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Effectiveness of Pressure Biofeedback in Core Stabilization for Low Back Pain: A Literature Review

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Abstract

Introduction: Low back pain (LBP) is a highly prevalent musculoskeletal disorder that limits functional activities due to pain, postural abnormalities, and muscle imbalance. Core stabilization exercises (CSE) are commonly prescribed in rehabilitation. The use of a pressure biofeedback unit (PBU) during CSE provides real-time feedback, improving the accuracy of deep abdominal muscle activation. This review evaluates the effectiveness of integrating a PBU into CSE for individuals with LBP.
Methods: A literature review was conducted by searching Google Scholar, PEDro, and PubMed. Four eligible studies were included based on criteria related to the application of PBU in CSE for patients with LBP.
Results: The findings indicate that CSE combined with PBU is more effective than CSE alone. The addition of PBU improved proprioception, increased transversus abdominis thickness, enhanced lumbopelvic stability, optimized muscle coordination, and significantly reduced pain intensity.
Conclusion: Incorporating a PBU into core stabilization training enhances neuromuscular control and facilitates short-term pain reduction in individuals with LBP. This combined approach is recommended as an effective clinical intervention for LBP rehabilitation.

Keywords

Low back pain, Exercise therapy, Core stabilization, Biofeedback, Literature review

Introduction

Low back pain (LBP) is one of the most common musculoskeletal complaints affecting individuals across various age groups. Its clinical presentation ranges from mild discomfort to severe pain that significantly interferes with daily activities.[1,2] LBP is defined as muscle tension or stiffness localized in the region between the costal margin and the gluteal folds, with or without radiation to the lower extremities. It may present in acute, subacute, or chronic phases. Clinically, LBP is categorized into two main types: specific and non-specific. Specific LBP results from identifiable pathological conditions such as intervertebral disc herniation, fractures, osteoporosis, rheumatic diseases, spondyloarthropathies, infections, or malignancies. The high recurrence rate and persistent symptoms of LBP make it a global health concern, contributing to significant psychosocial and economic burdens.[3]

According to the World Health Organization (WHO), approximately 619 million individuals were affected by LBP in 2020, with projections estimating this number will rise to 843 million by 2050.[4] In Indonesia, the 2021 National Basic Health Research (RISKESDAS) reported a prevalence rate of 3.71%, accounting for approximately 12,914 cases, making it the second most common musculoskeletal complaint after influenza.[5] Several factors contribute to the onset and persistence of LBP, including physical factors (e.g., weakness of the core muscles), psychosocial stressors (e.g., anxiety and depression), and occupational demands (e.g., prolonged sitting or repetitive lifting). This condition is often associated with dysfunction of deep trunk muscles, impaired coordination, muscle imbalance, and postural deviations, all of which can lead to reduced quality of life.[6,7]

Among the various rehabilitation strategies for LBP, exercise therapy is commonly recommended to reduce pain, correct muscle imbalance, and improve posture. Core stabilization exercise (CSE) is one of the most effective approaches for managing LBP.[8,9] CSE focuses on motor control and the co-activation of deep stabilizing muscles, particularly the transversus abdominis (TrA) and lumbar multifidus (LM). These muscles are essential for stabilizing the thoracolumbar fascia and providing segmental support to the spine. CSE aims to improve neuromuscular coordination and trunk muscle function to maintain spinal stability. It has been shown to reduce pain and disability, enhance proprioception, correct postural abnormalities, and improve spinal stability in patients with LBP.[10,11]

One challenge in performing CSE is maintaining appropriate intra-abdominal pressure, which reflects the effectiveness of deep muscle activation. Difficulty maintaining this pressure may indicate poor control or weakness in

the abdominal musculature, increasing the risk of uncontrolled spinal movement and lumbar instability. To optimize training outcomes, a pressure biofeedback unit (PBU) can be integrated as an external feedback tool to monitor and guide muscle contractions.[12]

The PBU is a non-invasive, low-cost, and user-friendly device that detects pressure changes as a proxy for muscle activation during specific movements.[13] It is widely used in lumbopelvic stabilization training to enhance motor control and segmental spinal stability in individuals with LBP.[14,15] While CSE alone is beneficial, the incorporation of PBU has gained attention for its potential to further enhance neuromuscular training. However, evidence supporting the added value of PBU in conjunction with CSE remains fragmented. Therefore, this literature review aims to evaluate the effectiveness of adding a pressure biofeedback unit to core stabilization exercises in the management of low back pain.

Methods

This study adopted a structured literature review design to explore the effectiveness of incorporating a Pressure Biofeedback Unit (PBU) into core stabilization exercises for the management of low back pain. The literature search was conducted using three major electronic databases: Google Scholar, PEDro, and PubMed. A combination of Boolean operators and controlled vocabulary was employed to enhance the sensitivity of the search process. Keywords used in various combinations included: *"low back pain," "core stabilization exercise," "pressure biofeedback unit," "transversus abdominis,"* and *"core stabilization in low back pain."* The search aimed to identify peer-reviewed articles that directly addressed the role of PBU when integrated with core stabilization interventions in individuals diagnosed with non-specific low back pain.

To ensure the relevance and quality of the selected literature, a set of inclusion and exclusion criteria was applied. Articles were included if they: (1) were relevant to the review objective and research question; (2) were published in national or international peer-reviewed journals; (3) were published within the past ten years, specifically between 2015 and 2025; and (4) were not published in predatory or non-academic sources. Studies were excluded if they were published before 2015 or if they involved participants diagnosed with specific spinal conditions, such as spondylosis, vertebral fractures, or neuromuscular disorders, which could introduce confounding factors not representative of non-specific low back pain populations.

From an initial pool of 40 articles identified through database searching, a title and abstract screening process was performed to eliminate irrelevant studies. Fifteen full-text articles were then assessed for eligibility based on the predefined criteria. Following this thorough selection process, four articles were deemed appropriate and included in the final analysis.

The selected studies were subjected to a qualitative thematic analysis. Key data were extracted and categorized into major thematic areas, including the effectiveness of the intervention, degree of muscle activation (particularly of the transversus abdominis and lumbar multifidus), changes in proprioception, and functional outcomes such as pain reduction and postural control. The extracted themes were synthesized narratively to provide a comprehensive understanding of the clinical implications of combining a Pressure Biofeedback Unit with core stabilization exercises in the rehabilitation of low back pain. This approach allowed for a meaningful integration of findings across the selected studies and aligned with the primary objective of the review.

Results

This literature review discusses a total of four randomized controlled trials (RCTs). A summary of these studies is presented in Table 1.

Table 1. Summary of Reviewed Articles

Author	Study Type and Sample	Objective	Intervention	Outcome Measures	Key Findings
Hlaing et al.	RCT, n = 36	To compare the effects of Core Stabilization Exercise (CSE) and Strengthening Exercise (STE) on proprioception, balance, muscle thickness, and pain in individuals with subacute non-specific low back pain.	CSE using Pressure Biofeedback Unit (PBU) vs STE; 4-week intervention	Joint repositioning test, Romberg test, Rehabilitative Ultrasound Imaging (RUSI), Visual Analogue Scale (VAS), Modified Oswestry Disability Questionnaire (MODQ), Tampa Scale for Kinesiophobia (TSK)	Both groups showed significant improvements in proprioception ($p < 0.001$). The CSE group exhibited significantly greater improvement in balance ($p < 0.05$), and a significant increase in TrA ($p = 0.001$) and LM thickness ($p < 0.01$) compared to STE. The CSE group also demonstrated greater reductions in pain, functional disability, and fear of movement ($p < 0.05$).
Xu et al.	RCT, n = 45	To examine the effects of different intensities of Transversus Abdominis (TrA) training on pressure-pain threshold in individuals with chronic low back pain (CLBP).	TrA training with PBU (sham, low, and high intensity groups)	Pressure-Pain Threshold (PPT) Tester, Short-form McGill Pain Questionnaire, Body surface pain radiation map	High-intensity TrA training activated more core muscles, resulting in significantly higher pressure-pain thresholds compared to low-intensity and sham training.

Table 1 (Continued). Summary of Reviewed Articles

Author	Study Type and Sample	Objective	Intervention	Outcome Measures	Key Findings
V et al.	RCT, n = 34	To determine the effect of varied PBU training on TrA muscle thickness in patients with low back pain.	CSE alone vs CSE with PBU; 3-week intervention	Musculoskeletal ultrasonography, PBU	The PBU group demonstrated significant increases in TrA thickness both at rest (0.41 ± 0.06 cm) and during the abdominal drawing-in maneuver (0.54 ± 0.05 cm).
Noh et al.	RCT, n = 40	To evaluate the effect of lumbar extension exercises with and without the Abdominal Drawing-In Maneuver (ADIM) and PBU on muscle strength imbalance, lumbar instability, pain, and functional status in individuals with low back pain.	Group 1: ADIM + Lumbar Extension + PBU; Group 2: Lumbar Extension only; 2-week intervention	VAS, Modified Oswestry Disability Index (MODI), Muscle Strength Imbalance (MSI), Radiographic imaging	The experimental group showed significant improvements in radiographic imaging findings, reduction in pain, and correction of muscle strength imbalance (all $p < 0.05$).

This literature review analyzed four randomized controlled trials (RCTs) examining the effectiveness of Pressure Biofeedback Unit (PBU)-assisted core stabilization exercises in individuals with low back pain (LBP). The reviewed studies consistently demonstrated that integrating PBU into core stabilization exercises leads to superior outcomes compared to conventional strengthening exercises alone. These outcomes include enhanced proprioception, increased muscle thickness (especially the transversus abdominis and lumbar multifidus), improved balance, greater pain reduction, and reduced functional disability and fear of movement.

In particular, high-intensity training using PBU significantly improved pressure-pain thresholds and core muscle activation. Additionally, short-term interventions (2–4 weeks) involving PBU-based training were found to be effective in producing measurable improvements in muscle performance and functional outcomes. These findings support the clinical application of PBU in core stabilization protocols for managing subacute and chronic LBP.

Discussion

Low back pain (LBP) is commonly associated with muscle imbalance, pain, impaired motor coordination, and postural abnormalities, all of which contribute to reduced functional capacity. It also results in compromised postural control, which is essential for performing daily activities. Stabilization exercises have been shown to enhance postural stability, correct postural disturbances, and reduce pain and disability in individuals with LBP.[16]

Core muscle weakness is frequently observed in individuals with LBP. Over time, exercise therapy has evolved significantly, with Core Stabilization Exercise (CSE) emerging as an effective method to activate the transversus abdominis (TrA) and lumbar multifidus (LM) muscles—key stabilizers of the lumbar spine. Activating these muscles facilitates balance between agonist and antagonist contractions and improves neuromuscular control required for spinal stability.[17] The coordination between abdominal and lumbar muscles further enhances body awareness and motor control in the lumbar region, thus supporting optimal postural correction. CSE also promotes balanced development of flexor and extensor muscles.[18]

The addition of a Pressure Biofeedback Unit (PBU) to CSE allows for precise monitoring of pressure changes, thereby increasing the accuracy and effectiveness of the exercise and ultimately enhancing functional spinal stability.[19] Hlaing et al. demonstrated that CSE improves proprioception, balance, and TrA/LM muscle thickness, while reducing pain.[20] Focused activation of the TrA and LM during CSE enhances muscle spindle and joint receptor activity, strengthens sensorimotor integration, and improves joint repositioning accuracy. This results in better movement control, decreased trunk stiffness, reduced spinal compressive load, and subsequent reductions in pain, disability, and fear of movement.[21,22]

High-intensity core exercises are more effective than low-intensity training in stimulating core muscles such as the iliopsoas, quadratus lumborum, erector spinae, and TrA. These results confirm that using a PBU is effective in activating the TrA and other relevant muscle groups involved in spinal stabilization.[23] CSE combined with PBU has demonstrated good sensitivity and moderate specificity in training core muscles of individuals with LBP, leading to enhanced spinal stability, improved muscle tone, better motor patterns, and reduced pain symptoms.[24]

The integration of PBU in CSE helps measure TrA muscle activity and facilitates coordinated contractions of the abdominal and lumbar muscles. After engaging in CSE with PBU, patients experience pain relief and improved joint stability due to the synergistic activation of trunk stabilizers.[25] Furthermore, PBU provides real-time feedback during exercise, assisting patients in regaining trunk control, modulating muscle activity, reducing disability, improving psychological outcomes, and enhancing overall quality of life.[26]

V et al. found that all three types of biofeedback—visual, auditory, and tactile—can be used effectively during CSE to train TrA muscle activity. These forms of feedback enhance muscle activation, increase muscle thickness, and decrease pain intensity.[27]

These findings suggest that CSE can help alleviate chronic LBP symptoms and modulate pain mechanisms. In chronic LBP, nociceptive input resulting from motor control deficits and lumbopelvic instability may lead to sensitization of dorsal horn neurons in the spinal cord—a condition known as peripheral sensitization. This lowers the pain threshold, making minor stimuli produce greater pain responses. If left unmanaged, this can progress to central sensitization, amplifying the central nervous system's response to pain. However, appropriate interventions that restore motor control and reduce peripheral nociceptive input can prevent this progression and significantly alleviate the patient's pain.[28]

Noh et al. demonstrated that adding PBU to lumbar extension exercises significantly improves spinal stability in individuals with LBP.[29] Enhanced lumbar stabilization results in decreased pain, particularly during flexion movements

in daily activities. Neuromuscular activation of the TrA through PBU-assisted exercises also promotes synergistic contraction with the internal oblique muscle and increases tension in the thoracolumbar fascia. This mechanism raises intra-abdominal pressure, which plays a crucial role in maintaining spinal stability and proper lumbar lordotic curvature alignment.

These results highlight the importance of incorporating targeted core muscle training with feedback mechanisms in the rehabilitation of chronic LBP patients. Physiotherapists should consider applying CSE with PBU to improve patient outcomes. Nevertheless, this review has limitations. The intervention duration in the reviewed studies ranged only from two to four weeks, limiting the understanding of long-term effects. Additionally, the small sample sizes reduce the generalizability of the findings. Future research is needed to examine the long-term outcomes of PBU-assisted CSE and to investigate its effectiveness across diverse patient populations.

Conclusion

Based on findings from several previous studies, incorporating a Pressure Biofeedback Unit (PBU) into Core Stabilization Exercise (CSE) has been shown to be an effective therapeutic approach for the management of low back pain. This combination enhances proprioception, improves joint stability, increases muscle thickness, restores muscle balance, and significantly reduces pain in the short term. However, further research is needed to evaluate the long-term effectiveness of PBU-integrated CSE programs, as current evidence remains limited regarding the sustained benefits of this intervention.

Author Contribution

NNMK conceptualized the study, performed the literature search, and drafted the manuscript. NMND contributed to data extraction, analysis, and critical revision of the manuscript. ADA participated in interpretation of findings, writing assistance, and final editing. All authors reviewed and approved the final version of the manuscript.

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Conflict of Interest Statement

The authors declare that there are no conflicts of interest related to this study.

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Ethics Statement

This study is a literature review and did not involve human participants, animals, or identifiable personal data. Therefore, ethical approval was not required.

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