?
	• Skills to teach
	o Building a routine
	o Maintaining a routine
	o Returning to sleep strategies
Training relaxation techniques	Teaching relaxation techniques such as diaphragmatic breathing and progressive muscle relaxation

as the most dominant peripheral dysfunction. The progressive exercise program mainly entailed an increase in exercise intensity, and an evolution towards functional activities and more physically demanding tasks while keeping the spine in physiologically neutral positions to minimize strain imposed upon the spinal structures. All exercises were performed in a symptom-contingent way (Additional file 3). They also received electrotherapy, the same as the experimental group.

Training of the physiotherapists and treatment fidelity

The two independent physiotherapists provided interventions in each group. The physiotherapist who conducted treatment in the active control group had ten-year experience in musculoskeletal treatment. The specific training for CBT-based psychoeducation was developed to enhance the standardization. The training involved (1) participating in learning sessions and interactive classes with an expert psychologic in the field of psychoeducation on pain, as well as clinical workshops where the management of NSCLBP as a multidimensional disorder was discussed (2) assessing and treating actual patients with NSCLBP (3) assessing and treating patients with NSCLBP in front of an expert.

A fidelity evaluation was conducted in which the physiotherapists were observed while assessing and treating actual patients from the study. For each participant, session-by-session documentation of treatment content was recorded by the physiotherapists. Regular training, supervision, and feedback were provided to the physiotherapists throughout the study to facilitate the successful delivery of both treatments. Physiotherapists provided demographic details and information about their training at each session. For qualitative evaluation, some sessions of both intervention groups were observed and audio recorded.

Sample size calculation

The sample size was calculated using G*Power software 3.1.9.4 (Düsseldorf, Germany) based on the effects on pain in the pilot study (partial $\eta2=0.04$, $\alpha=0.025$, power$=0.95$) and accounted for F tests and 10% loss to follow-up after 22 weeks, resulting in a total sample size of 70 individuals [48].

Statistical analysis

Stata 14.2 (StataCorp LLC; College Station, TX, USA) and SPSS (version 22) were used to analyze all data. We performed an intention-to-treat analysis for participants who dropped out of the study at follow-up. Continuous and categorical baseline variables were summarized using mean (standard deviation), median (interquartile range), and frequency (percentages) to determine descriptive statistics. A mixed model ANOVA/ANCOVA was used to determine the time effect, group effect, and time × group interaction effect between groups, using the Bonferroni post hoc method and adjusting for differences in patients' characteristics at baseline where appropriate were done. The assumption of homogeneity and sphericity were checked by Levene's and Mauchly's tests respectively. When the assumption of sphericity is violated, Greenhouse-Geisser corrections are used. Similar
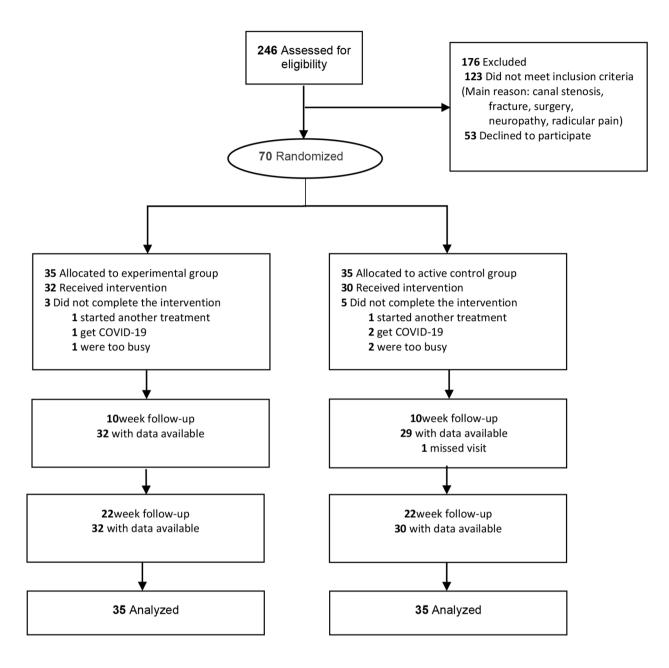
Fig. 1 CONSORT flow diagram of randomized controlled trial

analyses examined the treatment effect for all secondary outcomes. Subgroup analyses were planned for the pain catastrophizing variable (mild, moderate, and severe pain catastrophizing). We also calculated the effect size (Cohen's d) for each pairwise comparison, using the pooled SD of baseline scores, where 0.2 was considered a small effect, 0.5 a moderate effect, and 0.8 a large effect [49]. Statistical significance was indicated at $p \leq 0.05$ (2-sided), and the confidence interval was set at 95%. The statistician was blinded to group allocation.

Deviations from the registered trial protocol
We made some deviations from our protocol. In calculating the follow-up period of one and four months, we considered the end of the treatment period, which was finally corrected 10- and 22 weeks after randomization. In the design phase of the trial, we designed a three-blind study, but in the pilot study, it was not possible to implement the first phase of blinding, so we conducted the study as an outcome assessor blind study.

Table 2 Demographic and baseline characteristics of the participants with NSCLBP (N = 70)

Characteristic	Experimental group (n = 35)	Active control group (n = 35)
Demographic		
Sex, No. (%)		
female	18 (51)	17 (49)
Age, year, mean (SD)	34.57 (6.98)	35.94 (7.51)
Body height, cm, mean (SD)	171.09 (11.01)	173.03 (9.43)
Body weight, kg, mean (SD)	72.29 (11.29)	74.49 (9.95)
Education, year, mean (SD)	15.60 (1.87)	15.26 (2.12)
Pain duration, No. (%)		
3–12 month	3 (9)	4 (11)
12–60 month	24 (69)	24 (69)
>60 month	8 (23)	7 (20)
Baseline		
NRS, Mean (SD)	5.03 (0.92)	5.09 (0.95)
ODI, Median (IQR)	28 (22–32)	26 (20–34)
TSK, Median (IQR)	40 (38–46)	40 (37–42)
PCS, Mean (SD)	27.11 (6.68)	29.60 (8.80)
SF36, Mean (SD)	58.29 (16.28)	59.26 (17.40)
FABQ, Mean (SD)	40.71 (9.47)	37.74 (17.83)
Flexion ROM, Median (IQR), cm	18 (1–25)	17 (2–27)

Abbreviations: NRS, Numeric Rating Scale; ODI, Oswestry Disability Index; TSK, Tampa Scale for Kinesiophobia; PCS, Total Score of the Pain Catastrophizing Scale; SF36, 36-Item Short-Form Health Survey; FABQ, Fear Avoidance Beliefs Questionnaire; Flexion ROM, Lumbar Active Forward Flexion Range of Motion; cm, centimeter; SD, Standard Deviation; IQR, Inter Quartile Range

Results

A total of 70 people with NSCLBP (mean [SD] age, 35.26 [7.23] years; age range, 22–50 years) were included in the present trial and received either experimental group (mean [SD] age, 34.57 [6.98] years; 18 [51%] women and 17 [49%] men) or active control group (mean [SD] age, 35.94 [7.51] years; 17 [49%] women and 18 [51%] men). Figure 1 shows the flow of participants through the trial. The baseline characteristics of these participants are presented in Table 2. As shown in Table 2, the two groups had similar demographic (except for body weight) and clinical characteristics (except for PCS, FABQ) at baseline. Sixty-two of the 70 participants completed all treatment sessions and 22 weeks of follow-up.

Primary outcome

The results indicated that the primary outcome, pain, has a significant main effect of time and treatment × time interaction effects. Post hoc tests revealed that the experimental group experienced greater pain improvement in comparison to the active control group. The mean [SD] pain intensity decreased from 5.03 [0.92] at baseline to 1.74 [1.74] at 10 weeks and 1.66 [2.00] at 22 weeks in the experimental group. The mean [SD] pain intensity in the active control group decreased from 5.09 [0.95] at baseline to 3.29 [2.01] at 10 weeks and 3.86 [2.35] at 22 weeks (Fig. 2). The mean between-group difference [MD] and 95% confidence intervals (95% CI) was (MD, 1.54; 95% CI, -2.59 to -0.49) in 10 weeks follow up and (MD, 2.20; 95% CI, -3.25 to -1.15) in 22 weeks follow up. Standardize
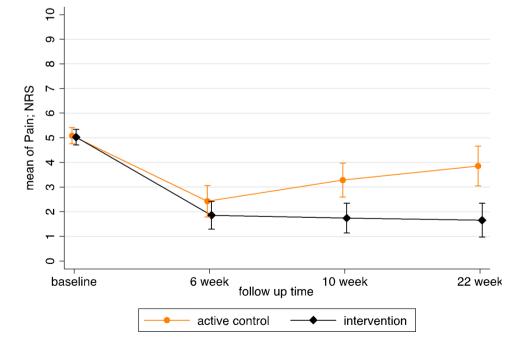

Fig. 2 Treatment Effects of multidimensional treatment on Pain. Mean pain intensity score (primary outcome) using NRS, Numeric Rating Scale. Error bars indicate 95% CIs.

mean between-group difference and their 95% CI (Cohen's d, 95% CI) showed a medium effect (Cohen's d, -0.62; 95% CI (-1.10 to -0.14)) in 10 weeks and a large effect (Cohen's d, -0.89; 95% CI (-1.38 to -0.39)) in 22 weeks follow up of treatment group on pain intensity (Tables 3 and 4).

Secondary outcomes

There were an inconclusive (medium effect size; statistically significant) effect for absolute power of alpha frequency in frontal (Cohen's d, -0.59; 95% CI (-1.03 to -0.79)) and central (Cohen's d, -0.70; 95% CI (-1.18 to -0.21)) region in active lumbar forward flexion. Also, there were an inconclusive and statistically significant effect for relative power of alpha frequency in the frontal (Cohen's d, -0.82; 95% CI (-1.31 to -0.33)), parietal (Cohen's d, -0.70; 95% CI (-1.19 to -0.22)), temporal (Cohen's d, -0.72; 95% CI (0.25 to 1.21)), and occipital (Cohen's d, -1.04; 95% CI (-1.53 to -0.53)) regions, and gamma frequency in the central (Cohen's d, -0.93; 95% CI (-1.42 to -0.43)), and temporal (Cohen's d, -0.68; 95% CI (-1.16 to -0.19)) regions in the open-eye resting position. For other EEG outcomes, there were no statistically significant differences at any of the time points (Additional file 2).

Multidimensional physiotherapy was not more effective than usual physiotherapy (no statistically significant differences) in other secondary outcomes (Tables 3 and 4). The comparison between the full model and the reduced model ANOVA/ANCOVA to assess the effect of the baseline, and demographic characteristics of pain catastrophizing, fear-avoidance beliefs, and body weight on the intervention effect showed that the result of the primary outcome was not affected by the potential confounder of the participants' body weight or differences of pain catastrophizing and fear avoidance believes at baseline. Subgroup analysis on pain catastrophizing (mild_PCS (n=26), moderate_PCS (n=35), severe_PCS (n=9)) showed a very large effect of treatment in mild (Glass'Δ: -1.44; 95%CI (-2.36 to -0.47)) and moderate (Glass'Δ: -1.41; 95%CI (-2.26 to -0.54)) catastrophizing and a low effect in severe catastrophizing (Glass'Δ: -0.25; 95%CI (-1.40 to -1.80)).

Discussion

This randomized controlled trial aimed to evaluate the efficacy of multidimensional physiotherapy compared to usual physiotherapy in people with NSCLBP. The results provided evidence that multidimensional physiotherapy improves pain in people with NSCLBP. The effect on pain was of clinical importance [50] (large effect size and three points of improvement in pain) and lasted for medium-term follow-up.

Primary outcome: pain

The results showed that both physiotherapy treatments improved the pain intensity in individuals with NSCLBP. The multidimensional physiotherapy was not more effective than usual physiotherapy at the end of the six-week treatment but the effects emerged during the follow-up period. We found a meaningful, large, and acceptable power effect on pain reduction in the experimental group. Moreover, the number needed to treat (NNT) was three, which means three participants would need to be treated with multidimensional physiotherapy instead of usual physiotherapy for one of them to benefit from reduced pain (large effect). Potential hypotheses for this result could be the biopsychosocial content of multidimensional physiotherapy, which affects modifiable psychological dimensions of pain rather than focusing specifically on signs and symptoms associated with the NSCLBP [51–53]. The psychoeducation about chronic pain revealed the role of beliefs, emotions, and behavior in coping strategies with NSCLBP. In multidimensional physiotherapy, there was a clear focus on self-management of NSCLBP to enable patients to develop an adaptive response pattern and deal with pain in daily life. People with chronic pain have a selective attentional bias toward their pain, and the difficulty to disengage from it can be driven by pain-related cognitions and emotions. When a physiotherapist provides psychoeducation, graded activity, and lifestyle modifications, participants better learn to put pain into proper perspective, feel empowered to control their pain, and be physically active [48, 51–55]. It is worth noting that psychoeducation based on the biopsychosocial approach had a sustained improvement in pain reduction in the experimental group over time rather than a substantial improvement in the short term. Although our study results provided valuable insights into the efficacy of multidimensional physiotherapy, it's crucial to exercise prudence when generalizing the results. It's important to acknowledge the constraint of the limited sample size in this study. Consequently, future research should address this limitation and provide a more holistic comprehension of the subject matter.

The significant pain improvement obtained in the present study for multidimensional physiotherapy was consistent with that reported in previous systematic reviews [16]. There have been studies on physiotherapy-based treatments with behavioral and cognitive components. Classification Based-Cognitive Functional Therapy (CB-CFT) is an example. CB-CFT provides individualized, pathoanatomical, neurophysiological, psychosocial, physical, and lifestyle treatment for low back pain [56]. O'Keeffe M et al. found no significant between-group differences in pain intensity at either six months or 12 months of CFT treatment compared with the

Table 3 Primary and secondary outcomes of the participants with NSCLBP (N=70)[a]

Characteristic	Experimental group (n = 35)	Active control group (n = 35)	Main effect of time	Interaction effect	Post hoc test	
	mean (SD)	mean (SD)	P value	P value	Time	Group
Pain as a Primary Outcome						
NRS Score (10)						
Baseline	5.03 (0.92)	5.09 (0.95)	< 0.001	< 0.001	Baseline > 6, 10, 22w (p < 0.001 [e, c])	10w (p = 0.00)
6W	1.86 (1.65)	2.43 (1.85)				22W (p < 0.001)
10W	1.74 (1.74)	3.29 (2.01)				
22W	1.66 (2.00)	3.86 (2.35)				
Secondary Outcomes Measures						
ODI Score (60)						
Baseline	28.69 (8.57)	28.46 (8.51)	< 0.001	0.08	Baseline > 6, 10, 22w (p < 0.001 [e, c])	NA
6W	15.97 (9.17)	16.06 (10.87)				
10W	15.69 (10.10)	17.49 (10.27)				
22W	15.37 (11.12)	19.77 (12.07)				
TSK Score (68)						
Baseline	41.74 (4.57)	40.97 (4.85)	< 0.001	0.01	Baseline > 6, 10, 22 w (p < 0.001 [e]) Baseline > 6w 22w > 10w (p < 0.001 [c])	22w (p = 0.03)
6W	35.80 (7.62)	34.63 (6.53)				
10W	36.86 (7.46)	38.60 (6.71)				
22W	36.26 (8.70)	39.83 (7.81)				
PCS Score (52)						
Baseline	27.11 (6.68)	29.60 (8.80)	< 0.001	0.47	Baseline > 6w (p < 0.001 [e]) Baseline > 10w (p = 0.00 [e]) Baseline > 22w (p = 0.01 [e]) Baseline > 6w (p = 0.00 [c])	NA
6W	23.23 (6.35)	26.66 (8.12)				
10W	24.26 (7.12)	27.43 (7.71)				
22W	24.46 (7.62)	28.74 (8.46)				
Secondary Outcomes Measures						
SF36 Score (400)						
Baseline	58.29 (16.28)	59.26 (17.40)	< 0.001	< 0.001	Baseline < 6, 10, 22w (p < 0.001 [e]) Baseline < 6w (p = 0.00 [c]) Baseline < 10w (p = 0.01 [c])	22w (p = 0.03)
6W	66.84 (15.83)	64.71 (18.53)				
10W	68.08 (15.58)	63.84 (16.57				
22W	68.90 (15.78)	60.43 (18.07)				
FABQ Score (96)						
Baseline	40.71 (9.47)	37.74 (17.83)	< 0.001	0.02	Baseline > 6,10, 22w (p < 0.001 [e]) Baseline > 6w (p < 0.001 [c]) 10w > 6w (p = 0.03 [c]) 22w > 6w (p < 0.001 [c])	NA
6W	32.77 (12.75)	29.94 (15.76)				
10W	32.91 (13.56)	34.91 (14.95)				
22W	33.49 (17.47)	37.49 (16.03)				
Flexion ROM (cm)						

Table 3 (continued)

Characteristic	Experimental group (n = 35)	Active control group (n = 35)	Main effect of time	Interaction effect	Post hoc test	
	mean (SD)	mean (SD)	P value	P value	Time	Group
Baseline	15.54 (11.42)	16.74 (12.14)	< 0.001	0.43	Baseline > 6, 10w (p = 0.00[e])	NA
6W	11.94 (10.77)	12.34 (10.42)			Baseline > 22w (p < 0.001[e])	
10W	11.69 (10.63)	12.54 (10.71)			Baseline > 6, 10w (p = 0.00[c])	
22W	11.43 (10.57)	13.89 (12.42)			Baseline > 22w (p < 0.001[c])	

Abbreviations: NRS, Numeric Rating Scale; ODI, Oswestry Disability Index; TSK, Tampa Scale for Kinesiophobia; PCS, Total Score of the Pain Catastrophizing Scale; SF36, 36-Item Short-Form Health Survey; FABQ, Fear Avoidance Beliefs Questionnaire; Flexion ROM, Lumbar Active Forward Flexion Range of Motion; w, weak; cm, centimeter

[a] All analyses were performed using mixed model ANOVA/ANCOVA.

[e] Results of Bonferroni post hoc tests in the experimental group

[c] Results of Bonferroni post hoc tests in the experimental group

NA Not Applicable

Table 4 The effect sizes of the primary and secondary outcomes of the participants with NSCLBP (N=70)

characteristic	Effect size	
	Mean difference (95% CI)	Cohen's d (95% CI)
Pain as a Primary Outcome Measure		
NRS Score (10)		
6w	-0.57 (-1.62 to 0.48)	-0.23 (-0.70 to 0.24)
10w	-1.54 (-2.59 to -0.49)	-0.62 (-1.10 to -0.14)
22w	-2.20 (-3.25 to -1.15)	-0.89 (-1.38 to -0.39)
Secondary Outcome Measures		
ODI Score (60)		
6w	-0.09 (-6.19 to 6.02)	-0.01 (-0.47 to 0.46)
10w	-1.8 (-7.90 to 4.30)	-0.12 (-0.59 to 0.34)
22w	-4.4 (-10.50 to 1.70)	-0.31 (-0.78 to 0.17)
TSK Score (68)		
6w	1.17 (-2.98 to 5.33)	0.12 (-0.35 to 0.59)
10w	-1.74 (-5.90 to 2.41)	-0.18 (-0.65 to 0.29)
22w	-3.57 (-7.73 to 0.58)	-0.37 (-0.84 to 0.11)
PCS Score (52)		
6w	-2.49 (-7.08 to 2.11)	-0.32 (-0.79 to 0.16)
10w	-3.43 (-8.03 to 1.17)	-0.29 (-0.76 to 0.18)
22w	-3.17 (-7.77 to 1.43)	-0.40 (-0.87 to 0.08)
SF36 Score (400)		
6w	2.12 (-7.97 to 12.21)	0.09 (-0.38 to 0.57)
10w	4.24 (-5.85 to 14.33)	0.18 (-0.29 to 0.65)
22w	8.47 (-1.62 to 18.56)	0.36 (-0.12 to 0.83)
FABQ Score (96)		
6w	2.83 (-6.16 to 11.82)	0.14 (-0.34 to 0.60)
10w	-2.00 (-10.99 to 6.99)	-0.09 (-0.56 to 0.37)
22w	-4.00 (-12.99 to 4.99)	-0.19 (-0.66 to 0.28)
Flexion ROM (cm)		
6w	-0.40 (-7.11 to 6.31)	-0.03 (-0.49 to 0.44)
10w	-0.86 (-7.56 to 5.85)	-0.05 (-0.52 to 0.41)
22w	-2.46 (-9.16 to 4.25)	-0.16 (-0.62 to 0.31)

Abbreviations: NRS, Numeric Rating Scale; ODI, Oswestry Disability Index; TSK, Tampa Scale for Kinesiophobia; PCS, Total Score of the Pain Catastrophizing Scale; SF36, 36-Item Short-Form Health Survey; FABQ, Fear Avoidance Beliefs Questionnaire; Flexion ROM, Lumbar Active Forward Flexion Range of Motion; w, weak; cm, centimeter

Cohen's d is interpreted as very large (> 1), large (0.80-0.99), medium (0.50-0.79), small (0.20-0.49), and negligible (<0.20)

group-based exercise and education intervention in 206 adults with CLBP [5]. Vibe-Fersum K. et al. found significant between-group differences in pain intensity at 12 months in favor of CFT compared with manual therapy and exercise but no significant between-group differences at three years of follow-up [57, 58].

Secondary outcomes: brain function and pain cognitions

According to studies, there is a general trend toward increased power at EEG frequencies, mainly in theta and alpha frequencies, in different types of chronic pain at rest in various brain regions, including frontal, parietal, occipital, sensorimotor, and somatosensory [31, 59].

Based on the previous research [37, 59], an effective treatment may reduce the power of EEG at different frequency bands. Our findings showed a decrease in alpha frequency relative power in lumbar forward flexion in all electrode locations after treatment, as we expected. This outcome indicates that intervention led to a change in brain function in favor of decreased power, especially in alpha frequency. As far as we know, this is the first randomized controlled trial study to record EEG in lumbar forward flexion. Our data is in contrast with Schmidt et al., who couldn't show any changes in EEG findings after Mindfulness-based Stress Reduction (MBSR) treatment in people with chronic back pain [60]. Wang et al. showed that the overall EEG spectral power after the CBT group was lower than that of the control group, especially in the theta and beta frequency bands during the treatment period[58]. The result of the study didn't show any meaningful differences in the relative power of EEG frequency in active lumbar flexion between both groups.

Regarding other secondary outcomes, the results showed the non-considerable effect of multidimensional physiotherapy (Table 4). Although our hypothesis was greater improvement in pain-related psychological factors, disability and quality of life, and active lumbar flexion in the experimental group, the result didn't show a considerable effect on these outcomes. Multidimensional physiotherapy is no better at reducing fear-avoidance beliefs, kinesiophobia, pain catastrophizing, disability, quality of life, and active lumbar flexion than usual physiotherapy (Additional file 2).

Clinical implications

This exploratory randomized controlled trial showed multidimensional physiotherapy produced greater improvement in pain (large effect size and clinically important result) compared to usual physiotherapy in people with NSCLBP. Providing multidimensional treatment by a trained physiotherapist can be cost-effective and time-effective for patients and healthcare providers. These findings provide crucial information for clinical

decision-making, optimization of health care services, and a basis for future research.

Limitations

This study has some limitations. First, because of the exploratory content of the study, the sample size consisted mainly of people aged between 18 and 50 years with moderate pain, moderate to severe disability ($20 < ODI < 60$), and also $TSK \geq 37$, which indicates there is kinesiophobia. Therefore, our results may not generalize to adults with NSCLBP over 50 years, people with more severe pain, more or less disability and kinesiophobia, and those with anxiety or depression. Second, because this study included people with NSCLBP, other populations require study to see if these results can be generalized to a broad population with chronic pain. Third, this study was a medium-term follow-up. Future research should be designed by long-term follow-up. Fifth, because of a wide range of CI, our main result of pain was inconclusive; therefore, we recommended repeating the study with a large sample size.

Abbreviations

NSCLBP	Non-specific chronic low back pain
NRS	Numeric Rating Scale
CNS	Central nervous system
EEG	Electroencephalography
ROM	Range of Motion
ODI	Oswestry Disability Index
TSK	Tampa Scale for Kinesiophobia
SF-36	36 Health Status Survey
PCS	Pain Catastrophizing Scale
FABQ	Fear Avoidance Beliefs Questionnaire
CBT	Cognitive behavioral therapy
MBR	Multidisciplinary biopsychosocial rehabilitation
CI	Confidence Interval
SD	Standard Deviation

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s42358-023-00329-9.

Supplementary Material 1

Supplementary Material 2

Supplementary Material 3

Supplementary Material 4

Declarations

Ethics approval and consent to participate
This study was approved by the ethical committee of the Iran University of Medical Sciences (IUMS) approved this study (IR.IUMS.REC.1398.1041) and all participants gave their informed consent before participation.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

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