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Original Article

Effect of Diaphragmatic Breathing Exercises on Stress, Pain Perception, and Functional Mobility in Chronic Low Back Pain

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ABSTRACT

Background: Chronic low back pain (CLBP) is perpetuated by elevated stress, maladaptive breathing patterns, and reduced functional mobility; however, the independent efficacy of diaphragmatic breathing exercises remains insufficiently examined in outpatient settings. Objective: To determine the effect of a 6-week diaphragmatic breathing exercise program on pain, perceived stress, and functional mobility in patients with chronic non-specific low back pain compared with routine care. Methods: Assessor-blinded, two-arm randomized controlled trial conducted in physiotherapy outpatient departments in Faisalabad, Pakistan. Seventy adults with CLBP ≥12 weeks were randomized to breathing exercises (twice-weekly supervised plus daily home practice) or control (routine advice). Primary outcome was pain intensity (VAS 0–10); secondary outcomes included perceived stress (PSS-10), Timed Up and Go test, respiratory rate, lumbar flexion ROM, and sleep quality, assessed at baseline and 6 weeks. Between-group differences were analyzed using ANCOVA adjusted for baseline values. Results: The breathing group achieved significantly greater reductions in pain (−2.8 vs −0.5 VAS points; mean difference −2.3, 95% CI −2.9 to −1.7), perceived stress (−7.2 vs −1.2 PSS points; mean difference −6.0, 95% CI −8.1 to −3.9), and TUG time (−2.8 vs −0.6 s; $p < 0.001$ for all). Allocation to breathing exercises independently predicted lower post-treatment stress ($\beta = -5.68$, $p < 0.001$). Conclusion: A structured 6-week diaphragmatic breathing program is an effective, low-cost adjunct therapy for reducing pain, stress, and functional limitations in chronic low back pain. Keywords: chronic low back pain, diaphragmatic breathing, perceived stress, functional mobility, randomized controlled trial

INTRODUCTION

Chronic low back pain (CLBP) affects up to 84% of adults at some point in their lives and remains the leading cause of years lived with disability worldwide (1). Beyond nociceptive input, CLBP is strongly modulated by psychological stress, central sensitization, and maladaptive breathing patterns that perpetuate muscle guarding, reduced diaphragmatic excursion, and impaired core stability (2,3). Elevated perceived stress correlates with higher pain intensity, poorer functional mobility, and sleep disturbance in CLBP cohorts (4), while hyperventilation and apical breathing increase paraspinal muscle tone and intradiscal pressure (5). Diaphragmatic breathing exercises restore parasympathetic dominance, reduce respiratory rate, normalize end-tidal CO_2, and decrease pain perception through descending inhibitory pathways and reduced sympathetic arousal (6,7). Several randomized trials have

demonstrated moderate pain reduction and improved function with diaphragmatic breathing as an adjunct in CLBP (8–10); however, most studies were limited by short intervention duration, lack of supervised sessions, inadequate blinding, or failure to control for baseline stress and respiratory parameters. Moreover, the independent contribution of breathing exercises to stress reduction after adjusting for pain improvement and demographic confounders remains underexplored. Therefore, a knowledge gap persists regarding the specific efficacy of a structured, partially supervised 6-week diaphragmatic breathing program on perceived stress, pain perception, and functional mobility in patients with non-specific CLBP in a developing-country outpatient setting. The present two-group randomized controlled trial was conducted to determine whether adding diaphragmatic breathing exercises to routine care yields superior outcomes compared with routine care alone in adults with CLBP of at least 12 weeks' duration.

The specific objective was to evaluate the effect of a 6-week diaphragmatic breathing exercise program on pain intensity (primary outcome), perceived stress, functional mobility, lumbar flexion range of motion, respiratory rate, heart rate, and sleep quality compared with a control group receiving only routine physiotherapy advice. We hypothesized that the breathing exercise group would demonstrate significantly greater improvements across all outcomes at 6 weeks.

MATERIALS AND METHODS

A two-arm, parallel-group, assessor-blinded randomized controlled trial was conducted between March 2023 and February 2024 in the physiotherapy outpatient departments of three tertiary-care hospitals in Faisalabad, Pakistan. Adults aged 25–60 years with non-specific chronic low back pain (duration ≥12 weeks) and average pain intensity ≥4/10 on the visual analogue scale (VAS) in the preceding week were eligible. Exclusion criteria comprised red flags suggestive of serious spinal pathology, radiculopathy below the knee, spinal surgery within the preceding year, pregnancy, diagnosed respiratory or psychiatric disorders, regular practice of yoga or mindfulness in the past six months, and inability to comprehend Urdu instructions. Consecutive eligible patients attending the clinics were screened by an independent physiotherapist; those meeting criteria were informed about the study and provided written informed consent prior to enrolment.

After baseline assessment, participants were randomized in a 1:1 ratio using computer-generated random sequences in permuted blocks of four, stratified by sex and baseline pain severity (VAS <7 vs ≥7). Allocation was concealed using sequentially numbered opaque sealed envelopes opened by a research assistant not involved in assessments. Participants in the breathing exercise group received two supervised 30-minute sessions per week for six weeks plus a daily home program (10–15 minutes twice daily) of standardized diaphragmatic breathing in crook-lying and sitting positions, paced at 6–8 breaths per minute using audio guidance. The control group received routine care consisting of written advice on posture, activity modification, and simple stretching without breathing instruction. Both groups continued any prescribed analgesics.

All outcomes were assessed at baseline and immediately after the 6-week intervention by a blinded assessor. Pain intensity over the past week was measured using a 0–10 VAS. Perceived stress was quantified with the validated Urdu version of the 10-item Perceived Stress Scale (PSS-10; score 0–40). Functional mobility was evaluated using the Timed Up and Go (TUG) test. Secondary outcomes included resting respiratory rate and heart rate (measured over one minute in sitting), active lumbar flexion range of motion using the modified Schober method, and self-reported sleep quality over the past week (0–10 numerical scale). Intra-rater reliability for range-of-motion and timing measures exceeded ICC 0.91 in a pilot subsample.

To minimize performance bias, supervised sessions were delivered by a single trained physiotherapist following a standardized script. Detection bias was addressed through assessor blinding and use of objective timing devices. Missing data were handled by multiple imputation using chained equations if

>5%; otherwise, available-case analysis was planned. Sample size was calculated to detect a between-group difference of 1.5 points on VAS pain (SD 2.0, $\alpha = 0.05$, power 90%, 20% attrition), yielding 35 participants per group. Data were analyzed using SPSS version 27 according to intention-to-treat principles. Between-group differences in change scores were examined using analysis of covariance (ANCOVA) adjusted for baseline values. Effect sizes were reported as mean differences with 95% confidence intervals. Pearson correlation and multiple linear regression (enter method) were performed to explore relationships and independent predictors of post-treatment stress. Assumptions of normality, linearity, and homoscedasticity were verified; $p < 0.05$ was considered significant. The study was approved by the Institutional Review Board of Government College University Faisalabad (Ref: GCUF/ERB/2023/112) and prospectively registered (ClinicalTrials.gov NCT06234540). All procedures followed the Declaration of Helsinki.

RESULTS

Seventy participants were randomized (35 per group); all completed the 6-week assessment with no loss to follow-up and <2% missing data across variables, precluding the need for imputation.

Table 1. Baseline Characteristics of Breathing Exercise vs Control Groups

Variable	Breathing Exercise (n = 35)	Control (n = 35)	Total (n = 70)	p-value
Age (years), mean ± SD	42.6 ± 9.8	43.2 ± 10.4	42.9 ± 10.1	0.792
Sex, n (%) Male / Female	18 (51.4%) / 17 (48.6%)	16 (45.7%) / 19 (54.3%)	34 (48.6%) / 36 (51.4%)	0.818
BMI (kg/m²), mean ± SD	27.4 ± 4.2	28.1 ± 4.6	27.8 ± 4.4	0.512
Duration of LBP (weeks), mean ± SD	28.4 ± 14.6	26.8 ± 13.9	27.6 ± 14.2	0.678
Baseline pain (VAS 0–10), mean ± SD	6.2 ± 1.4	6.1 ± 1.5	6.2 ± 1.4	0.756
Baseline stress score (PSS 0–40), mean ± SD	25.8 ± 5.6	25.4 ± 5.9	25.6 ± 5.7	0.768
Baseline TUG time (sec), mean ± SD	12.6 ± 2.8	12.8 ± 3.1	12.7 ± 2.9	0.792
Baseline respiratory rate (breaths/min)	18.4 ± 2.2	18.6 ± 2.4	18.5 ± 2.3	0.712
Baseline lumbar flexion ROM (°), mean ± SD	42.8 ± 8.6	41.9 ± 9.2	42.4 ± 8.9	0.678
Baseline sleep quality score (0–10), mean ± SD	5.2 ± 1.6	5.1 ± 1.8	5.2 ± 1.7	0.812

Table 2. Pre- and Post-Intervention Outcomes (6 weeks)

Outcome Variable	Breathing Pre	Breathing Post	Control Pre	Control Post	Δ Difference (95% CI)	p-value*
Pain (VAS 0–10)	6.2 ± 1.4	3.4 ± 1.1	6.1 ± 1.5	5.6 ± 1.4	−2.3 (−2.9 to −1.7)	<0.001
Stress score (PSS 0–40)	25.8 ± 5.6	18.6 ± 4.8	25.4 ± 5.9	24.2 ± 5.6	−6.0 (−8.1 to −3.9)	<0.001
TUG time (seconds)	12.6 ± 2.8	9.8 ± 2.2	12.8 ± 3.1	12.2 ± 2.9	−2.2 (−3.3 to −1.1)	<0.001
Respiratory rate (breaths/min)	18.4 ± 2.2	14.2 ± 1.8	18.6 ± 2.4	18.1 ± 2.3	−3.7 (−4.6 to −2.8)	<0.001
Heart rate (bpm)	82 ± 8	74 ± 7	84 ± 9	82 ± 8	−6 (−9 to −3)	<0.001
Lumbar flexion ROM (°)	42.8 ± 8.6	52.4 ± 7.8	41.9 ± 9.2	43.6 ± 8.9	+7.9 (4.8 to 11.0)	<0.001
Sleep quality score (0–10)	5.2 ± 1.6	7.8 ± 1.2	5.1 ± 1.8	5.4 ± 1.7	+2.3 (1.7 to 2.9)	<0.001

*p-value for between-group difference in change (ANCOVA adjusted for baseline)

Table 3. Correlation Matrix Between Key Post-Treatment Outcomes (n = 70)

Variables	Pain	Stress	TUG	Respiratory Rate	ROM	Sleep Quality
Pain (VAS)	1	0.68***	0.62***	0.58***	−0.64***	−0.66***
Stress Score (PSS)	0.68***	1	0.58***	0.64***	−0.60***	−0.70***
TUG (sec)	0.62***	0.58***	1	0.52***	−0.68***	−0.56***
Respiratory Rate	0.58***	0.64***	0.52***	1	−0.54***	−0.60***
Lumbar Flexion ROM	−0.64***	−0.60***	−0.68***	−0.54***	1	0.62***
Sleep Quality Score	−0.66***	−0.70***	−0.56***	−0.60***	0.62***	1

***$p < 0.001$

Table 4. Multiple Linear Regression Predicting Post-Treatment Stress Score

Predictor Variable	β Coefficient	SE	t-value	p-value	95% CI
Group (Breathing = 1, Control = 0)	−5.68	0.88	−6.45	<0.001	−7.44 to −3.92
Baseline stress score	0.52	0.09	5.78	<0.001	0.34 to 0.70

Predictor Variable	β Coefficient	SE	t-value	p-value	95% CI
Pain reduction (Pre–Post Δ VAS)	1.42	0.38	3.74	<0.001	0.66 to 2.18
Change in respiratory rate (Pre–Post)	0.88	0.26	3.38	0.001	0.36 to 1.40
Age (years)	0.06	0.06	1.00	0.321	−0.06 to 0.18
Sex (Female = 1)	1.12	0.92	1.22	0.227	−0.72 to 2.96
BMI (kg/m²)	0.18	0.12	1.50	0.139	−0.06 to 0.42
Duration of LBP (weeks)	0.04	0.04	1.00	0.321	−0.04 to 0.12
Occupation (Manual labor = 1)	1.48	1.08	1.37	0.176	−0.68 to 3.64
Constant	8.42	3.68	2.29	0.025	1.06 to 15.78

$R^2 = 0.72$; Adjusted $R^2 = 0.68$; $F = 18.6$, $p < 0.001$

The two groups were well matched at baseline with no significant differences in demographic or clinical characteristics (Table 1; all $p > 0.5$). After six weeks, the breathing exercise group exhibited markedly greater improvements across all outcomes (Table 2). Mean pain intensity decreased by 2.8 points on VAS in the intervention group versus only 0.5 points in controls (mean difference −2.3, 95% CI −2.9 to −1.7; $p < 0.001$). Perceived stress declined by 7.2 points on PSS in the breathing group compared with 1.2 points in controls (mean difference −6.0, 95% CI −8.1 to −3.9; $p < 0.001$). Functional mobility improved substantially, with TUG time reducing by 2.8 seconds versus 0.6 seconds (mean difference −2.2 s, 95% CI −3.3 to −1.1; $p < 0.001$). Respiratory rate normalized by an additional 3.7 breaths/min, heart rate by 6 bpm, lumbar flexion increased by 9.6° versus 1.7°, and sleep quality score rose by 2.6 versus 0.3 points—all highly significant between-group differences ($p < 0.001$). Post-treatment outcomes displayed moderate-to-strong inter-correlations ($r = 0.52–0.70$, all $p < 0.001$; Table 3), indicating shared physiological and psychological pathways. Multiple regression revealed that allocation to the breathing exercise group was the strongest independent predictor of lower post-treatment stress ($\beta = −5.68$, $p < 0.001$), even after adjusting for baseline stress, pain reduction, and respiratory rate change, explaining 72% of variance in final stress scores (Table 4).

DISCUSSION

The present trial demonstrates that a structured 6-week diaphragmatic breathing program, delivered with partial supervision, produces clinically meaningful reductions in pain, perceived stress, and functional limitations in patients with chronic low back pain, outperforming routine care alone. The observed 2.8-point VAS reduction exceeds the minimal clinically important difference of 2.0 points commonly cited for CLBP (11) and aligns with recent meta-analyses reporting standardized mean differences of 0.6–1.1 for mind–body interventions (12,13). The pronounced stress reduction (−7.2 PSS points) is particularly noteworthy, surpassing effects seen in pharmacological and many psychological interventions for CLBP (14), and remained significant after controlling for pain improvement, supporting direct central effects via vagal stimulation and reduced amygdala reactivity (15). Improvements in respiratory rate and heart rate confirm successful autonomic rebalancing, consistent with mechanistic studies showing diaphragmatic breathing restores baroreflex sensitivity and high-frequency heart-rate variability within weeks (16). Enhanced lumbar mobility and TUG performance likely reflect reduced paraspinal guarding secondary to lower sympathetic tone and improved core coordination (17). Strong inter-correlations among outcomes reinforce the biopsychosocial model of CLBP, where stress and maladaptive breathing perpetuate a vicious cycle that breathing retraining effectively interrupts (18). The regression findings underscore breathing exercises as an independent therapeutic target beyond mere pain relief. Strengths include concealed allocation, assessor blinding, complete follow-up, and adjustment for baseline values; limitations comprise absence of long-term follow-up, self-reported adherence monitoring, and generalizability restricted to outpatient settings in Pakistan. Future trials should incorporate objective adherence measures, longer-term outcomes, and cost-effectiveness analysis.

CONCLUSION

A 6-week diaphragmatic breathing exercise program, combining supervised and home practice, significantly reduces pain intensity, perceived stress, and functional disability while improving physiological and sleep parameters in adults with chronic low back pain, with effects independent of baseline pain reduction. These findings support integration of diaphragmatic breathing as a safe, low-cost, evidence-based adjunct in routine CLBP management.

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