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Analysis of the Mechanism of Exercise Interventions in Nurses with Chronic Non-Specific Low Back Pain Based on the CoVIn Pathogenetic Model: A Scoping Review

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Review Article

Abstract

Introduction: Chronic non-specific low back pain (LBP) has a high prevalence among nurses, and exercise interventions are proposed as a non-pharmacological treatment. However, the exact mechanism of their effect is not well understood. The novel COVIN (Compressive-Venous-Inflammatory) pathogenetic model may provide a theoretical framework to explain these mechanisms. This scoping review aimed to review exercise interventions in nurses with chronic non-specific LBP and to analyse their mechanism of action based on the COVIN model.

Materials and Methods: A scoping review was performed in PubMed, Scopus, SID, and Magiran databases using keywords related to nurses, chronic non-specific LBP, and exercise therapy, from 2017 to 2026 (and the equivalent Persian years 1395 to 1404). Original studies (randomized/non-randomized controlled trials, quasi-experimental) that examined an exercise intervention in nurses with chronic non-specific LBP were included. Finally, eight original studies met the inclusion criteria and were selected for analysis.

Results: From the eight included studies (five clinical trials and three quasi-experimental studies), the most effective exercise interventions were progressive core stability training, William's flexion exercises, aquatic exercise, resistance training, and combined approaches (exercise + ergonomic education). Analysis based on the COVIN model revealed that William's flexion exercises and aquatic exercise act by reducing venous congestion in the Batson plexus (Venous factor) and decreasing pressure on nerve roots (Compressive factor). Combined approaches that simultaneously targeted all three COVIN factors showed the highest effectiveness.

Conclusion: A variety of exercise interventions are effective in reducing chronic non-specific LBP in nurses. The COVIN model provides a powerful theoretical framework for understanding their mechanism of action. Combining exercise with ergonomic education, flexion exercises, aquatic therapy, and progressive core stability training is recommended, especially in younger nurses.

Keywords: Chronic non-specific low back pain; Nurses; Exercise therapy; William's flexion exercises; CoVIn model

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Introduction

Low back pain is one of the most common musculoskeletal disorders worldwide; studies have reported 619 million affected people in 2020 and a forecast increase to 843 million by 2050 (1, 2). Low back pain is also the leading cause of disability globally (3, 4). Among different occupational groups, nurses are at a very high risk of developing chronic low back pain due to the nature of their work, which includes prolonged standing, frequent patient

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handling, repetitive bending movements, and irregular shifts (5, 6). Epidemiological studies have shown that the prevalence of low back pain among nurses in different countries varies between 30% and 76%, and this problem not only reduces the nurses' personal and professional quality of life but also leads to absenteeism, reduced productivity, and even job desertion in about 18% of cases (7). In Iran, similar studies have reported a high prevalence of low back pain among nurses working in various wards, including operating rooms (74.3%) (8).

One of the major challenges in managing low back pain in nurses is that most cases (over 85%) are classified as non-specific low back pain (Non-specific), meaning that in clinical examinations and routine imaging (such as plain radiography or MRI), no definite pathological cause, such as vertebral fracture, tumor, infection, or obvious radiculopathy, is found (9, 10). This lack of a specific anatomical cause has led to a wide variety of treatment approaches and a lack of consensus on the most effective intervention methods. Recent systematic reviews have shown that exercise interventions, as a non-pharmacological, safe, and cost-effective treatment, can play an important role in reducing pain and improving function in nurses with chronic non-specific low back pain (4).

In recent years, two landmark network meta-analyses (Owen et al. 2020 and Fernández-Rodríguez et al. 2022) showed that in the general population, Pilates had the greatest effect on pain reduction, and strength and stability exercises were also highly effective (10, 11). However, direct evidence in nurses is more limited. A recent systematic review and meta-analysis showed that exercise is effective in nurses with chronic low back pain and that its effect is greater in nurses under 40 years of age (4). Another study found that combining back exercises with health education was the best approach (5).

These findings clearly indicate that exercise therapy is a promising approach, but its exact mechanism of action still needs to be elucidated.

Despite increasing evidence of exercise's effectiveness, the main question remains unanswered: why and how do different types of exercise reduce pain? Answering this question requires a pathogenetic framework that explains the underlying cause of chronic, non-specific low back pain. In this regard, a new model called CoVIn (Compressive-Venous-Inflammatory) has recently been proposed by Luigi Tesio (8, 9).

This model involves three main factors in the development and persistence of chronic low back pain: a compressive factor (Compressive) due to pressure on nerve roots, a venous factor (Venous) due to congestion in the epidural venous plexus (Batson's plexus) – which Tesio considers the most important factor – and an inflammatory factor (Inflammatory) due to the release of chemical mediators from the damaged disc. Based on this model, a successful treatment must target at least one of these three factors (Figure 1).

According to the CoVIn model, flexion exercises such as William's flexion exercises (Williams' flexion exercises) by flexing the spine forward increase the anteroposterior diameter of the spinal canal and the intervertebral foramen space. This widening directly reduces pressure on the nerve roots (Compressive factor) and, more importantly, by reducing the intraspinal pressure, facilitates venous outflow from the Batson plexus (Venous factor). Tesio (2024) explicitly states that William's flexion exercises are completely compatible with the CoVIn model.

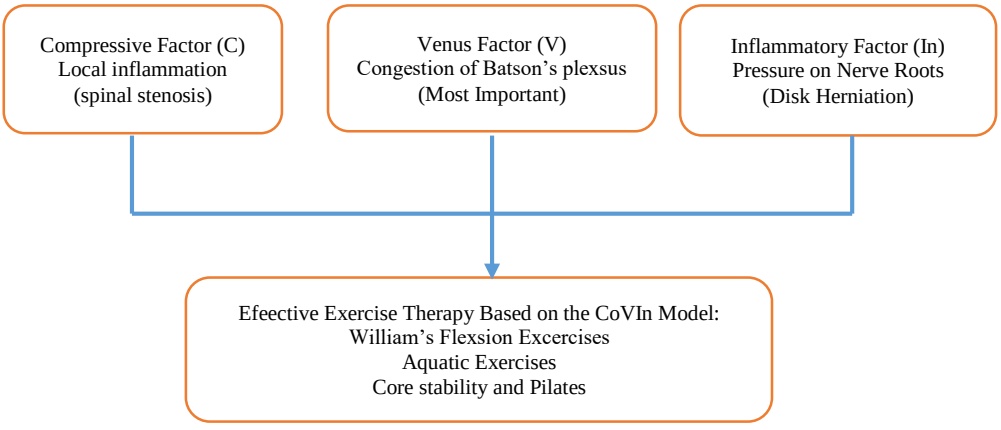


Figure 1. The CoVIn pathogenetic model in chronic non-specific low back pain

On the other hand, core stability exercises (e.g., Pilates), by strengthening the deep lumbopelvic muscles, increase dynamic spinal stability and prevent sudden increases in intra-abdominal pressure that lead to venous congestion (12, 13). Aquatic exercises also target all three CoVIn factors simultaneously by using buoyancy and hydrostatic pressure (14).

Despite relatively strong evidence for the overall effectiveness of exercise in nurses and the existence of a new pathogenetic model (CoVIn), no review has systematically analyzed the mechanisms of action of different types of exercise interventions based on this model in nurses. In other words, we know that exercise is effective. However, we do not know which type of exercise targets which of the three CoVIn factors and whether there is a relationship between the type of exercise and the predominance of a specific factor (e.g., venous in younger nurses). Moreover, previous reviews were unable to provide strong evidence due to the moderate quality of the primary studies (15). Given the publication of new high-quality articles in the years 2024-2026, an up-to-date theory-based review is needed (4, 9, 12, 16).

Therefore, this scoping review aimed to analyze the mechanism of effect of exercise interventions in nurses with chronic non-specific low back pain based on the CoVIn pathogenetic model. To answer this question, only original studies (Original), including clinical trials and quasi-experimental studies that directly examined an exercise intervention in nurses with chronic non-specific low back pain, were included in this review.

Materials and Methods

Study Design: This study was a scoping review focusing on original studies, including randomized controlled trials (RCTs), non-randomized controlled trials, and quasi-experimental studies, and was conducted in accordance with the PRISMA-ScR statement. The target population consisted of nurses with chronic non-specific low back pain who had undergone an exercise therapy program.

Search Strategy: A search was conducted in the PubMed, Scopus, SID, and Magiran databases using a combination of English keywords and their Persian equivalents. The keywords were organized into three main categories: the first category included terms related to nurses (nurse, nurses, nursing, nursing staff, nursing personnel); the second category included terms related to low back pain (low back pain, back pain, chronic low back pain, non-specific low back pain); and the third category included terms related to exercise therapy (exercise therapy, exercise, resistance training, core stabilization, William's flexion exercises, neuromuscular exercise, aquatic exercise, Pilates). Terms within each category were combined using the OR operator, and the categories were combined using the AND operator, so that only articles containing at least one term from each of the three categories were retrieved. All terms were searched in the titles and abstracts of the articles. The search period was set from January 1, 2017, to December 31, 2025 (corresponding to Dey 1395 to Dey 1404 in the Iranian calendar), and the search was performed in Bahman 1404 (January–February 2026).

The final search strategy was designed for the PubMed database as follows and was adapted and rewritten for the other databases (Scopus, SID, and Magiran) according to the search structure, operators, and language of each database:

(nurses[Title/Abstract] OR nurse[Title/Abstract] OR nursing[Title/Abstract] OR "nursing staff" [Title/Abstract] OR "nursing personnel" [Title/Abstract]) AND ("low back pain"[Title/Abstract] OR "back pain" [Title/Abstract] OR "chronic low back pain" [Title/Abstract] OR "non-specific low back pain" [Title/Abstract] OR "nonspecific low back pain" [Title/Abstract]) AND ("exercise therapy" [Title/Abstract] OR exercise [Title/Abstract] OR exercises[Title/Abstract] OR "resistance training"[Title/Abstract] OR "core stabilization"[Title/Abstract] OR "core stability"[Title/Abstract] OR "William's flexion exercises"[Title/Abstract] OR "Williams flexion exercises"[Title/Abstract] OR "neuromuscular exercise"[Title/Abstract] OR "aquatic exercise"[Title/Abstract] OR Pilates[Title/Abstract]) AND ("2017/01/01"[Date - Publication] : "2025/12/31"[Date - Publication]).

Inclusion and Exclusion Criteria

The inclusion criteria were as follows: original articles with a randomized controlled trial, non-randomized controlled trial, or quasi-experimental design; a target population of nurses (male or female) with chronic non-specific low back pain (pain duration of at least 12 weeks); receipt of an exercise therapy program (flexion, stabilization, resistance, aquatic, neuromuscular, or combined exercises); reporting of at least one primary outcome (pain intensity) or secondary outcome (functional disability, quality of life, balance, muscle strength); and publication in Persian or English with full-text availability.

Review articles (systematic reviews, narrative reviews, and meta-analyses), letters to the editor, case reports, animal studies, and studies examining acute or specific low back pain (e.g., symptomatic disc

herniation without confirmed chronicity) were excluded. Articles whose full text could not be obtained after two weeks of follow-up through correspondence with the authors were also excluded.

Study Selection: First, the titles of the articles retrieved from each database were screened, and when a title matched the keywords and the objective of the study, the abstract was reviewed and the article was imported into EndNote software. After importing the articles into the software, duplicates were removed. Two authors then independently screened the titles and abstracts against the inclusion criteria, and in the next step, the full texts of the remaining articles were assessed by the first author. Finally, eight original studies that met all the inclusion criteria were selected for the final analysis. The screening process is presented in Figure 2 (flow diagram) in accordance with the PRISMA statement.

Results

Characteristics of the included studies

After applying the inclusion and exclusion criteria and following the screening steps (Figure 1), eight original studies – including five clinical trials (RCT and non-randomized) and three quasi-experimental studies – were selected for final analysis. The total number of participants in these studies was 366 nurses (predominantly female). The duration of exercise interventions ranged from 4 to 24 weeks. The most commonly used instruments were the Visual Analog Scale (VAS) for pain and the Oswestry Disability Index (ODI) for disability. The full characteristics of these studies are presented in Table 1.

Findings categorized by type of exercise intervention

In this section, the articles' findings are divided into six main categories based on the type of exercise intervention.

William's flexion exercises: In the study by Sulaiman et al. (2024), an experimental study with a pre-test/post-test design, 40 nurses with non-specific low back pain performed William's flexion exercises for 6 weeks. The mean pain score on the VAS decreased from 6.8±0.6 before the intervention to 3.2±0.5 after the intervention. Also, the ODI disability score decreased significantly from 42.6±2.4 to 24.1±1.8. The study concluded that there is a significant difference in pain and disability among nurses using William's flexion exercises (17).

In another comparative study on nurses, Williams exercises were reported to be more effective than core stability exercises in improving dynamic balance, further emphasizing the role of these exercises in motor control (18).

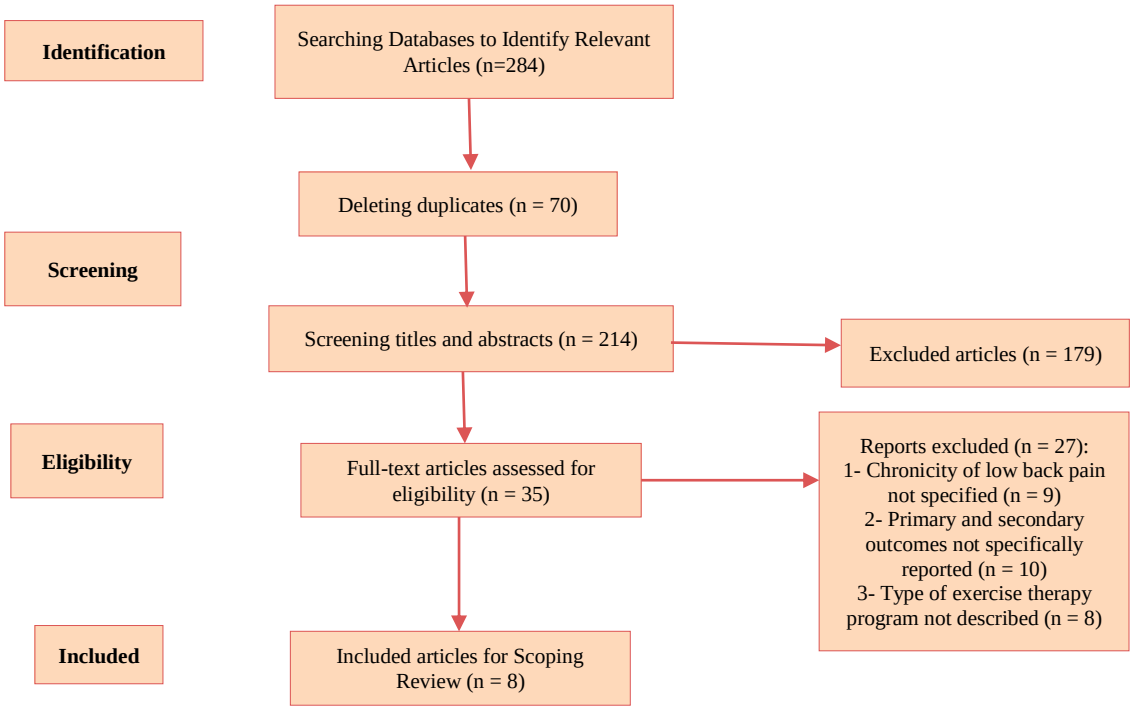


Figure 2. Flowchart of the search, screening, and selection process

Table 1. Characteristics of the original studies included in the Scoping review

Author (year)	Title	Study design	Population	Exercise intervention	Outcome measures	Main result
Dehghan et al. (2017) (19)	Comparison of the Effect of Williams Training and Walking on Low Back Pain in Nurses.	Quasi-experimental	30 nurses (female)	Williams Exercise	VAS	Pain reduction in chronic low back pain ($p \leq 0.05$)
Chiu et al. (2022) (20)	The Effectiveness of Group-Based Core Stability Exercise and Educational Booklet for Hospital Workers in Taiwan with Non-specific Low Back Pain.	Quasi-experimental	۴۶hospital workers (including nurses)	Core stability exercise	NRS, ODI, WHOQOL-BREF	Significant improvement in disability and quality of life in the exercise group ($p < 0.05$)
Taulaniemi et al. (2019) (24)	Neuromuscular exercise reduces low back pain intensity and improves physical functioning during nursing duties among female healthcare workers.	Randomized clinical trial	110 female nurses	Neuromuscular exercise	NRS, ODI, RM-18	Neuromuscular exercise reduced pain ($p = 0.047$) and improved lumbar motor control ($p = 0.007$), abdominal strength, and function in nursing duties ($p = 0.007$) compared with no exercise
Ezadi & Ghanizadeh Hesar (2021) (16)	The effect of eight weeks of selected aquatic exercises on pain and balance of female nurses with chronic low back pain.	Quasi-experimental	30 female nurses	Selected aquatic exercises	VAS, SEBT	Eight weeks of selected aquatic exercises significantly reduced pain ($p = 0.001$) and improved static and dynamic balance in female nurses with chronic low back pain
Safaeian et al. (2021) (23)	Comparison of corrective exercises and ergonomic principles in nurses with chronic low back pain.	Non-randomized clinical trial	40 nurses (male and female)	Corrective exercises and ergonomic education	VAS, ODI	Although both interventions were effective, corrective exercises were more effective than ergonomic education in reducing pain intensity and disability due to low back pain ($p < 0.05$)
Tabatabaei & Bijnovand (22)	Effect of eight weeks of resistance training on pain, flexibility, and function in nurses with chronic non-specific low back pain.	Quasi-experimental	30 nurses (male and female)	Resistance training	VAS, FMS	This intervention led to a significant reduction in pain and improvement in flexibility and function in nurses with chronic non-specific low back pain ($p < 0.001$)
Sulaiman et al. (2024) (17)	Effectiveness of William's Flexion Exercises on Non-Specific Low Back Pain Among Nurses.	Clinical trial	40 female nurses	William's Flexion Exercises	VAS, ODI	Significant reduction in pain and disability ($p < 0.001$)
Noormohammadpour et al. (2018) (21)	Effect of a progressive core stability exercise program on chronic low back pain in female nurses.	Randomized clinical trial	36 female nurses	Progressive core stability exercise	VAS, RMQ, SF-36	Significant reduction in pain, disability, and improvement in quality of life ($p < 0.005$)

In the study by Dehghan et al., a quasi-experimental pre-test/post-test study on nurses with non-traumatic low back pain, the effectiveness of Williams exercises was compared with walking. The results showed that walking was more effective at reducing pain in nurses with acute low back pain, while Williams exercises were more effective in nurses with chronic low back pain. The researchers concluded that walking was more effective in reducing pain in people with acute low back pain, and that Williams exercises were more effective in reducing pain in people with chronic low back pain (19).

Core stability exercises and aquatic exercises: In the study by Chiu et al. (2022), a quasi-experimental study of 46 hospital workers (including nurses) with non-specific low back pain in Taiwan, the effectiveness of a group-based core stability exercise program, along with an educational booklet, was investigated. Participants performed core stability exercises for 8 weeks (60 minutes per week). The results showed that disability scores (ODI) and quality of life (WHOQOL-BREF) improved significantly in the core stability exercise group ($p < 0.05$). The study concluded that group-based core stability exercises can improve quality of life better than education alone (20).

In the study by Noormohammadpour et al. (2018) involving 36 nurses, progressive core stability exercises also significantly reduced pain (VAS) and disability (RMQ) and improved quality of life (SF-36) ($p<0.005$) (21).

In the study by Ezadi and Ghanizadeh Hesar (2021), a quasi-experimental study on female nurses with chronic low back pain, the effect of eight weeks of selected aquatic exercises with a core stability approach on pain and balance of nurses was investigated. The results showed that this intervention significantly reduced pain and improved static and dynamic balance in female nurses with chronic low back pain ($p=0.001$). The researchers recommended that special attention be paid to aquatic therapy with a core muscle-strengthening approach when designing exercise protocols for patients with chronic low back pain (16).

Resistance and strength training: The study by Tabatabaei and Bijnovand (2024), a quasi-experimental study of nurses with chronic non-specific low back pain, examined the effects of 8 weeks of resistance training on pain, flexibility, and function. The results showed that this intervention led to a significant reduction in pain and improvements in flexibility and function in nurses with chronic non-specific low back pain (22).

Combined approaches (exercise + ergonomic and health education): The study by Safaeian et al. (2021), a non-randomized clinical trial of nurses with chronic low back pain, compared the effectiveness of corrective exercises with that of education on ergonomic principles. The results showed that although both interventions were effective, corrective exercises were more effective than ergonomic education in reducing pain intensity and disability due to low back pain (23).

Neuromuscular exercise: The study by Taulaniemi et al. (2019) was a secondary analysis of a randomized controlled trial involving 219 female healthcare workers with non-specific low back pain, with 110 in the exercise group and 109 in the no-exercise group. Participants performed neuromuscular exercises focusing on neutral spine control for 6 months (48 sessions of 60 minutes in three progressive phases). The mean attendance at exercise sessions was 26.3 (SD 12.2) out of 48 sessions. The results showed that the exercise intervention reduced pain ($p=0.047$) and reduced pain interference with work ($p=0.046$). Significant improvements were also observed in lumbar motor control ($p=0.042$), abdominal muscle strength ($p=0.033$), and physical function in heavy nursing duties ($p=0.007$) compared to the no-exercise group. The study concluded that neuromuscular exercises were effective in reducing pain and improving lumbar motor control, abdominal muscle strength, and physical function during nursing duties compared with no exercise (24).

Overall summary of findings

Overall, the eight included original studies showed that different types of exercise interventions, including William's flexion exercises, core stability exercises (including Pilates and progressive protocols), aquatic exercises, resistance training, combined approaches (exercise with ergonomic education), and neuromuscular exercises, were all effective in reducing pain and improving function in nurses with chronic non-specific low back pain. The effectiveness of these interventions varied, with progressive core stability, combined approaches, and flexion exercises showing the greatest effects.

Discussion

The findings of this scoping review demonstrated that a variety of exercise interventions – including William's flexion exercises, core stability exercises, aquatic exercise, resistance training, combined approaches, and neuromuscular exercises – were all effective in reducing pain and improving function in nurses with chronic non-specific low back pain(19, 25). However, the magnitude and mechanism of this effectiveness differ across methods.

To gain a deeper understanding of why and how these effects occur, the CoVIn model, recently introduced by Tesio (2024, 2025), provides a suitable theoretical framework (8, 9).

The CoVIn model states that chronic non-specific low back pain is the result of the interaction of three main factors: the compressive factor (Compressive) (mechanical pressure on nerve roots), the venous factor (Venous) (congestion in the epidural venous plexus – Batson's plexus) which Tesio considers the most important factor, and the inflammatory factor (Inflammatory) (release of chemical mediators from the damaged disc) (8, 9).

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This widening directly reduces pressure on the nerve roots (Compressive factor). More importantly, by reducing intraspinal pressure, flexion facilitates venous outflow from the Batson plexus (Venous factor). Tesio explicitly states that William's flexion exercises are fully compatible with the CoVIn model (9). This mechanism is vital for nurses who suffer from chronic venous congestion due to prolonged standing (4).

Core stability exercises (including progressive protocol): These exercises, by strengthening the deep muscles (multifidus and transversus abdominis), increase dynamic stability and reduce sudden pressure on discs and nerve roots (Compressive factor) (12). Co-contraction of the abdominal muscles and diaphragm acts as a pump to promote venous return and, by improving breathing patterns, reduces fluctuations in intra-abdominal pressure. The study by Noormohammadpour, which demonstrated the high effectiveness of progressive core stability training, confirms that this approach can target both compressive and venous factors (6).

Aquatic exercise: Buoyancy reduces the compressive load on discs by up to 90% (Compressive factor). The hydrostatic pressure of warm water promotes venous return and alleviates venous congestion (Venous factor). Warm water also has an anti-inflammatory and muscle-relaxing effect, reducing the Inflammatory factor (16).

Combined approaches (exercise + ergonomic education): The highest effectiveness was observed in these studies. From the CoVIn model perspective, education, as a non-mechanical intervention, mainly targets the Venous factor. Ergonomic education teaches nurses correct patient-handling techniques and proper standing postures, preventing sudden increases in intra-abdominal pressure and venous congestion (23). Exercise alone may reduce the Compressive factor, but without correcting daily movement patterns, the Venous factor remains.

These findings are also consistent with higher-level evidence. A network meta-analysis showed that Tai Chi and core stability exercises have a significant effect on reducing low back pain (26). Active physiotherapy (e.g., exercise) is also more effective than passive methods (27), and multidisciplinary approaches (including exercise, education, and stress management) have a significant effect on reducing pain and disability(28).

This finding is also consistent with the clinical practice guideline of the American College of Physicians, which recommends exercise as the first-line non-pharmacological treatment for chronic low back pain (29).

Our findings appear to contradict the systematic review by Van Hoof et al., which found insufficient evidence (15). However, this contradiction can be explained: the review mainly examined studies published up to 2016, which were of low methodological quality. In contrast, the present review includes more recent, higher-quality articles (2017-2026). Recent evidence has increasingly confirmed the effectiveness of exercise for nurses.

Limitations

The first limitation of this study was that the included studies employed highly heterogeneous protocols in terms of exercise type (flexion, stabilization, resistance), intensity, duration, and frequency; this heterogeneity made it impossible to perform a pooled meta-analysis across all studies. Furthermore, only a small number of studies directly compared two or more types of exercise in nurses; most studies compared a single type of exercise with no exercise. This limited number of studies precluded comparison and conclusions regarding the relative effects of different exercise types on low back pain. The third limitation was the moderate quality of some studies (particularly the quasi-experimental studies) and the lack of complete methodological details in some articles.

Recommendations

The authors' recommendations are presented in two sections: clinical research and clinical practice. In the field of clinical research, it is recommended that

high-quality randomized controlled trials be designed to specifically test the mechanism of action of exercise based on the CoVIn model—for example, comparing the effects of flexion exercises (targeting the venous factor) versus extension exercises (targeting the compressive factor) using objective measures of venous congestion (Doppler ultrasonography of Batson's plexus) and intraspinal canal pressure. In addition, examining the effects of combined protocols (exercise + ergonomic education + stress management + psychological counseling) on long-term outcomes (with at least 12 months of follow-up) in nurses could be a research objective for future studies. Moreover, cohort studies are needed to determine the moderating role of individual factors (age, body mass index [BMI], history of low back pain, physical activity level) on the response to exercise therapy, so that personalized protocols can be developed. Finally, evaluating the effectiveness of remotely delivered (tele-) exercise therapy for nurses who are unable to attend in-person programs due to irregular shift work is recommended.

In the field of clinical practice, combining back exercises with health/ergonomic education is recommended as the first-line non-pharmacological treatment for chronic low back pain in nurses (5, 23). For younger nurses (under 40 years of age), in whom the venous factor is likely predominant, Williams flexion exercises and aquatic exercises are suitable options (16, 17). For nurses with marked weakness of the deep trunk muscles, progressive core stabilization exercises (such as the Noormohammadpour protocol) should be prioritized (21). Exercise programs should be continued for at least 8 weeks (preferably 12 weeks) with a frequency of 2–3 sessions per week to produce lasting effects (4).

Conclusion

This Scoping review found that various exercise interventions are effective in reducing chronic, nonspecific low back pain among nurses. The analysis based on the CoVIn model showed that the most effective approaches are those that simultaneously target all three factors – compressive, venous, and inflammatory. The combination of back exercise with health/ergonomic education, William's flexion exercises, aquatic exercise, and progressive core stability training had the greatest compatibility with the CoVIn model. Recent evidence has increasingly confirmed the effectiveness of exercise among nurses, especially younger nurses.

Clinical application: It is recommended that nurses, physiotherapists, and exercise therapy specialists use combined exercise programs (including core stability, William's flexion exercises, and ergonomic education) as the first-line non-pharmacological treatment for chronic low back pain in nurses. Personalizing the program based on the CoVIn model can significantly increase effectiveness.

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Conflict of Interest

The authors did not have a conflict of interest.

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