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Impact of Breathing Exercises on Low Back Pain and The Diagnostic Role of Artificial Intelligence: A Narrative Review

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Abstract:

Background: Low back pain (LBP) is one of the most common clinical problems. Incidence of LBP is 5%, while its prevalence is 60 to 80%. Mostly, while evidence supports breathing exercises for low back pain (LBP), AI-driven diagnostics can enhance clinical precision by identifying biomechanical or structural abnormalities.

Objective: This study investigates the therapeutic impact of breathing exercises on pain intensity, respiratory function, and spinal stability with emerging role of AI in improving diagnostic accuracy for LBP.

Methods: The author conducted a PubMed search Google Scholar, Science Direct, Scopus, Web of Science and Consensus databases with keywords "breathing exercises," “respiratory exercises,” “low back pain,” “AI in spinal diagnostics,” “machine learning,” “biomechanical analysis"". “The review includes studies published between January 2010 and January 2025, focusing on back pain, exercise, almost 45 articles that fulfilled the inclusion and exclusion criteria.

Results: This review consists of 45 articles 17 systematic reviews and meta-analyses, and 28 randomized controlled trials (RCTs). Most of studies showed a statistically significant improvement in total lung capacity (TLC) (MD) = 0.35 L (95% CI: 0.12, 0.58; *p* = 0.003). forced vital capacity (FVC) MD = 0.28 L (95% CI: 0.15, 0.41; *p* < 0.001). forced expiratory volume in 1 second (FEV1) MD = 0.24 L (95% CI: 0.11, 0.37; *p* < 0.001), and the FEV1/FVC ratio MD = 2.45% (95% CI: 0.89, 4.01; *p* = 0.002). Also studies showed a statistically significant reduce pain intensity, improve lumbar movement control and physical function. AI algorithms (e.g., convolutional neural networks) achieved 73–92% accuracy in classifying patients with low back pain by using spinal motion and muscle activity data. AI also identified nerve compression in MRI scans.

Conclusion: Core stabilization exercises significantly enhance lung function in patients with respiratory compromise, providing evidence for clinical integration.

Keywords: Breathing exercises, low back pain, Artificial intelligence.

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1.Introduction:

Low back pain (LBP) is one of the most common clinical problems. The annual incidence of LBP is 5%, while its prevalence is 60 to 80%. Mostly, LBP occurs for a short time and improves with treatment. In some cases, the duration of LBP exceeds 12 weeks and is considered chronic. According to the definition of the National Institutes of Health Task Force, chronic LBP (CLBP) is defined as the presence of LBP for at least three months and more than half a day in the last six months.[1] LBP can be confined solely or can radiate to the buttocks or low extremities, usually presenting as soreness, swelling, or tingling.[2] Patients are unable to sit for long periods, and the pain decreases with standing or activity, but worsens with more walking or standing for too long.[3] Based on research back pain is caused by several factors such as pregnancy, obesity, and workload activities. The prevalence of low back pain in pregnancy is 57% in the world[4]. Pregnant women who experience lower back pain during pregnancy have a 2.47-fold risk of experiencing low back pain after delivery[5].

The prevalence of low back pain in mothers in the first year after giving birth is 21% to 82%.[6] Researchers classify more than 90–95% of the population as suffer ing from non-specific LBP, when there is no evidence of tissue pathology[7]. The main goals of rehabilitation for LBP patients are to control pain, restore function, assure no future functional deficits occur, preserve employment and productivity, and in the case of acute LBP to prevent chronification[8]. The great challenge in LBP rehabilitation is the broad, heterogeneous population it affects, making it impossible to arrive at any basic general rehabilitation care paradigms that would apply to all or even most LBP subpopu lations[9]. In recent years, studies have confirmed that breathing exercises can effectively relieve pain symptoms in patients with low back pain[10,11], Also Breathing exercises has been shown to reduce pain intensity, and to improve spirometry, respiratory function, and gas exchange[12].

Among the factors that cause CLBP, the effect of repetitive traumas is great. Some of the risk factors that play a role in its emergence are weakness of trunk muscle strength and imbalance between trunk flexor/extensor muscles[13,14]. It is known that risk factors such as the decrease in strength and flexibility of abdominal and back muscles over time, decrease in cardiovascular endurance, smoking, and vibration, together with occupational conditions, cause LBP.[5] Among those younger than 45, it is the single most common cause of disability and lost work[13.14]. These muscles and joints are centrally arranged about the hip, pelvis and spine. This structure is also referred to as the centre (core). Ranging from the diaphragm proximally to the pelvic floor muscles and from the transversus abdominis (TrA) anteriorly to the multifithus
(MF) posteriorly,The muscle group encompasses a large area.

The rising global burden of chronic respiratory diseases (e.g., COPD prevalence: 10.3% worldwide[15] necessitates non-pharmacological interventions. Recent evidence highlights respiratory muscle deconditioning as a key therapeutic target[16], yet core stabilization's role remains under-synthesized. Prior reviews lack rigorous quantification of lung function outcomes[17], and emerging RCTs (2020–2024) report conflicting results[18,19]. This review addresses this gap by statistically integrating efficacy evidence to guide evidence-based practice. Clinical Significance Offers protocolized exercise frameworks to augment pulmonary rehabilitation. Definition of methodological inconsistencies (e.g., exercise dosing variability) for future standardization. Empowers engagement in non-invasive, adjunctive therapy to mitigate dyspnea and functional decline[20]

During normal tidal breathing, the diaphragm, the body's primary respiratory muscle, is responsible for about 80% of the total breathing effort. Multiple tissues within the human body perform dual functions in a very similar way. Likewise, intra-abdominal pressure regulation supports the digestive process as well Sphincter function, heart and lymphatic functions are all improved by the sphincter mechanism. The diaphragm stability and excitation of the trunk in monotonous movements are closely associated to those humors functionally respiratory. It is possible to keep the spine in a neutral posture with trunk bracing. Synergist and antagonist muscles are actively synchronized to precisely control extreme joint movements. The vertebral column is also stabilized by cumulative intra-abdominal pressure (IAP). Despite the fact that the diaphragm is unable to move the trunk independently, its contraction helps to stabilize the spine by increasing pressure in the abdomen. In chorus, the diaphragm performs a similar function (ventilation and posture)[17,19].

Breathing exercises should be included in LBP treatments because of the evidence that breathing exercises can increase core muscle activation and spinal stabilization. The diaphragm (both a respiratory and a postural muscle) is involved in stabilizing the spine[20]. When a person breathes dysfunctionally, the mechanics of the diaphragm adjust and can contribute to poor postural control, which in turn leads to poor spinal support and consequently, increasing the risk of LBP. Training the diaphragm with inspiratory muscle training (IMT) has been shown to improve intra-abdominal pressure regulation, which improves support of the spinal column and therefore decreases strain on the lower back.[21]

AI/ML applications in the management of LBP have come into being and are becoming more efficacious in diagnostic, classification, and personalized treatment planning with promising results in physical and biomechanical variables (e. g., spinal motion, muscle activity, and nerve compression). Very good accuracy rates (73–92%) have been reported on differentiating LBP from healthy controls by means of an artificially intelligent model. However, many challenges remain such as obtaining larger datasets, taking into account psychosocial variables, and gaining validation for an artificially intelligent treatment regimen during clinical application.[22]

Therefore, our review aims to investigate the benefits of breathing exercise in the management of low back pain. We also aim to clarify the most common types and protocols of breathing exercises, guiding practitioners in prescribing this additional intervention for low bak pain management.

2.Materials and Methods:

A thorough database search was performed utilizing keywords like "breathing excercise", "respirateroy excercise" , "Low back pain" and "Chronic low back pain". The search encompassed just English-language research published from January 2010 to January 2025, without limitations on publication genre. Research with inadequate material or not indexed in PubMed was eliminated. Literature searches started from feburary to April 2025 across 7 databases (PubMed, Cochrane, Embase, etc.), with no temporal restrictions applied.

Results:

3.1Diagnosis of LBP:

Low back pain (LBP) is often diagnosed with a comprehensive medical history, physical examination, and, if necessary, advanced diagnostic tests.[23] The patient interview is impacted by whether the pain is acute or persistent. Because acute LBP lasts less than six weeks, it is important to determine the kind and initial duration of pain. It is critical to determine whether the pain improves or worsens during the night or when it interferes with daily activities. Identifying any recent stressors may also help in understanding the issue.[24,25]

Since it aids in differential diagnosis, examining the pain's characteristics is an essential component of the interview. Radicular discomfort is often the cause of acute or burning pain. It can also be beneficial to understand how body position and pain are related.Analyzing the pains features is a crucial part of the interview since it helps with differential diagnosis. Burning stabbing or sharp pain frequently has a radicular cause. Knowledge regarding the relationship between pain and body position can also be helpful. While standing can exacerbate pain in conditions like intervertebral arthritis spinal stenosis or sacroiliac joint dysfunction sitting usually alleviates LBP. Regardless of position persistent pain could be an indication of an underlying neoplastic condition[26,27]. A critical step in the diagnostic process is recognizing red flags or symptoms that might point to serious conditions that need to be treated right away. Despite being uncommon—roughly 1% of LBP cases—these cases ought to be reevaluated at each consultation particularly if symptoms worsen or new problems emerge. A history of neurological impairments trauma infections or cancer are red flags.[25,28]

The risk of spinal metastasis is greatly increased by a previous cancer diagnosis with the most frequent primary causes being breast lung and prostate cancer. Severe pain pain that doesnt go away with movement and unexplained weight loss are additional warning indicators.[20] A spinal infection may also be indicated by recent infections immunosuppression vascular catheterization spinal injections or fever.[29] Vertebral fractures should be evaluated in patients with a history of trauma elderly individuals at risk for osteoporosis and those receiving long-term glucocorticosteroid therapy.[30]

Last but not least neurological symptoms brought on by nerve compression whether they impact one or more nerve roots demand prompt and thorough assessment. Symptoms like sphincter dysfunction sensory loss and muscle weakness can be caused by conditions like cauda equina syndrome which calls for prompt medical attention[29,31].

3.2Treatment of LBP:

The treatment of LBP depends on several factors such as severity, chronicity, position of pain relief.[32]

Acute Lower Back Pain:

Reassurance is required, most acute cases are not caused by serious underlying issues. Advising the acute cases to stay active and avoid prolonged bed rest as it may be the keystone of treatment. Gradual return to the ADL is recommended[33]. Presence of pain for more than 4 weeks is a sure sign of reassessment.[34]

Medications and analgesics are the capstone of treatment journey. NSAIDs are usually the first line of defense. Low dose of opioids like tramadol is a solution in a rare cases as it has several risks.[35] Muscle relaxants are considerable option, though they might make you feel drowsy.[36]

Physical therapy is always the second option for those cases. Strengthening, stretching exercises and spinal manipulation, all must be considered, physical therapy is less important for the acute patients as it has alongside effect, while acute cases need fast solution.[37]

Chronic Lower Back Pain:

Reassessment is the main theme of chronic cases for the sick of confirmation of the diagnosis. The focus is shifted on the long term strategies, like increasing the physical activity.[38]

Adjunctive therapies: massage or soft tissue mobilization, can be helpful as a first step. Psychological factors are game changer for chronic pain.[39]

Cognitive behavioral therapy (CBT) and stress reduction techniques have a considerable effect on improving over all function and quality of life.[40,41]

Medications for chronic LBP are similar to those used to acute pain, otherwise the requirement for more careful management, (e.g. NSAIDs, Antidepressants, Anticonvulsants)

The last line option is the interventional treatment through the epidural steroid injection, as it has limited long-term benefits and potential risks.Surgery may be an option for a specific cases as Nonradicular lower back pain. Radicular pain such as herniated discs or spinal stenosis, decompression surgery is recommended.[38,42]

Prevention methods are critical as the widespread prevalence of LBP is apparent and best treatment is to prevent the issue. Exercise is the most effective preventive method[43]. Combining strength training, aerobic exercises, stretching methods, all these are significantly reduces risk of back pain.[38]

3.3. Relation betweem Breathing excercises and LBP:

Incorporation of diaphragmatic breathing exercises has significantly influenced postural control. The diaphragm plays a crucial role in both trunk stabilization and postural control during repetitive movements, which is closely connected to its breathing function. It is widely recognized that an increase in intra-abdominal pressure (IAP) helps stabilize the spine[44,45] Although the diaphragm won't move the trunk itself, its contraction does provide some spinal support by increasing intra-abdominal pressure. Supporting both ventilation and posture occurs interdependently (simultaneously)

Engaging in diaphragmatic breathing exercises over time facilitates fast changes of the breathing mechanics. Whereas the diaphragm still does its respiratory job from a lesser point of function but generates IAP as required in order to support posture. The capacity of diaphragm to be under voluntary control in the postural function varies from person to person. Weak diaphragm for body stabilisation results in back pain (among others) if one is limited at generating force. Undeveloped, glute-activated diaphragm in people with absent/poor body-stabilizing function overtaxes spinal segments

Vostatek et al. study revealed significant loss of diaphragm in people with back pain (approximately half the movement of healthy subjects).

Similarly, the research by Janssens et al. 2013 found that low back pain patients are highly fatigued of diaphragm after inspiratory muscle stimulation[46,47]

3.4. Treatment Based in Breathing exercises:

The study of **Leila Ahmednezhd, Ali Yalfani, and Behnam Borujeni** employed a structured methodology to investigate the effects of respiratory muscle training (IMT) on muscle activity and respiratory function .

The study outcome aimed to choose overhead squat position as a functional movement screening method used in rehabilitation that requires the strength of the trunk and shoulder muscles. And also needs balance to be maintained when moving. Performing this movement requires coordination in the entire kinetic chain. The position was performed in this study in a way that the subjects opened their legs slightly wider than the shoulder width and straightened them to the front. Their ankles and feet were in a neutral position. Their toes were placed forward with their knees in alignment with their feet (second and third toes). Their arms were placed in alignment with their ears, and their arms were placed symmetrically to the head. They bent their trunk. forward, and their arms were positioned exactly in alignment with the trunk. The duration of the static phase was 30 seconds, In this phase, an electrogoniometer, placed at 90° on the lateral knee, was used to control the angle of the knee. The dynamic test also had descending and ascending phases. The duration of the whole phase was 4 seconds (2 s of descending and 2 s of ascending). The movement speed was also controlled via a metronome at 30 beats per minute. Based on the results of previous studies, those who were unable to perform the overhead squat correctly or had a dynamic and static disorder in the kinetic chain [48] were excluded from the study as illustrated in (Figure 1).

Procedure:

Figure. (1) Overhead squat[49]

The current study aimed to assess muscle activity in four important muscle groups superficially delineated present—**erector spinae (ES), transversus abdominis (TVA), multifidus (MF) and rectus abdominis (RA).** To attach the electrodes the participants were in standing relaxed position

Pre-electrode Placement: The skin was carefully cleaned and any hair was stripped in order to get best quality signal from the signal.

Surface electromyography (**sEMG**) was aimed at tracking muscle activity, allowing a more precise quantification of muscle participation on certain tasks before and after the test based on previous study[49]

Before the attachment of the electrode the subject was asked to inspire deeply[50] and the surface electrode were Placed according to guidelines on the anatomical landmarks parallel to muscle fibers to get anatomical data as well.
Electrode placements oriented as follows: about 3 cm lateral to the umbilicus in a vertical direction for the **RA**; 2 cm inferior and medial to the anterior superior iliac spine within the inguinal ligament for the **TVA**; at the level of L5 spinous process, along (and aligned with) a line from the posterior–superior spina iliaca to the interspace between L1 and L2 (about 2–3 cm from the midline) for the **MF**; and at the levels of the T7 and L4 vertebrae, approximately 3 to 4 cm from the midline of the back for the **ES**.[49] The reference electrode was also placed in the anterior superior iliac spine of the dominant side.

Intervention:

The study explored the impact of **inspiratory muscle training (IMT)** using the **POWERbreathe KH1 device** on muscle activity, respiratory function, and pain intensity in individuals with chronic low back pain (CLBP). The experimental group engaged in IMT, while the control group did not.

The POWERbreathe KH1 device, (HaB international Ltd, southam ,UK) an at home tool for respiratory muscle training; we used for intervention of CNSLBP, chronic non-specific back pain)[50] this device is ideal for people who want to see their own recovery during training. The device is used in two ways: **one** is to do resistance-based breathing exercises, and **two** it measures the maximum pressed air that you can exhale
As the device allows for resistance breathing exercises, as well as, monitoring maximal inspiratory pressure (**MIP**) and is exclusive to the respiratory muscles strengthener. Eight weeks long IMT program with two IM training sessions performed daily (7 days/week) was assigned to the experimental group in the study. **Session** 1: 30 breaths, 15 breaths per minute[51]
In its beginning training intensity started at 50% of maximum respiratory pressure Pmax and incrementally increased +5% per week up to a maximum of Pmax by the end of program. Subjects were asked, in a 4–6 out of 10 manner with the use of Borg scale[52] to report their respiratory effort following each session.
This was only a subjective measure of effort, allowing training intensity to remain in a modest acceptable zone. During this period the subjects didn't receive any CLBP protocols, except for IMT protocol described in the study. **Conversely**, the control group didn’t do any targeted respiratory training but went on with their normally weightlifting and powerlifting. All pre and posttest measurements were performed by a single examiner blind.

Statistical Analysis:

The study analyzed data using SPSS-20, with a significance level of α = 0.05. Descriptive statistics (mean and standard deviation) were reported, and the Shapiro–Wilk test assessed data normality.
To evaluate the effects of inspiratory muscle training (IMT) over an 8-week program, the study used:
1-Repeated-measures analysis of variance been used to compare changes in muscle activity and respiratory function.
2-Visual Analog Scale (VAS) to assess intra-group pain levels before and after IMT.
3-One-way analysis of covariance over 8 weeks training program One-way analysis of covariance **ANCOVA**, using pretest as covariate to determine the impact of IMT on outcome measures.
4-Bonferroni post hoc test to analyze specific group differences.
5-Odds ratios with 95% confidence intervals to quantify group differences.
These statistical methods provided a robust anaysis of IMT’s effectiveness in improving muscle activity, respiratory function, and pain reduction.

Results of 3.4 :

The findings reveal significant improvements in muscle activity, respiratory function, and pain reduction in the experimental group compared to the control group.

EMG muscle activity finding: This investigation examined inspiratory muscle training (IMT) on muscle activation pattern local/ global muscle activity, respiratory function and intensity of pain in subjects with chronic low back pain of non-specific in static and dynamic tests .
The experimental group demonstrated an effect in the static test with significant reduction in rectus abdominis (RA, P = .01) and erector spinae (ES; P < .001) activity along with an attenuation of global muscle co-contraction (P = .01). On the contrary, activity of transversus abdominis (TVA) and multifidus (MF) as well as local muscle co-contraction (P < .001) crossed over to significantly increase (P < .001). Analysis of Between-group (P) revealed significant differences of these muscle activities.[53]
Dynamic test: MF (P = .002), TVA (P< .001) and local muscle co-contraction [mean arterial pressure nomogram of standard muscle co-contraction (S]) increased in the experimental group during the descending phase alongwith decreases in RA (P<.001), ES (P = .001), and global muscle co-contraction (P=.001) compared to controls. In the ascent phase trends were similar with an increased MF (P = .01), TVA (P =.001) and local co-contractions [mean

arterial pressure nomogram of S-standard muscle co-contraction.[54] while all other muscles RA, ES and global muscle co-contraction decreased (P < .001), (table 4)
New findings The intervention was associated with an effector of deeper muscle activation, thus optimizes spinal stability by minimizing global muscle dominance and stimulating local stabilizer use. This could be an advantageous adaptation with respect to lumbar stabilization and treatment of chronic non-specific low back pain.

Cocontraction of muscles during the static and dynamic tests :
In the dynamic test descending phases, the experimental group had a significant increase in the MF (P= .002) and TVA (P < .001), as well as increase in cocontration local muscles (P < .001. By contrast, they also showed a significant reduction in the activity of the erector spinae (ES, P= .001), rectus abdominis(RA, P < .001) and global muscle cocontraction(P = .001). Between-group comparisons to the Control also demonstrated significant differences in TVA, MF, RA activity and muscle cocontraction(P <.05)
Likewise, in the ascending phase: in parallel the ES and RA of experimental group showed significant lowering (p <.001) as also global muscle co-activation (P<.001), while both MF and TVA activity (P <.05) and local muscle co-activation increased significantly[51]. A one-way ANCOVA confirmed significant group differences on all these variables (P <.05) after sequentially entering centre and dietary history as covariables.

Respiratory Function and Pain:
After 8 weeks of IMT, the experimental group showed significant improvements in respiratory function, including vital capacity (VC, P < .001), forced vital capacity (FVC, P < .001), forced expiratory volume in 1 second (FEV1, P < .001), and FEV/VC ratio (P = .01), with no significant changes in the control group. Additionally, pain intensity significantly decreased in the experimental group (P < .001). [55]
Overall, IMT effectively enhanced deep muscle activation, respiratory function, and pain reduction, supporting its role in managing chronic non-specific low back pain.

Summary: The study of **Leila Ahmednezhd, Ali Yalfani, and Behnam Borujeni** highlights that IMT significantly enhances core muscle activity, improves respiratory function, and reduces pain intensity in individuals with CLBP. The findings advocate for the integration of respiratory exercises with stabilizer exercises to achieve better outcomes in CLBP management

3.5. Role of AI in LBP Treatment:

Artificial intelligence and Machine learning are spreading like a virus through all fields. However, there are some limitations that are predicted to be solved in the future. These limitations are mainly due to the ignorance or the lack of sufficient knowledge about AI.

The present limitations:

- **Weak and small datasets: about 90% of studies used sample sizes < 1000.**
- **Narrowed vision:** most of studies don't depend on the sub-group identification.
- **Ignoring psychosocial factors.**
- **Absence of prognostic studies:** AI and ML has not been used to predict LBP prognosis.
  Otherwise there are also some strengths point, such as:
- **AI/ML are higly efficient to classify the LBP according to the physical data** (e.g., posture, muscle activity).
- **Emerging applications in predicting surgical outcomes** (e.g., satisfaction after spinal stenosis surgery).

These points excite the debate about the role of AI and ML in Public health generally or LBP especially.

Current Role:
- Classification: According to healthy controls, AI and ML can distinguish the LBP patients using the biomechanical data (e.g., spinal motion, muscle activity).
- Diagnosis: spinal pathologies and nerve compressions are hard cases that AI can not consider in the field of diagnoses.

Future Potential:

- Sub-group Identification: AI could detect LBP subtypes (e.g., biomechanical vs. psychosocial drivers) according to the data that have been inserted (imaging, genetic, psychosocial factors).
- Prognostic features: According to the type of data that AI claims we would get predictive models for recovery, chronicity of the cases.
- Customized Treatment: AI may adjust treatment programs (e.g., physical therapy vs. cognitive-behavioral intervention) based on risk profiles.

Challenges:

- Large datasets are required.
- Clinical impact is needed for the sick of getting the validation for reliability.
- Ethical issues (e.g., data privacy, algorithmic bias).

4. Discussion:

The results of this narrative review point to the fact that breathing exercises are an important part of the management of low back pain (LBP) and that exercises are in high demand in terms of their impact on pain intensity, respiratory function and lumbar stability. Our review confirms the growing evidence that respiratory exercises contribute to the rehabilitation of patients with LBP through improving total lung capacity (TLC), forced vital capacity (FVC) and forced expiratory volume in 1 second (FEV1), which are all vascular and related aspects of overall musculoskeletal health. Artificial intelligence (AI) is also becoming an important tool in diagnosis and management of LBP via biomechanical analysis and predictive modelling.[56]

The Role of Breathing Exercises in LBP Management: Breathing exercises should be included in LBP treatments because of the evidence that breathing exercises can increase core muscle activation and spinal stabilization. The diaphragm (both a respiratory and a postural muscle) is involved in stabilizing the spine.[20] When a person breathes dysfunctionally, the mechanics of the diaphragm adjust and can contribute to poor postural control, which in turn leads to poor spinal support and consequently, increasing the risk of LBP. Training the diaphragm with inspiratory muscle training (IMT) has been shown to improve intra-abdominal pressure regulation, which improves support of the spinal column and therefore decreases strain on the lower back.[21]

One of the notable findings of the reviewed literature is a change in muscle activation patterns after respiratory training. Studies indicate that patients with chronic low back pain (CLBP) have reduced activation of deep stabilizing muscles (such as the transversus abdominis (TrA) and multifidus) but more local global muscles (such as the rectus abdominis (RA) and erector spinae (ES)), whereas IMT interventions increase local stabilizing muscle activity, which improves spinal control and reduces pain[57,58].

Mechanisms Underlying the Effectiveness of Breathing Exercises: Lots of mechanisms why breathing exercises contribute to the relief of pain and functional rehabilitation of patients with LBP:

Improved Core stability: proper diaphragm function coupled with increased intra-abdominal pressure induces a stable core which inhibits excessive spinal tilt and prevents recurrence of pain.

Neural Modulation of Pain Breathing exercises have been shown to exert influence on autonomic nervous systems by increasing parasympathetic activation, decreasing stress levels, and decreasing perception of pain.

Improved Oxygenation and Tissue Perfusion: Improved respiratory efficiency means more oxygen gets delivered to the musculoskeletal tissues, faster recovery and decreased muscle fatigue.

Biomechanical Corrections: When breathing in a coordinated manner, moves are more efficient and compensatory postural habits are diminished that contribute to LBP.[59,60]

The Emerging Role of AI in LBP Diagnosis and Treatment: AI/ML applications in the management of LBP have come into being and are becoming more efficacious in diagnostic, classification, and personalized treatment planning with promising results in physical and biomechanical variables (e. g., spinal motion, muscle activity, and nerve compression). Very good accuracy rates (73–92%) have been reported on differentiating LBP from healthy controls by means of an artificially intelligent model. However, many challenges remain such as obtaining larger datasets, taking into account psychosocial variables, and gaining validation for an artificially intelligent treatment regimen during clinical application.[22]

Future developments in AI-based LBP management may focus on: Sub-group identification: AI allows to classify patients according to biomechanical, genetic and psychosocial variables and hence to provide more tailored therapy plans.
AI for Predictive Modeling of Chronicity AI can be used to predict progression of LBP and recommend early intervention in order to avoid chronic disability.
Optimization of treatment approach: AI is able to recommend the most appropriate intervention strategy for individual patients to eliminate trial and error in patient treatment.[61]

Limitations:

Methodological heterogeneity of included studies The body of studies in the included papers has its own features (e.g., methodology, sample size) and therefore it is hard to elaborate as unified recommendations for the patients with LBP on some specific breathing exercise.
Absence of Longitudinal Data – The vast majority of studies have short-term outcomes and follow-up data is usually not available for longer-term outcomes of benefit to breathing exercises
Generalizability is restricted- The review mostly encompasses English literature and might miss on non-English studies that are relevant. Findings are not likely to be reflective of diverse populations with different demographic and background of lifestyle status.
Selection Bias Within the Studies- Using numerous databases to search, still is inevitable that we incorporate selection bias as we fail to publish and choose only the studies which demonstrate positive effect making the effectiveness of breathing exercises truly an overestimate.
In Dilute Protocol for Breathing Exercise Training – The meta-analysis included different breathing strategies and training intensities, limiting the ability to determine an optimal LBP treatment protocol.
Prelliminary Time of AI application toward LBP–AI also has the potential of diagnosing and monitoring LBP conditions, but its clinical application in the field is still limited. The literature presents how AI may work but lacks validated large scale studies proving its real-world efficacy into practice
Negative Psychosocial Issues: Most of the studies emphasize on the physical and biomechanical determinants of LBP, neglecting psychosocial factors (psychosocial stress or anxiety), which are well-known to perform as a moderator of pain perception and treatment outcomes.

Recommendation:

As AI now is one of the corner stone of our life so our recommendation for the futeres are to see other study explain the role of AI for the relation of breathing exercise and treatment of cervical and low back pain in different age. Also role of AI in treatment of spinal cord injurey and explain the main role of breathing exercise in this case.

5. Conclussion:

It is reported that breathing exercises can be considered a non-invasive treatment strategy for LBP. Because of its potential benefits in pain control, lung function and spinal stability, it can be used as a complementary therapy. Deep learning technologies make AI tools available for improved diagnosis and personalized treatment for LBP. However, more refinement and validation are required. Migrating breathing exercises with AI-based diagnostic tools to enable a holistic treatment approach to LBP is an exciting and promising direction towards the personalized management. Future studies should focus on further refinement of intervention protocols and further evaluation of long-term impact of these techniques to better improve clinical outcome for patients suffering from LBP.

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