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Review Article

Effects of breathing exercises on chronic low back pain: A systematic review and meta-analysis of randomized controlled trials

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Abstract.
BACKGROUND: A range of studies concerning the effects of breathing exercises on chronic low back pain (CLBP) have been proven inconclusive.
OBJECTIVE: The study aimed to evaluate the effectiveness of breathing exercises for the treatment of CLBP.
METHODS: We considered randomized controlled trials in English or Chinese that used breathing exercises for the treatment of CLBP. An electronic search was performed in the MEDLINE, EMBASE, Web of Science, Cochrane Library, CNKI, Wan Fang, and CBM databases for articles published up to November 2022. Two reviewers independently screened the articles, assessed the risk of bias using the Cochrane risk of bias tool, and extracted the data. The outcomes included pain, lumbar function and pulmonary function post-intervention.
RESULTS: A total of thirteen studies ($n = 677$) satisfied the inclusion criteria. The meta-analysis results demonstrated a significant effect of breathing exercises on the Visual Analog Scale (VAS) score (SMD $= -0.84$, 95% CI: -1.24 to -0.45, $P < 0.0001$), the Oswestry Disability Index (ODI) score (SMD $= -0.74$, 95% CI: -0.95 to -0.54, $P < 0.00001$), Forced Vital Capacity (FVC) score (MD $= 0.24$, 95% CI: 0.10 to 0.37, $P = 0.0006$), Forced Expiratory Volume in 1 second /Forced Vital Capacity (FEV1/FVC) (MD $= 1.90$, 95% CI: 0.73 to 3.07, $P = 0.001$), although there was no significant difference between the breathing exercises and control interventions for Forced Expiratory Volume in the first second (FEV1) score (MD $= 0.22$, 95% CI $= [0.00, 0.43]$, $P = 0.05$), and Maximal Voluntary Ventilation (MVV) score (MD $= 8.22$, 95% CI $= [-4.02, 20.45]$, $P = 0.19$).
CONCLUSION: Breathing exercises can reduce pain, assist people with lumbar disabilities, and improve pulmonary function, and could be considered as a potential alternative treatment for CLBP.

Keywords: Low back pain, respiratory exercise, exercise therapy, pulmonary function, meta-analysis

1. Introduction

Low back pain (LBP) is clinically defined as pain, muscle tension, or stiffness localized below the costal margin and above the inferior gluteal folds, with or without leg pain [1]. Chronic low back pain (CLBP) is characterized as experiencing LBP for more than 12 weeks [2]. It causes pain and functional impairment and has in recent years, been the leading cause of disability across the globe [3,4]. The lifetime prevalence of LBP is approximately 80% while the prevalence of CLBP is in the region of 23% [5] with more than half

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a billion people suffering from CLBP globally [6]. As global incidents of CLBP have escalated, it has impacted its sufferers physically and psychologically; additionally, it has placed overwhelming financial strain on economies around the world, due to the expense of medical treatment and widespread absenteeism from work in all socio-economic areas [7,8].

Currently, there is no well-defined, established paradigm for the treatment and management of CLBP. Although patients with CLBP are frequently managed with pharmacological therapy, a lack of efficacy combined with adverse events can result in unresolved complications [9]. Nonpharmacologic therapies, including exercise and psychosocial management, are the preferred approach for the majority of patients and may be supplemented with adjunctive drug therapies [10–12]. According to clinical practice guidelines, the implementation of exercise therapy is advocated as a primary treatment as it performs a fundamental role in pain reduction and developing improved levels of mobility and function [13,14]. Clinical observations have noted that breathing exercises are crucial to the treatment and prevention of CLBP [15–17]. Breathing exercises support muscle activation which strengthens core muscles; greatly improves spinal stabilization via the co-contracting of deep muscles such as the internal oblique abdominals, multifidus, and pelvic floor muscles; and significantly increases muscle thickness (in contraction); and improves contraction rates [18,19]. Additionally, breathing exercises modify the patient's pulmonary function by improving their forced vital capacity alongside other oxygenation and blood volume indicators, allowing for the development of enhanced breathing patterns and improving lumbar pain and function [20]. A combination of these physical factors creates a scenario whereby a patient will experience reduced levels of anxiety concerning their motor performance and improvements in their mental well-being [21].

While some studies have demonstrated the potential benefits of breathing exercises for the treatment of CLBP, it remains whether breathing exercises are more effective than the current rehabilitation therapy paradigm [22]. Therefore, this systematic review and meta-analysis intend to quantitatively analyze clinical studies concerning the implementation of breathing exercises for the treatment of CLBP as it relates to the symptoms (pain, lumbar function, and pulmonary function) and to conduct a direct comparison between breathing exercises and the current routine rehabilitation exercises.

2. Methods

This systematic review was performed in accordance with the preferred reporting items for systematic reviews and meta-analyses (PRISMA) and was registered in the PROSPERO database under identification number CRD42022380578.

2.1. Search strategy

We searched for articles in PubMed, EMBASE, Web of Science, Cochrane, CNKI, Wan Fang, and the CBM databases from their inception to November 2022. The following Medical Subject Headings (MeSH) terms and keywords were used as the primary search terms: breathing exercise, respiratory exercise, expiratory training, respiratory muscle training, LBP, back pain, and CLBP. Reference lists of the relevant studies and reviews were manually screened to ascertain the existence of additional studies that were suitable for inclusion. The Appendix provides an example of PubMed's search strategy.

2.2. Inclusion and exclusion criteria

Studies were eligible if they met the following criteria: (1) used the randomized controlled trial (RCT) design; (2) included participants diagnosed with CLBP (18 years of age or older), regardless of gender, social factors, or the clinical setting; (3) compared breathing exercises with the placebo (sham tape) or routine rehabilitation intervention (e.g., physical therapy, exercise therapy, spinal stabilization); (4) the study included at least one of the following outcome assessments: pain, pulmonary function, or lumbar function; and (5) where chronic pain was defined as lasting more than 12 weeks.

Studies were excluded if any of the following criteria were met: (1) studies were crossover trials, quasi-RCTs, case reports, animal experiments, conference abstracts, and review articles; (2) studies with unavailable data or low-quality; (3) included patients with LBP caused by pathological changes such as tumours, spinal infections, ankylosing spondylitis, spondylolisthesis, or any extensive neurological disorder.

2.3. Literature screening and data extraction

After the titles and abstracts from the search results on the electronic databases were browsed, the full texts of all potentially eligible studies were downloaded and analyzed. Relevant data, including the title, first author,

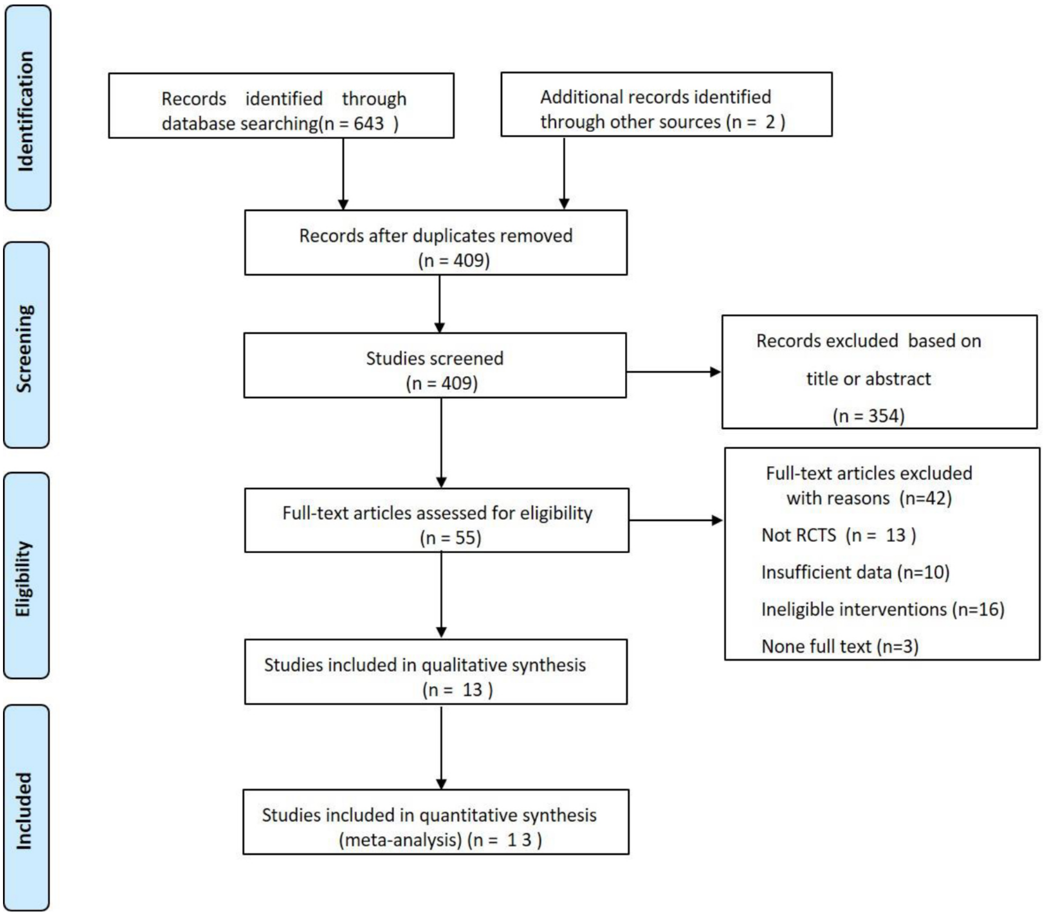

Fig. 1. Flowchart of search strategy and study selection.

publication year, details of participants (size in each group, baseline characteristics), details of the study (study design; Randomization methods), interventions for each group (details of breathing exercises used), measurements of primary and secondary outcomes, statistical methods, exit conditions and reasons, information was independently extracted and confirmed by the independent researchers using standardized data extraction tables according to inclusion criteria. A research team obtained information from the included studies, and disagreements among the reviewers were resolved through discussion.

2.4. Quality assessment

The quality of all included studies in this review was independently evaluated by the research team by using the Cochrane collaboration tool of risk of bias. Studies included low, unclear or high risk of bias in the following domains: random sequence generation, allocation concealment, blinding of participants, blinding of outcome assessment, incomplete outcome data, selective reporting and other sources of bias. Each study was independently assessed by the research team, and any discrepancies were resolved through discussion.

2.5. Statistical analysis

Statistical analyses were performed using Cochrane Review Manager 5.3 and Comprehensive Meta-Analysis. Continuous data will use the weighted mean difference (MD) or standardized mean difference (SMD), while the corresponding 95% confidence interval (CI) will be reported. Heterogeneity among the studies was evaluated using the I^2 statistic and the χ^2 test. The fixed effects model was employed when the heterogeneity test did not reveal any statistical significance ($I^2 \leqslant 50\%$, $P > 0.05$). If a significant degree of statistical heterogeneity was seen ($I^2 > 50\%$, $P < 0.05$), then the random effect model was employed for

Table 1
Summary of included studies

Author (year)	Country	Group (n): age (mean ± SD)	Male/ Female	Description of intervention: Intervention group	Description of intervention: Control group	Duration	Outcome measurements
Ahmadnezhad, 2020 [19]	Iran	E(23)21.43 ± 2.16 C(24)22.33 ± 1.41	11/12 12/12	Breathing exercise + Strength Training	Strength Training	8 ws, 2t/d, 7x/wk	FVC, FEV1, VAS,
Park, 2020 [20]	Korea	E(20)39.5 ± 9.43 C1(20)43.42 ± 9.92 C2(19)40.20 ± 9.17	20 20 19	Breathing exercise + Lumbar stabilization exercise	Lumbar stabilization exercise	6 ws, 10-min sessions, 5x/wk	FVC, FEV1
Borujeni, 2020 [18]	Iran	E(24) 20.14 ± 1.34 /22.34 ± 1.67 C(24)21.65 ± 1.25 /22.20 ± 1.64	11/13 12/12	Breathing exercise + Strength Training	Strength Training	8 ws, 2t/d, 7x/wk	VAS
Park, 2019 [21]	South Korea	E(20)30.9 ± 4.53 C(23)30.70 ± 6.32	12/8 12/11	Breathing exercise + lumbar stabilization exercises	lumbar stabilization exercises	4 ws, 40-min sessions, 3x/wk	FVC, FEV1, FEV1/FVC, MVV, ODI
Mehling, 2005 [23]	USA	E(16)49.7 ± 12.1 C(12)48.7 ± 12.5	5/11 5/7	Breathing exercise + physical therapy	physical therapy	6 ws 45-min sessions, 12t/6ws	VAS
Oh, 2020 [16]	South Korea	E(22)46.14 ± 2.59 C(22)44.45 ± 2.54	0/22 0/22	Breathing exercise + lumbar stabilization exercises	lumbar stabilization exercises	4 ws, 50-min Sessions, 3x/wk	FVC, FEV1, FEV1/FVC, MVV, VAS, ODI
Kang, 2016 [24]	Korea	E(10)42.5 ± 5.3 C(10)40.1 ± 5.3	10/0 10/0	Breathing exercise + spinal stabilization exercise	spinal stabilization exercise	6 ws. 20-min sessions, 5x/wk	ODI
Zhang, 2019 [25]	China	E(33)39.43 ± 3.65 C(33)40.18 ± 4.01	18/15 20/13	Breathing exercise + core strength training	core strength training	4 ws, 10 to 30-min sessions, 5x/wk	VAS
Fan, 2018 [26]	China	E(30)40.87 ± 9.56 C(30)38.53 ± 11.19	17/13 15/15	Breathing exercise + core strength training	core strength training	4 ws, 10 to 30-min sessions, 5x/wk	VAS, ODI
Fei, 2018 [27]	China	E(13)25.78 ± 5.39 C(14)25.69 ± 4.44	5/8 5/9	Breathing exercise + sling exercise training	sling exercise training	8 ws, 30 to 55-min sessions, 3x/wk	VAS, ODI
Yang, 2020 [28]	China	E(42)28.26 ± 6.60 C(42)27.18 ± 7.79	27/15 24/18	Breathing exercise + Postural control training	Postural control training	6 ms, 3x/wk	VAS, ODI
Zhang, 2021 [29]	China	E(40)67.22 ± 6.67 C(40)67.87 ± 6.03	25/15 23/17	Breathing exercise + core strength training	Core strength training	3 ms, 15-min sessions, 4x/wk	VAS, ODI
Liu, 2022 [30]	China	E(24)40.1 ± 9.3 C1(23)42.5 ± 11.6 C2(23)39.8 ± 10.6	10/14 12/11 11/12	Breathing exercise + core strength training	Core strength training	6 ws, 2t/d, 5x/wk	VAS, ODI

Note: EG: experimental group; CG: control group; FVC: Forced Vital Capacity; FEV1: Forced Expiratory Volume in the first second; FEV1/FVC: Forced Expiratory Volume in the first second /Forced Vital Capacity; MVV: Maximal Voluntary Ventilation VAS: Visual Analog Scale; ODI: Oswestry Disability Index; ws: weeks; ms: months.

merging the results. $P < 0.05$ indicates that the difference between the two groups is significant. The source of heterogeneity was explored by performing the sensitivity analysis method. A potential publication bias was qualitatively evaluated using Egger's test.

3. Results

3.1. Literature selection

The flow diagram of the article screening process is exhibited in Fig. 1. 643 related articles were identified through database searching and 2 additional records were identified through reading the published reviews. After the whole selection process, 13 studies with 807 patients were included in the meta-analysis for statistical comparison.

3.2. Characteristics of included literature

The main features of the included studies are recorded in Table 1. Sixteen studies (from China, the USA, Iran, and Korea) were included in this summary. All of the results were published between 2005 and 2022 and contained the details of a total of 807 participants. The baseline data of the included studies demonstrated no significant difference. Ten studies [20,21,28] chose VAS assessment as the primary method of pain assessment for CLBP patients. Eight studies [20,21,28] elected to use the ODI for lumbar function assessment. Four studies [23–25,27,29,30,33,35] assessed pulmonary function by FEV1; four studies [22–25,32, 33,35] assessed pulmonary function using FVC; three studies assessed pulmonary function by FEV/FVC, and two studies reported pulmonary function with MVV.

3.3. *Quality assessment*

The quality assessment results for the included articles are shown in Fig. 2. Randomization was performed in all the studies, and eight of them detailed the randomization methods [16,19,21,23,26–28,30]. The blinding of participants and personnel was mentioned in two articles [16,19]; two studies reported the blinding of participants and personnel [16,21], and four studies recorded the blinding of outcome assessment [18,19,27,30]. Only one study [26] contained incomplete data as it should have reported dropout reasons and was, therefore, considered to demonstrate high-risk detection bias. The overall risk of bias was assessed as low when considering incomplete outcome data, selective reporting, and other forms of bias.

3.4. *Results of meta-analysis*

3.4.1. *VAS*

Ten studies [16,18,19,23,25–30] reported that VAS was employed to evaluate lumbar pain. The meta-analysis indicated that breathing exercises could significantly improve lumbar pain when compared with the control group (SMD = -0.84, 95% CI = [-1.24, -0.45], $P < 0.0001$). The result indicated a lack of significant heterogeneity ($\chi 2 = 0.30$, $P < 0.00001$, $\mathrm{I}^2 = 77\%$) and the random effects model was applied (Fig. 3).

3.4.2. *ODI*

Eight studies [16,21,24,26–30] reported that ODI was used to evaluate lumbar function. The meta-analysis indicated that breathing exercise could significantly improve lumbar function when compared with the control group (SMD = -0.74, 95% CI = [-0.95, -0.54], $P < 0.00001$). The result indicated no significant heterogeneity ($\chi 2 = 8.59$, $P = 0.28$, $\mathrm{I}^2 = 18\%$) and a fixed-effect model was applied (Fig. 4).

3.4.3. *FEV1*

Four studies [16,19–21] reported that FEV1 was used to evaluate pulmonary function. The meta-analysis indicated that breathing exercises could not significantly improve pulmonary function when compared with the control group (MD = 0.22, 95% CI = [0.00, 0.43], $P =$ 0.05). The result indicated no significant heterogeneity ($\chi 2 = 3.72$, $P = 0.29$, $\mathrm{I}^2 = 19\%$) and a fixed-effect model was applied (Fig. 5).

3.4.4. *FVC*

Four studies [16,19–21] reported that FVC was used to evaluate pulmonary function. The meta-analysis indicated that breathing exercises could significantly improve pulmonary function when compared with the control group (MD = 0.24, 95% CI = [0.10, 0.37], $P =$ 0.0006). The result revealed no significant heterogeneity ($\chi 2 = 5.16$, $P = 0.16$, $\mathrm{I}^2 = 42\%$) and a fixed-effect model was applied (Fig. 6).

3.4.5. *FEV/FVC*

Three studies [16,19,21] reported that FVC/FEV1 was used to evaluate pulmonary function. The meta-analysis indicated that breathing exercises could significantly improve pulmonary function compared with the control group (MD = 1.90, 95% CI = [0.73, 3.07], $P =$ 0.001). The result revealed no significant heterogeneity ($\chi 2 = 0.55$, $P = 0.76$, $\mathrm{I}^2 = 0\%$) and a fixed-effect model was applied (Fig. 7).

3.4.6. *MVV*

Two studies [16,21] reported that the MVV was used to evaluate pulmonary function. The meta-analysis indicated that breathing exercises could not significantly improve pulmonary function when compared with the control group (MD = 8.22, 95% CI = [-4.02, 20.45], $P = 0.19$). The result indicated no significant heterogeneity ($\chi 2 = 0.50$, $P = 0.48$, $\mathrm{I}^2 = 0\%$) and a fixed effects model was applied (Fig. 8).

4. Discussion

CLBP is a complex musculoskeletal disorder characterized by pain, reduced muscle strength, imbalance and motor dysfunction [29]. The primary cause of LBP is lumbar instability and muscle imbalances [3,30]. Additionally, many studies have demonstrated that CLBP patients are susceptible to respiratory diseases and respiratory muscle atrophy, and there may be an association between respiratory function, breathing patterns,

Fig. 2. Plot of the risk of bias of the included studies.

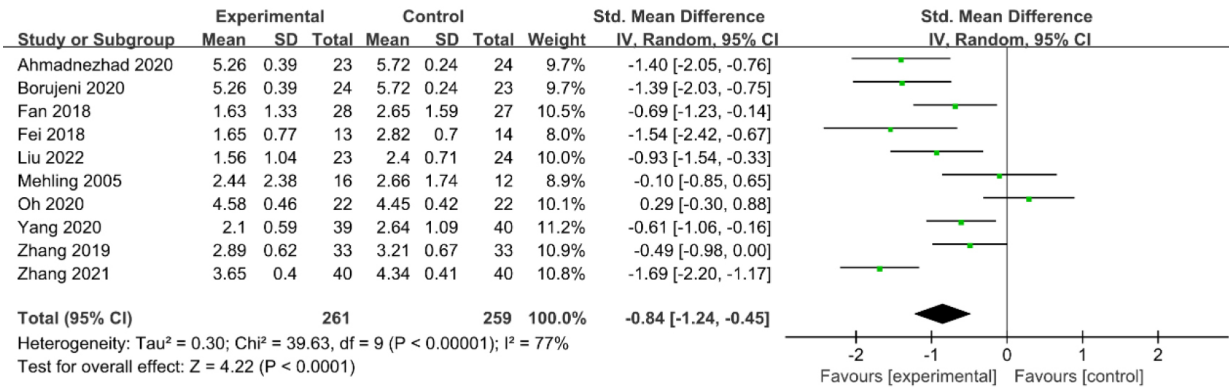

Fig. 3. Forest plot of pain. Abbreviation. VAS, Visual Analog Scale.

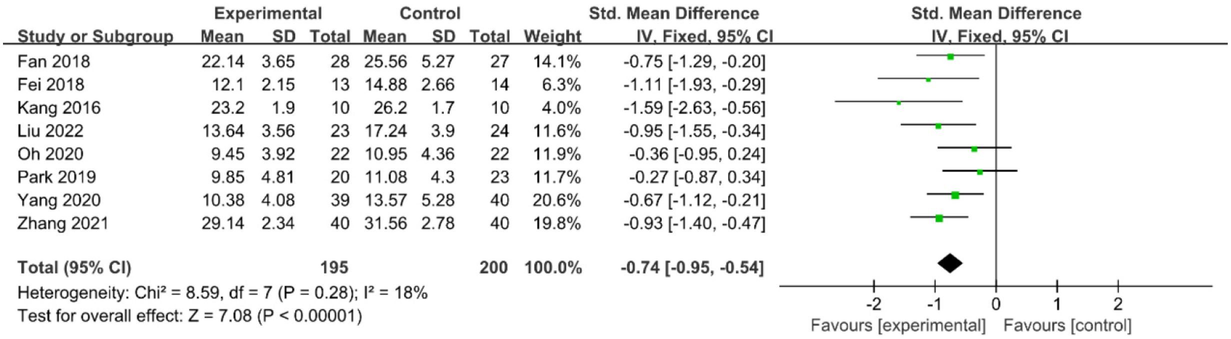

Fig. 4. Forest plot of lumbar function. Abbreviation. ODI, Oswestry Disability Index.

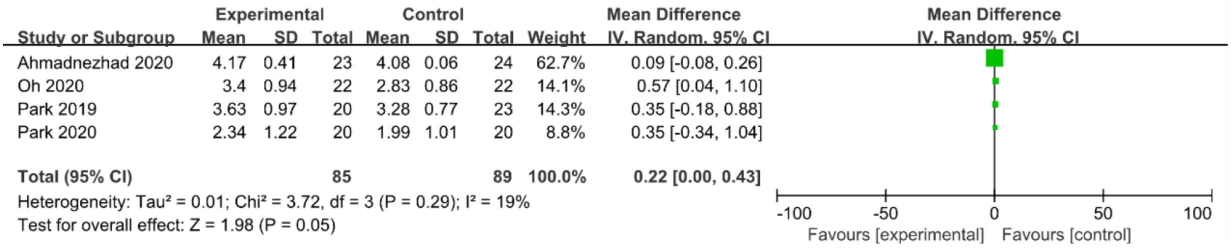

Fig. 5. Forest plot of lung function. Abbreviation. FEV1, Forced Expiratory Volume in the first second.

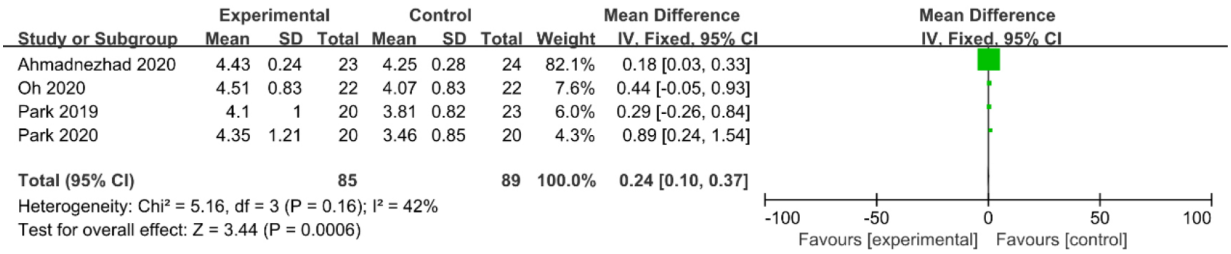

Fig. 6. Forest plot of lung function. Abbreviation. FVC, Forced Vital Capacity.

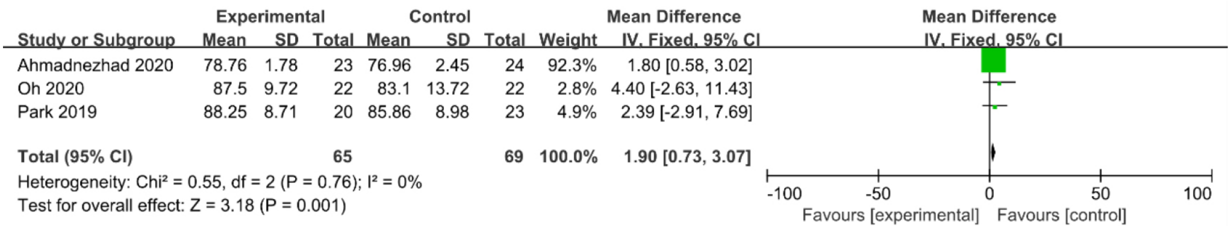

Fig. 7. Forest plot of lung function. Abbreviation. FEV1/FVC, Forced Expiratory Volume in 1 second /Forced Vital Capacity.

core stability, and CLBP [12,31]. Clinical studies have revealed that breathing exercises can enhance respiratory function, reduce pain, and improve low back function in patients experiencing CLBP [27,28]. This study was the first meta-analysis to evaluate the effectiveness and safety of breathing exercises for treating CLBP. Following a comprehensive search of the major academic databases, thirteen studies with 677 participants were involved in this meta-analysis. The results of the meta-analysis conclude that breathing exercises were effective for the treatment of CLBP: in cases involving the use of VAS and ODI, breathing exercises provided improved pain relief and enhanced lumbar function in comparison with the control group. In addition, when

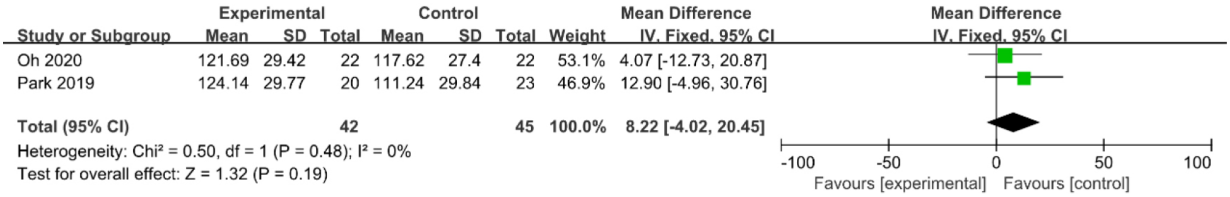

Fig. 8. Forest plot of lung function. Abbreviation. MVV, Maximal Voluntary Ventilation.

examining the indicators of pulmonary function outcomes such as FVC and FEV/FVC, the implementation of breathing exercises improved pulmonary function more effectively than the control group. However, no statistical significance was demonstrated in FEV1 and MVV: these results should be interpreted with care due to the low number of studies available for FEV1 and MVV pulmonary function outcomes ($\leqslant 4$), and this area requires further research to confirm these findings.

The meta-analysis revealed that breathing exercises significantly improved VAS and ODI scores compared to the control group, indicating that breathing exercises are effective for relieving and enhancing low back function in CLBP patients. The underlying mechanisms of breathing exercises for the treatment of CLBP were unclear; however, chronic pain can occur when the muscles of the low back experience instability caused by dysfunction and motor control damage [31]. Studies have revealed that postural control and respiratory function are mechanically and neuromuscularly co-dependent [32]. Respiration and spinal stabilization involve the diaphragm, the transverse abdominal muscle, the pelvic floor muscle, and the intercostal and internal oblique muscles [33,34]. The pain experienced by CLBP patients can be effectively managed and reduced via increased local muscle activity. Co-contraction of the muscles, instigated by breathing exercises, combined with sustained muscle activity, proper muscle length and muscle strength, promotes the development of the deep abdominal muscles [32,35]. As a result, the distribution of stimuli on pain receptor tissues surrounding the spine, articular capsules, and ligaments will decrease [33]. As well as being vital to respiration, the respiratory muscles play a fundamental role in controlling posture, acting as core stabilizing muscles. Therefore, breathing exercises are likely to impact postural control by affecting the core stabilisers and altering posture, increasing co-contraction of the core muscles that determine trunk stabilisation, improving the intervertebral joints and increasing motor control, which may lead to an increase in a patient's spinal stability and balance ability [36,37].

Many studies have demonstrated that respiratory muscle function and back proprioception control are mechanically and physiologically dependent on each other [38]. The intense contraction of the abdominal muscles caused by breathing exercises increases intra-abdominal pressure, which may lower the lumbar curve and significantly reduce the pressure exerted vertically, helping to improve balance and proprioception [16,39]. Breathing patterns have been demonstrated through improvement following the introduction of various forms of breathing exercises which activate the deep stabilizing muscles of the trunk to maintain spinal stability and control [35]. When focusing on diaphragmatic breathing, it is essential to re-establish correct breathing patterns and ensure lumbar spine stabilization by increasing intraabdominal pressure and activating core structures to transfer force from the centre of the body to the lower extremities [40]. Following the action of the diaphragm, intra-abdominal pressure increases and activates the pelvic floor muscle causing it to contract, which enables the transversus abdominis to be easily activated during breathing due to strong abdominal contractions [24]. Furthermore, the nerves of the associated muscles are stimulated by the movement, such as the thoracoabdominal nerve, are stimulated by the movement, which results in increased local muscle activity [19,41]. Respiratory interventions can enhance the diaphragm's trunk stabilizing function, enabling individuals to use lumbar proprioception and reduce postural sway during balance control [35].

The findings of this review have partially clarified that breathing exercises can improve the respiratory function of CLBP patients, as demonstrated by FVV and FEV/FVC. CLBP is closely correlated with respiratory disorders [42]. Patients with CLBP are reported to be susceptible to diaphragmatic and muscular fatigue, lung capacity deviations, and diaphragm biomechanics [35,43]. Respiratory function is often overlooked when examining patients with CLBP, although it can contribute to the instability of the lumbar spine and injuries in this region [30]. Meanwhile, a bi-directional interconnection exists between pain and respiration:

respiratory fluctuations can occur in response to pain. As established by previous theories, long-term respiratory exercise has the potential to influence core muscle activity and improve respiratory and lumbar function [19,44]. The respiratory muscles may promote lung ventilation, improve lung function parameters, deliver oxygen to the blood, and relieve pain [45]. Local muscle activity may also alter lung function parameters [46,47]. Enhancing the stability of the trunk muscle through appropriate breathing pattern training, has been demonstrated to be a vital factor in reducing CLBP and preventing recurrence [38]. When considering reports detailing the adverse effects of respiratory training included in the literature, it was found that only one patient, in a study conducted by Mehling et al. [19], chose to withdraw due to the resurfacing of old memories, which resulted in the participant experiencing uncomfortable emotions. Subsequent other studies found no other adverse events.

Breathing exercises appear to be a promising and practical approach to treating CLBP and may enhance performance, prevent injury, encourage rehabilitation, and improve breathing capacity, trunk stability and balance [34]. Currently, control intervention (passive physiotherapy) is not recommended by the National Institute for Health and Care Excellence (NICE) [48]. The current consensus is that any active component of the intervention is more likely to demonstrate improved long-term outcomes for pain than passive physiotherapy [48,49]. Breathing exercises are aerobic exercises that focus on motor control and reinforcing proper breathing patterns, which can increase the strength of respiratory muscles, improve spinal stability, and can be easily incorporated into daily activities to prevent CLBP and its related conditions [19,35]. A recent study also reported reduced diaphragm thickness and lower respiratory function in athletes who suffered from LBP compared to healthy athletes [50]. For sports people undergoing CLBP rehabilitation or sports training, it is essential to incorporate breathing exercises to effectively activate the deeper trunk muscles and nerves associated with the low back, improve muscle blood flow and muscle oxygenation to the low back, and enhance athletic physical performance [51]. For medical workers with CLBP, such as nurses, breathing exercises effectively lower the parasympathetic nerves, inhibit pain gate control, improve stress management, and relieve CLBP symptoms, preventing occurrences of LBP or accelerating recovery [49,52,53]. Therefore, it is recommended that athletes and workers employ breathing exercises in training or daily activities to strengthen the health management of CLBP.

4.1. Strengths and limitations

Breathing exercises are beneficial and are proven clinically effective. They do not require any rehabilitation equipment and, once mastered, can be performed at home, at work or in a hospital as part of a prevention or recuperation programme. In addition, no adverse events were reported in the literature analysed by this study, and the employment of breathing exercises should be promoted. However, the meta-analysis conducted by this study does contain limitations which require consideration. Meta-analysis can increase diagnostic power by amalgamating small-scale, low-quality studies; however, its findings can be affected by certain factors, including the variety of exercises (abdominal breathing, inspiratory muscle training, and respiratory resistance training), the varied quality and heterogeneity of the studies selected for inclusion, and possible biases. There were significant variances between the ten clinical trials included in the meta-analysis; these disparities concerned factors such as sample size, study design, and outcome definition. Additionally, these studies lacked indicators such as balance function and long-term prognosis, and there is a requirement for additional, well-organised trials to further evaluate the efficacy of breathing exercises.

5. Conclusion

In this study, the evidence indicated that breathing exercises may be an effective treatment for CLBP. However, further studies with rigorous methodological quality are needed to support the conclusions of this research. Future studies should investigate different varieties, frequencies and intensities of breathing exercises to discover the most clinically effective breathing exercises.

Ethical approval

Not applicable.

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Informed consent

Not applicable.

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Conflict of interest

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Author contributions

X.J. and H.B. made substantial contributions to the conception and design of the work; Q.C. and Q.X. researched and selected materials and extracted data; X.J. wrote this manuscript; X.J., Q.C., G.C. and H.B. revised the paper carefully and contributed to the statistical analyses. All authors read and approved the final manuscript.

Supplementary data

The supplementary files are available to download from http://dx.doi.org/10.3233/BMR-230054.

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