Comparison of Home-based William's Exercises and Abdominal Training on Pain and Functional Disability among Thai Farmers with Chronic Non-Specific Low Back Pain

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Abstract

Low back pain (LBP) is a significant global health concern, particularly among agricultural workers, who face increased risk due to the physically strenuous nature of their occupations. The COVID-19 pandemic further compounded this issue, limiting access to traditional healthcare services and highlighting the need for effective, home-based therapeutic options. This study aimed to assess the effectiveness of supervised, home-based William's flexion exercises (WFE) and progressive abdominal training (PAT) in improving pain, functional disability, core stability, lumbar range of motion (ROM), and exercise satisfaction among Thai farmers with chronic non-specific LBP. Forty-five participants (mean age 35.0 ± 3.2 years), with an average of 9.4 ± 4.0 years of agricultural work experience and a history of LBP for 8.6 ± 3.6 months, were randomly assigned to either the WFE, PAT, or a control group, with 15 each. The control group received informational pamphlets on LBP. The WFE group engaged in 8 flexion exercises with 10 repetitions per set, 3 sets daily, while the PAT group completed a 5-step progressive curl-up training, performing 11 sets at their 50-90% of maximum capacity. Supervised exercise sessions were conducted 3 times weekly for 4 weeks. The Kruskal-Wallis test was employed to evaluate differences among the three groups. Results showed significant pain reduction in both exercise groups compared to the control (WFE: mean reduction = 38.11%, 95% CI [30.5%, 45.7%]; PAT: mean reduction = 51.56%, 95% CI [42.3%, 60.8%], p<0.01). The PAT group demonstrated superior pain reduction compared to the WFE group (mean difference: 13.45%, 95% CI [6.5%, 20.4%], p<0.01). However, no significant differences were observed in functional disability, core stability, lumbar ROM, and exercise satisfaction between the two groups (p>0.05). However, no significant differences were observed between the two groups in terms of functional disability, core stability, lumbar ROM, and exercise satisfaction. These findings indicate that while both home-based exercises were effective in reducing pain, PAT may provide additional pain relief. However, neither intervention showed superior effects on functional outcomes, suggesting that both are viable home-based options for managing LBP, particularly within the post-COVID and "new normal" paradigm.

Keywords : William exercises, Curl-up exercises, Low back pain, Home-based exercises

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เปรียบเทียบผลของการออกกำลังกายแบบวิลเลียมและการบริหารกล้ามเนื้อหน้าท้องที่ปฏิบัติที่บ้าน ต่ออาการปวดและความสามารถในการทำกิจกรรม ในเกษตรกรไทยที่มีอาการปวดหลังส่วนล่างเรื้อรังแบบไม่จำเพาะเจาะจง

ธฤษณุวัชร ไชยโคตร*, หทัยชนก หมากผิน*, วลีวรรณ เจริญกิจการค้า*

บทคัดย่อ

อาการปวดหลังส่วนล่างเป็นปัญหาสุขภาพที่สำคัญในระดับโลก โดยเฉพาะแรงงานภาคเกษตรกรรม ที่ต้องเผชิญกับความเสี่ยงที่สูงขึ้นจากลักษณะงานที่ต้องใช้ร่างกายอย่างหนัก กอปรกับการระบาดของโควิด-19 ได้ทวีปัญหานี้ให้ซับซ้อนยิ่งขึ้น เนื่องจากการเข้าถึงบริการสุขภาพแบบดั้งเดิมถูกจำกัด ดังนั้นจึงมีความจำเป็นในการพัฒนาทางเลือกการรักษาที่มีประสิทธิภาพซึ่งสามารถทำได้ที่บ้าน งานวิจัยนี้มีวัตถุประสงค์เพื่อประเมินประสิทธิผลของการออกกำลังกายที่บ้านภายใต้การดูแล ระหว่างการออกกำลังกายแบบก้มหลังของวิลเลียมและการบริหารกล้ามเนื้อหน้าท้องแบบก้าวหน้า ต่อการลดปวด ความสามารถในการทำกิจกรรม ความมั่นคงของแกนกลางร่างกาย องศาการเคลื่อนไหวของหลังส่วนล่าง และระดับความพึงพอใจต่อการออกกำลังกาย ในเกษตรกรไทยที่มีอาการปวดหลังส่วนล่างเรื้อรังแบบไม่เฉพาะเจาะจง โดยมีผู้เข้าร่วมการศึกษาจำนวน 45 คน (อายุเฉลี่ย 35.0±3.2 ปี) ประกอบอาชีพเกษตรกรรม 9.4±4.0 ปี มีอาการปวดหลังส่วนล่าง 8.6±3.6 เดือน ถูกสุ่มมาเข้าร่วมกลุ่มการออกกำลังกายแบบก้มหลังของวิลเลียม กลุ่มบริหารหน้าท้องแบบก้าวหน้า หรือกลุ่มควบคุม จำนวนกลุ่มละ 15 คน กลุ่มควบคุมได้รับแผ่นพับความรู้เกี่ยวกับอาการปวดหลัง กลุ่มออกกำลังกายแบบก้มหลังของวิลเลียม จำนวน 8 ท่า 10 ครั้งต่อเซ็ต 3 เซ็ตต่อวัน และกลุ่มบริหารกล้ามเนื้อหน้าท้องแบบก้าวหน้า จำนวน 5 ขั้น รวม 11 เซ็ตที่ระดับความหนัก 50-90% ของความสามารถสูงสุด โดยเป็นการออกกำลังกายที่บ้านภายใต้การดูแลของนักกายภาพบำบัด 3 วันต่อสัปดาห์ เป็นเวลา 4 สัปดาห์ วิเคราะห์ความแตกต่างระหว่างสามกลุ่มด้วยการทดสอบครัสคาลและวอลลิส ผลการวิจัยพบว่า ทั้งสองกลุ่มออกกำลังกายมีอาการปวดลดลงอย่างมีนัยสำคัญเมื่อเทียบกับกลุ่มควบคุม (กลุ่มออกกำลังกายแบบวิลเลียม: ค่าเฉลี่ยการลดลง = 38.11%, 95% CI [30.5%, 45.7%]; กลุ่มบริหารกล้ามเนื้อหน้าท้อง: ค่าเฉลี่ยการลดลง = 51.56%, 95% CI [42.3%, 60.8%], $p<0.01$) โดยกลุ่มบริหารกล้ามเนื้อหน้าท้องลดอาการปวดได้มากกว่ากลุ่มการออกกำลังกายแบบวิลเลียม (ความแตกต่างของค่าเฉลี่ย: 13.45%, 95% CI [6.5%, 20.4%], $p<0.01$) อย่างไรก็ตาม ไม่พบความแตกต่างกันระหว่างการออกกำลังกายทั้งสองกลุ่มในด้านความสามารถในการทำกิจกรรม ความแข็งแรงมั่นคงของแกนกลางร่างกาย องศาการเคลื่อนไหวของหลังส่วนล่าง และระดับความพึงพอใจในการออกกำลังกาย ผลการวิจัยแสดงให้เห็นว่า แม้การออกกำลังกายที่บ้านทั้งสองรูปแบบมีประสิทธิผลในการลดปวดได้ แต่การบริหารกล้ามเนื้อหน้าท้องอาจมีประสิทธิภาพในการลดปวดได้มากกว่า อย่างไรก็ตาม ไม่พบประสิทธิภาพที่ดีกว่ากันในผลลัพธ์ด้านสมรรถภาพอื่นๆ ซึ่งชี้ให้เห็นว่า การออกกำลังกายทั้งสองรูปแบบสามารถเป็นทางเลือกในการรักษาดูแลผู้ที่มีอาการปวดหลังส่วนล่างได้ โดยเฉพาะในสถานการณ์หลังการระบาดของโควิด-19 และบริบทสังคมยุค "ความปกติใหม่"

คำสำคัญ : การออกกำลังกายแบบวิลเลียม, บริหารหน้าท้อง, ปวดหลังส่วนล่าง, การออกกำลังกายที่บ้าน

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Background and research rationale

Low back pain (LBP) is a widespread health issue affecting working-age adults globally, with prevalence rates ranging from 50% to 80% across their lifespan (Fatoye et al., 2019). In Thailand, where agricultural labor is prominent and involves physically demanding tasks, LBP has emerged as a predominant concern, constituting 33.3% of reported cases according to the Ministry of Public Health. Among agricultural workers engaged in activities including vegetable and crop farming, crop cultivation, and animal husbandry, the incidence rate reaches as high as 66.45% (Occupational and Environmental Diseases Division, Department of Disease Control, Ministry of Public Health, 2024). The repercussions of LBP extend beyond physical pain and discomfort, contributing significantly to disability, healthcare expenses, and decreased productivity (Fatoye et al., 2023).

The mechanism of low back pain (LBP) in Thai agricultural workers is multifactorial, driven by the specific demands of various tasks. Key contributing factors include repetitive movements, poor posture and heavy lifting. For example, frequent bending and stooping, as seen in crop cultivation and aquaculture, exerts continuous strain on the lumbar spine, leading to mechanical overload of the intervertebral discs and surrounding musculature. Workers in fruit orchards and vegetable farming often engage in repeated lifting and carrying of heavy baskets of produce, which places considerable strain on the lower back, heightening the risk of muscle sprains and disc injury. In animal husbandry, tasks that involve frequent bending or squatting require prolonged awkward postures, leading to postural fatigue and the development of LBP (Punnett & Wegman, 2004). The biomechanical demands of various agricultural tasks lead to similar patterns of muscle imbalances, specifically characterized by tight back muscles and weakened abdominal musculature. Such imbalances are a common contributing factor to the development of low back pain among agricultural workers, regardless of the specific type of work (Osborne et al., 2012). Targeted interventions, including core-strengthening exercises such as flexion exercises, may mitigate this risk by restoring muscle balance and enhancing spinal stability (Akbar & Zainuddin, 2020).

The highly contagious coronavirus disease 2019 (COVID-19) is the global health emergency. It causes worldwide adoption of social distancing and stay at home mandates to mitigate the spread of the virus. Prior to the COVID-19 pandemic, it was observed that up to 33% of the population in developing countries experienced LBP. This prevalence demonstrates a significant escalation, potentially reaching 44%, amidst the lockdown measures and the subsequent phases of the COVID-19 crisis (Papalia et al, 2022). In Thailand, LBP prevalence (30%) is in line with global statistics (Tansuchat et al., 2022). During the

COVID-19 crisis, the World Health Organization recommended not-urgent treatments should be postponed in an effort to ensure safety for both patients and therapists. As a result, most physical therapy services in hospitals, in particular chronic LBP, had been greatly affected and defined as universally non-essential services. As of the present year (2024), it is advisable to refrain from visiting hospitals unless absolutely essential due to the ongoing virus transmission (The Standard, 2024). Therefore, home-based interventions, such as exercises, play the essential role to ensure availability and continuity of care for chronic LBP during this unprecedented time (Falvey et al., 2020).

Exercise has been shown to be more effective than therapist hands-on treatment (e.g., manual therapy) for chronic LBP (Akbar & Zainuddin, 2020). However, there is no consensus on the superiority of any specific exercise intervention (Owen et al., 2020). Studies suggest that trunk flexion exercises, such as William's flexion exercises (WFE) and progressive abdominal training (PAT), also known as curl-up exercises, may provide similar benefits for pain control and disability improvement as other interventions like spinal stabilization or Pilates exercises (Amila et al., 2021; Luciano et al., 2020). Additionally, trunk flexion exercises offer greater simplicity exercise execution and may be suitable for most people, including sedentary individuals, whereas other types of exercises, such as spinal stabilization and Pilates, require a higher level of physical fitness and may not be well tolerated by those experiencing severe pain and dysfunction (Nava-Bringas et al., 2021). The literature suggests that a substantial proportion (25% to 40%) of individuals with chronic LBP encounter limitations in activities associated with standing or walking. Trunk flexion exercises have been identified as particularly suitable for patients experiencing difficulties with these tasks, which are frequently performed during agricultural work. Furthermore, these exercises are recommended for implementation in rural areas as a primary home-based intervention to alleviate LBP symptoms across age groups and reduce treatment costs (Sukmajaya et al., 2020).

During the COVID-19 crisis, home-based exercise is the first-line option for chronic LBP patients to avoid travel and personal interaction. However, the question still remains upon which type of home-based exercises is most effective for treating chronic LBP. Since there is no standardized exercise program, the effective home-based exercises need to be more specific, compliant, practical and safe for all patients (Nava-Bringas, et al., 2021). Among various available and widely studied exercises, WFE and PAT meet aforementioned criteria. They are among the simplest exercises to imitate and perform independently at home, even for inactive individuals and elderly. Furthermore, they can be easily modified to accommodate individuals of varying fitness levels and require no sophisticated equipment (Sukmajaya et al., 2020). WFE have been used as therapeutics for several decades for reducing pain in patients with chronic LBP, particularly in individuals with conditions such as lumbar disc problems (Akbar & Zainuddin, 2020). It also can improve muscular integrity and functions to provide lumbar stability and to prevent recurrence of injury (Fatemi et al., 2015). Meanwhile, the PAT has been proven effective in reducing pain in patients with chronic LBP through improved core stability and functional strength mechanisms (Sullivan et al., 2015). These exercises reduce pressure of the posterior element of the lumbar spine and keep them in a normal position, resulting in reducing pain and restoring mobility and core strength. Short-term (e.g., 5 session or 2 weeks) of trunk flexion exercise is effective in reducing pain intensity and disability (Zehra, 2013). Long-term training (4 weeks and more) causes physiological adaptation and adaptability to prevent over-loading on the lumbar spine and re-injury (Akbar & Zainuddin, 2020).

However, most studies examining the effects of WFE and PAT on chronic LBP have been conducted in controlled laboratory or clinical settings. The effectiveness of these exercises as a home-based intervention during periods of social distancing, particularly in rural agricultural settings, has not been thoroughly studied. This represents a critical gap in the literature, especially given the ongoing global pandemic and the heightened need for feasible home-based care options. There is an urgent need to explore how these exercises can be effectively implemented outside of traditional clinical environments, specifically among populations like Thai agricultural workers who face both occupational risk factors and limited access to healthcare. Understanding the effectiveness of these interventions in a home-based context is crucial for providing accessible, cost-effective care that can mitigate LBP's impact on this high-risk population. Moreover, the findings from such research have the potential to inform broader public health initiatives aimed at managing musculoskeletal disorders in similar high-risk occupational groups globally. Addressing this gap is therefore not only relevant to the current public health context but also critical to reducing the burden of LBP on both individuals and healthcare systems.

We hypothesized that supervised, home-based trunk flexion exercises, specifically WFE) and PAT, would significantly reduce pain and disability compared to a control group receiving standard care. Additionally, we hypothesized that these exercises would improve core stability, lumbar ROM, and increase exercise satisfaction and enjoyment among participants with chronic LBP.

Research objectives

Our objectives were twofold: first, to investigate the impact of supervised, home-based trunk flexion exercises on pain and functional disability and to compare these outcomes with those of the progressive abdominal training, defined as the primary outcomes; second, to assess the influence of these interventions on core stability, lumbar range of motion, and exercise satisfaction and enjoyment, while comparing these secondary outcomes between the two exercise approaches.

Materials and methods

Study design

An experimental study was used to compare the effectiveness of the 4-week home-based exercise intervention of William's exercises and progressive abdominal training regarding pain reduction, improvement in disability, core stability, lumbar ROM, and exercise satisfaction and enjoyment in patients with chronic LBP. Assessments were undertaken at baseline and 4th week of the study. The study was conducted at home-based or community centers in Mueang Nakhon Pathom district, Nakhon Pathom province and Banpaew district, Samut Sakhon province, between August 2020 and June 2021.

Ethical consideration

All procedures of this study were approved by the Ethics Committee of the Christian University of Thailand Ethics Committee with approval number B.03/2563.

Participants and procedure

This randomized controlled trial blinded assessors into WFE, PAT and control groups. The study flow is illustrated in Figure 1. The participants in this study comprised agricultural workers experiencing chronic non-specific low back pain (LBP) from Mueang Nakhon Pathom district in Nakhon Pathom province and Banpaew district in Samut Sakhon province. The agricultural activities undertaken by these individuals included crop cultivation, vegetable farming, fruit orcharding, aquaculture, animal husbandry, and various mixed farming practices. Sixty-one eligible participants were enrolled in this study. The screening and baseline characteristics of participants were assessed by licensed physical therapists, who were responsible for diagnosing chronic low back pain (LBP) using a systematic approach. This process encompassed obtaining a detailed patient history and performing a comprehensive physical examination, which included postural observation, range of motion assessments, palpation to identify tenderness and muscle tightness, and a neurological evaluation. Functional assessments were also implemented to evaluate the impact of LBP on daily activities. Additionally, differential diagnosis was utilized to exclude any serious underlying conditions.

A sample size was calculated using G*Power software version 3.1, as recommended by Kang (2021). Following preliminary data, the number of participants was determined based on the calculated effect size f = 0.28, α=0.05 and Power (1 - β) = 0.8. The total number of participants required was 36 with an additional 20% added to likely attrition over the 4-week intervention. As such, 15 participants were enrolled for each group. The inclusion criteria were: diagnosis of chronic LBP for more than 3 months and not more than 24 months; non-specific LBP characterized by the absence of signs of any serious underlying conditions (such as infection diseases, cancer, cauda equina syndrome, spinal radiculopathy or stenosis, spinal compression fracture, spinal degenerative conditions and deformity, ankylosing spondylitis); male or female aged between 30 and 40 years old; pain between 4 and 6 on a 11-point numerical rating scale (NRS); abdominal muscle weakness of at least grade 4, moderate disability due to LBP as defined by the Modified Oswestry Low Back Pain Disability Index (MODI) 21% to 40%. The exclusion criteria were: pregnancy; fibromyalgia; prior limb and spine surgery; having undergone treatment with physical therapy in the past 3 months; having any contraindication to physical exercise; body mass index > 25. Signed informed consent documents were received from all the participants after receiving a verbal and written explanation of the experiment protocol and its potential risks and benefits.

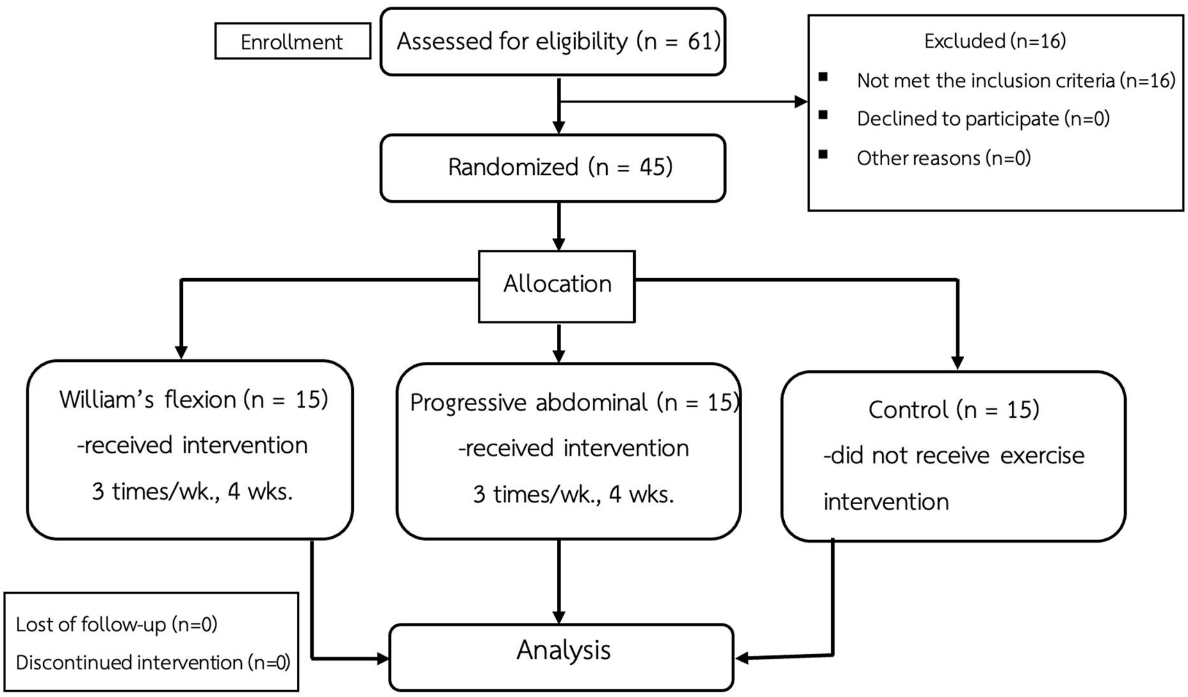

Figure 1 Experimental study flow

Randomization

Forty-five individuals with non-specific chronic low back pain (LBP) were allocated to intervention groups using a pseudorandomization method. Specifically, minimization was employed to ensure balanced group assignment based on predefined factors, including sex and duration of symptom onset. This approach helps maintain comparability among groups by stratifying participants accordingly. Participants were randomly assigned to one of three groups: William's Flexion Exercises (WFE), Progressive Abdominal Training (PAT), or a control group. The randomization process utilized a block design, with block sizes stratified by sex (male and female) and duration of symptom onset. The randomization was facilitated through the Sealed Envelope platform (Sealed Envelope, 2024). The term "pseudorandomization" is used here to denote that, while random assignment occurred, the process incorporated predetermined characteristics (sex and symptom duration) to achieve balance across groups. This method mitigates the risk of imbalances that could influence outcomes. Blinding was implemented in this trial through a single-blinded assessment. Although participants were aware of their group allocation due to the nature of the interventions, data collection was conducted by assessors who were blinded to the group assignments. To further minimize bias, participant forms did not disclose group numbers, ensuring that the assessors remained unaware of the specific group allocations during data collection.

Control of Covariates and homogeneity assessment

To account for potential confounding factors, covariates such as age, gender, body mass index (BMI), and baseline levels of pain and functional disability were controlled for in the analysis. We employed an analysis of covariance to adjust for these variables, ensuring that any differences in outcomes could be attributed to the interventions rather than extraneous factors. These covariates were selected based on their established influence on low back pain outcomes as reported in previous literature. The homogeneity of variance across the intervention groups was assessed using Levene's test for equality of variances. Additionally, baseline characteristics, including demographic variables and pre-intervention outcome measures, were compared between groups to ensure that no significant differences existed prior to the start of the interventions. The results indicated no significant differences in baseline measures, confirming the homogeneity of the groups. These findings are presented in Table 1.

Exercise intervention

Eligible participants were recruited into the study subsequent to screening procedures, with baseline characteristics duly documented. Prior to the intervention, all participants received education on LBP from the physical therapist. The control group received an informational pamphlet regarding LBP, including its meanings and causes, proper lifting techniques and postural adjustments. Both exercise groups, WFE and PAT, underwent supervised exercise sessions 3 times weekly for a duration of 4 weeks, totaling 12 sessions, conducted in their home environment under the guidance of physical therapists. In the WFE group, the training regimen consisted of 8 exercises including pelvic tilt, single knee to chest, double knee to chest, partial sit-up, hamstring stretch, standing lunges, seated trunk flexion, and full squat (Figure 2). Participants completed 10 repetitions of each exercise per set, with 3 sets performed per day, over 3 days per week. A 30-second rest interval followed each set, as detailed by Voinea & Iacobini (2014).

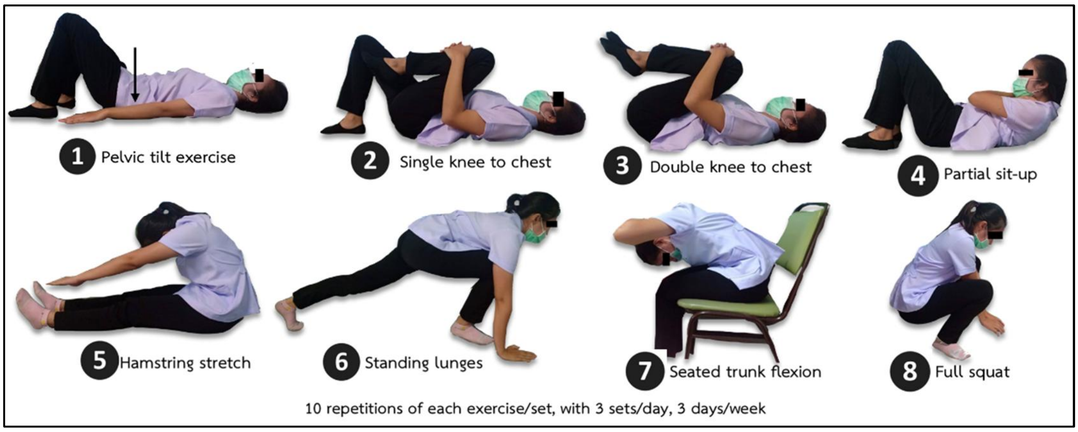

Figure 2 William's flexion exercises

In the PAT group, participants adopted a hook-lying position, with feet flat on the ground and knees bent at a 105-degree angle. The participants' hands were crossed, touching the opposite shoulder (Figure 3). During the exercise, they were instructed to raise their trunk from the ground until the inferior angle of the scapula was lifted, while avoiding excessive elevation, then returned to the starting position without pausing. The exercise protocol followed a modified Kersey method, conforming to the guidelines established by Baxter et al. (2003). The training protocol consisted of 5 steps, each involving specific guidelines for intensity and volume progression. Step 1 instructed participants to perform 3 sets of curl-ups at an intensity of 50% of their pre-training 1-minute curl-up test score, with a 2-minute rest interval between sets. To determine 50% of the pre-training score, the total number of curl-ups performed during the 1-minute test was multiplied by 0.5. For example, if a participant's pre-training score was 40 repetitions, 50% of this score would be 20 repetitions (40 × 0.5). Consequently, the participant was directed to perform 3 sets of 20 curl-ups in Step 1. Once participants could complete all repetitions for all 3 sets, they progressed to Step 2, which involved adding a fourth set with the same rest interval. This pattern continued for subsequent steps, with participants increasing intensity to 75% and then 90% of their pre-training test scores in Steps 3 and 5, respectively. At week 3, participants' strength was reassessed, and the training protocol was repeated with the new test scores determined from this assessment for weeks 3 and 4.

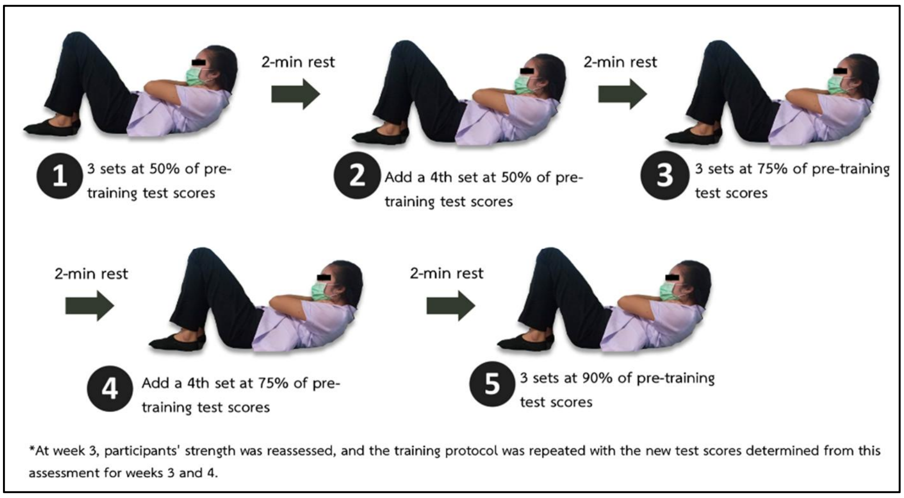

Figure 3 Progressive abdominal training

Each session of both interventions commenced with a 5-minute warm-up, consisting of stationary jogging followed by gentle dynamic stretching of the shoulders, chest, and calf muscles. This was followed by alternating between raising and lowering the heels and lifting the legs while seated. The session concluded with a 5-minute cool-down using the same method. In the exercise intervention groups, participants were instructed to engage in individualized exercises at home under the supervision of a physical therapist throughout the study period. The physical therapist conducted home visits to directly observe and correct exercise techniques, ensuring both safety and proper form. This approach is recognized as the most effective strategy for home-based exercise interventions for Chronic LBP (Fernández-Rodríguez et al., 2022). The study involved two physical therapists, previously standardized to ensure consistency in exercise program delivery. Each participant maintained the same therapist from baseline through the 4-week follow-up to ensure procedural consistency and promote adherence. Participants were encouraged to focus solely on the exercises without seeking additional information online and were also advised against incorporating additional exercise routines beyond the study protocol. No participants were allowed to receive other treatments or use oral or topical medications during the study.

Outcome measurement

The outcome measurements encompassed various domains. The primary outcomes were pain intensity and disability index. Pain intensity was evaluated using NRS, demonstrating a reliability coefficient of 0.95 (Alghadir et al., 2018). The impact of back pain on functional status and disability was assessed through the MODI, with a reliability coefficient of 0.81 (Sanjaroensuttikul, 2007). The secondary outcomes included core stability, ROM and exercise satisfaction and enjoyment. Core stability refers to the coordinated efforts of the core musculature to control the position and motion of the core over the pelvis to enable optimal production, transfer, and control of forces and motion towards the extremities. The term "core stability" and "core strength" is commonly used interchangeably throughout literature. In the present study, core stability was quantified using the 1-minute ACSM's curl-up test, one of the best field-based core stability measures with a reliability coefficient of 0.83 (Porcari et al., 2018). In the assessment protocol, participants were instructed to assume a supine position with knees flexed at a 90-degree angle and arms along the sides. Tape was placed under the heels and a second strip of tape was placed 12 cm from the first tape (toward the trunk). During the assessment, they initiated by raising their upper bodies until their shoulders off the floor to reach the second tape at 40 beat per minute. This cyclic movement was repeated continuously for 1 minute. To ensure procedural consistency, participants were provided with periodic reminders throughout the assessment to maintain proper form and technique. The test was terminated if compensatory movements, irregular rhythm, or failure to reach the second tape were observed (Behm et al., 2022). The ROM was conducted using a universal goniometer, with a reliability coefficient of 0.80 (Johnson & Mulcahey, 2021). The satisfaction and enjoyment of physical activity and its correlation with adherence, motivation and overall participation in exercise programs were evaluated using the Thai version of the Physical Activity Enjoyment Scale (PACES). Participants rated their agreement with each of the 5 items on a 7-point Likert-type scale. Total responses were summed to yield a score ranging from 5 to 35, and a percentage enjoyment score was calculated. Higher PACES scores reflect greater levels of satisfaction and enjoyment. The Cronbach's alpha coefficient for the Thai version PACES questionnaire was calculated to be 0.84 (Noradechanunt et al., 2019).

Data analysis

All statistical analyses were performed using IBM SPSS Statistics version 23.0 (IBM Co., Armonk, NY, USA). The normality of the measured variables was assessed using the Shapiro-Wilk and Levene tests, and data are presented as mean ± SD. Given that demographic data exhibited non-normal distributions, the Kruskal-Wallis test was employed to evaluate differences among the three groups, with post-hoc pairwise comparisons conducted using the Mann-Whitney U test. Since the baseline and post-test data for pain intensity, MODI, core stability, ROM, and PACES were also non-normally distributed, the Wilcoxon Signed Ranks test was used to assess significant differences within groups over time, and the Kruskal-Wallis test was applied to compare the three groups. For pairwise comparisons between individual groups, the Mann-Whitney U test was employed, and the Bonferroni correction was applied to adjust the significance level. The adjusted significance level ($\alpha_{adjusted}$) was calculated as α/m, where m is the number of pairwise comparisons. For this study, with three groups, m = 3 and $\alpha_{adjusted}$=0.05/3 = 0.0167. All statistical significance for pairwise comparisons was thus set at $p < 0.0167$, while the overall Kruskal-Wallis test retained $p < 0.05$. Outcomes were reported with 95% confidence intervals (CI) for both upper and lower limits, to indicate the range within which the true effect likely lies. Minimally important clinical difference (MICD) scores were investigated according to Schwind et al. (2013): ((Initial MODI raw score - Final MODI raw score) / Initial MODI raw score) × 100%. Similarly, the analysis of pain intensity was conducted using the same approach, with ≥ 30% (Ostelo et al., 2008). This denotes the smallest difference that would be meaningful to patients or physicians. Such scores reflect a patient's perception of improvement or recovery, corresponding to minimal changes in their outcome score (Sipaviciene & Pilelis, 2024). Partial eta-squared (η_p^2) was calculated to estimate the effect size for univariate tests and interpreted as small (≥0.01), medium (≥ 0.06) or large (≥ 0.14) (Cohen, 1988).

Results

A total of 61 subjects were initially approached for participation in the study. However, 16 individuals were subsequently excluded based on various criteria, including severe pain with a NRS score exceeding 6 (n=2), pain duration exceeding 24 months (n=3), presence of kyphosis (n=2), receipt of treatment within the past 3 months (n=6), contraindications to physical exercise (n=1), and a BMI exceeding 25 (n=2). Consequently, the final study cohort comprised 45 participants, with 15 individuals in each group. The demographic attributes, including sex, duration of symptoms onset, age, height, weight, BMI, and agricultural occupations-are presented in Table 1.

Baseline characteristics

In total, 45 participants were included in the analysis with WFE group (n=15), PAT group (n=15) and control group (n=15). No significant differences were detected in duration of symptoms onset, age, height, weight, BMI, and year of work.

Table 1. Descriptive characteristics of participants

Characteristic	**Control (n = 15)**	**WFE (n = 15)**	**PAT (n = 15)**	***p*-value**
Onset duration (months)	8.73 ± 0.51	8.53 ± 3.85	8.67 ± 3.58	0.99
Age (years)	36.13 ± 2.47	35.47 ± 3.31	33.53 ± 3. 46	0.71
Weight (kg)	58.80 ± 7.39	60.20 ± 7.04	55.29 ± 6.37	0.23
Height (cm)	163.80 ± 8.25	164.53 ± 8.25	162.20 ± 7.32	0.78
BMI (kg/m^2)	21.83 ± 1.10	22.03 ± 0.94	20.97 ± 1.47	0.34
Year of work (years)	10.13 ± 3.72	8.87 ± 3.46	9.13 ± 4.85	0.67
Sex (male/female)	6/9	5/10	5/10	
Agriculture work (n)				
Crop cultivation (n)	2	2	1	
Vegetable farming (n)	1	1	2	
Fruit orchards (n)	4	3	4	
Aquaculture (n)	3	4	3	
Animal husbandry (n)	2	2	2	
Mixed (n)	3	3	3	

The effects of supervised, home-based exercises; WFE and PAT, on pain, ROM, core stability, disability level and exercise satisfaction and enjoyment, compared to the control group, are shown in Table 2.

Table 2. A comparison of means and standard deviations of pain, ROM, core stability, disability level and exercise satisfaction and enjoyment at baseline and post intervention between the three groups

Variables	Control (n = 15)		WFE (n = 15)		PAT (n = 15)	
	Baseline	Posttest	Baseline	Posttest	Baseline	Posttest
NRS*	4.93 ± 0.80	4.87 ± 0.83[ab]	4.93 ± 0.70	3.07 ± 0.80[cd]	4.87 ± 0.74	2.33 ± 0.62
MODI (%)*	25.87 ± 5.09	25.93 ± 4.83[ab]	24.27 ± 3.28	19.40 ± 2.32[d]	25.60 ± 4.79	19.53 ± 2.33[c]
ROM						
Flexion (°)*	60.47 ± 3.50	60.27 ± 2.46[ab]	58.87 ± 3.64	64.00 ± 3.84[d]	58.60 ± 3.91	63.40 ± 4.32[d]
Extension (°)*	21.80 ± 3.28	21.87 ± 3.09[ab]	20.67 ± 3.48	25.40 ± 3.67[d]	20.60 ± 3.73	24.87 ± 3.46[d]
Rt. lateral flexion (°)*	31.87 ± 3.42	31.27 ± 3.90	30.13 ± 4.34	36.27 ± 4.23[d]	30.73 ± 3.45	36.07 ± 3.39[d]
Lt. lateral flexion (°)*	30.20 ± 2.86	30.40 ± 2.72	28.47 ± 3.18	34.07 ± 3.04[d]	28.87 ± 3.66	33.80 ± 3.47[d]
Rt. rotation (°)	40.60 ± 3.96	40.00 ± 4.08	39.47 ± 3.54	42.87 ± 2.20[d]	38.87 ±4.17	42.53 ± 2.75[d]
Lt. rotation (°)	38.20 ± 3.97	38.33 ± 4.06	36.13 ± 4.27	40.87 ± 2.99[d]	38.00 ± 4.50	41.13 ± 2.59[d]
1-min ACSM's push up test (time)*	28.93 ± 7.77	27.33 ± 7.49[abd]	28.20 ± 6.65	39.60 ± 4.98[d]	28.93 ± 4.94	42.00 ± 4.70[d]
PACES (%)*	73.71 ± 6.76	73.53 ± 6.70 [ab]	74.10 ± 5.00	87.81 ± 4.11[d]	75.23 ± 5.14	88.57 ± 4.45[d]

[*]significant difference between the three groups at post-test (*p<0.05*) using Kruskal-Wallis test, [a] significant difference between the control and WFE group (*p<0.01*) using Mann-Whitney U test, [b] significant difference between the control and PAT group (*p<0.01*) using Mann-Whitney U test, [c] significant difference between the WFE and PAT group (*p<0.01*) using Mann-Whitney U test, [d] significant difference between baseline and post-test within group (*p<0.05*) using Wilcoxon Signed Ranks test; NRS = numerical rating scale; WFE = William's flexion exercise group; PAT = progressive abdominal training group; ROM = range of motion; Rt = right, Lt = left, MODI = Modified Oswestry Disability Index; PACES = Physical Activity Enjoyment Scale)

Table 2 presents the means and standard deviations of pain intensity, ROM, core stability, MODI and PACES before and after the 4-week intervention across all three groups. Prior to the intervention, there were no statistically significant differences observed among the three groups in any of the variables examined. In the control group, no statistically significant differences in pain intensity, MODI score and PACES were found between pre- and post-intervention. However, there were statistically significant decreases in core stability (mean difference = 1.6, 95% CI [0.77, 2.43], $p < 0.05$).

After the 4-week intervention, both the WFE and PAT groups exhibited significant reductions in pain intensity and MODI scores. Notable improvements were also observed in ROM across all directions, core stability, and PACES ($p < 0.01$). In comparison to the control group, both the WFE and PAT groups demonstrated greater effectiveness in reducing pain intensity and showed statistically significant improvements in lumbar flexion, extension, lateral flexion (right and left), core stability, and MODI ($p < 0.01$). Both exercise groups also exhibited significantly elevated PACES ($p < 0.01$). The WFE group showed a reduction in pain intensity from 4.93 ± 0.70 to 3.07 ± 0.80 (mean difference: -1.86, 95% CI: -2.48 to -1.24), while the PAT group reduced pain intensity from 4.87 ± 0.74 to 2.33 ± 0.62 (mean difference: -2.54, 95% CI: -3.08 to -2.00). The PAT group showed a significantly larger reduction in pain intensity compared to the WFE group ($p < 0.01$). The WFE group demonstrated a reduction in MODI from 24.27 ± 3.28 to 19.40 ± 2.32 (mean difference: 4.87, 95% CI: 2.84 to 6.90), while the PAT group improved from 25.60 ± 4.79 to 19.53 ± 2.33 (mean difference: 6.07, 95% CI: 3.37 to 8.77). Both exercise groups exhibited significantly greater improvements compared to the control group ($p < 0.01$), though no significant differences were detected between WFE and PAT.

Core stability of the WFE group improved from 28.20 ± 6.65 to 39.60 ± 4.98 (mean difference: 11.40, 95% CI: 7.20 to 15.60), while the PAT group improved from 28.93 ± 4.94 to 42.00 ± 4.70 (mean difference: 13.07, 95% CI: 9.62 to 16.52). Both groups showed significant improvements in core stability compared to the control group ($p < 0.05$), with no significant differences between WFE and PAT. The WFE group exhibited an increase in PACES from 74.10 ± 5.00 to 87.81 ± 4.11 (mean difference: 13.71, 95% CI: 11.53 to 15.89), while the PAT group improved from 75.23 ± 5.14 to 88.57 ± 4.45 (mean difference: 13.34, 95% CI: 11.05 to 15.63). Both groups demonstrated significant increases in PACES compared to the control group ($p < 0.01$), though no statistically significant difference was found between WFE and PAT. Both the WFE and PAT groups showed significant improvements in lumbar flexion, extension, and lateral flexion in both directions, with mean differences ranging from

3.13 to 6.13 degrees (95% CIs: 1.73 to 6.97), significantly outperforming the control group ($p < 0.05$).

Table 3. A comparison of minimally important clinical difference (MICD) of pain intensity and disability level between the three groups.

MICD	Control (n = 15)	WFE (n = 15)	PAT (n = 15)	*F*	*p*-value	η_p^2
Pain intensity (%)	1.33 ± 5.16	38.11 ± 12.71	51.56 ± 13.28	83.45	0.00	0.80
MODI (%)	-0.65 ± 6.48	19.56 ± 8.29	22.44 ± 9.88	34.20	0.00	0.62

η_p^2 Partial eta-squared; MICD = minimally important clinical difference; WFE = William's flexion exercise; PAT = progressive abdominal training group; MODI = Modified Oswestry Disability Index

Table 3 illustrates the means, standard deviations, and effect sizes of the MICD for pain intensity and the MODI following the 4-week intervention across all three groups. After completing the supervised, home-based WFE and PAT regimens, reductions in pain intensity of 38.11 ± 12.71% (95% CI [31.4%, 44.8%]) and 51.56 ± 13.28% (95% CI [44.0%, 59.1%]), respectively, were observed. Significant differences were noted in the MICD for pain intensity between both home-based exercise groups (WFE and PAT) and the control group, with p-values < 0.01 for both comparisons. Additionally, the MICD for pain intensity in the PAT group was significantly higher than in the WFE group ($p < 0.01$, mean difference = 13.45%, 95% CI [6.5%, 20.4%]). Following the 4-week exercise intervention, improvements in MODI of 19.56 ± 8.29% (95% CI [14.8%, 24.3%]) and 22.44 ± 9.88% (95% CI [16.4%, 28.5%]) were found in the WFE group and PAT group, respectively. Significant differences were also detected in the MICD for MODI between both intervention groups (WFE and PAT) and the control group, with p-values < 0.01 for both comparisons.

Discussion

The high prevalence of lower back pain (LBP) during the pandemic and new normal era poses a significant challenge for healthcare professionals. The need for home-based healthcare services has become more critical due to social constraints (Bagherian et al., 2021). Our results provide evidence supporting the use of the home-based exercises for reducing pain and disability in individuals with chronic LBP. Exercise interventions were more effective for improving pain and reducing disability than education (booklet or advice).

The distribution of participants across agricultural work types is generally balanced across the control, WFE, and PAT groups, with only slight variations in vegetable farming, fruit orchards, and aquaculture. Given the relatively small differences in participant numbers across groups and the fact that these types of agricultural work share similar physical demands—such as repetitive bending, lifting, carrying, and postural stress—these differences are unlikely to lead to significant variations in the mechanics of low back pain between groups. Since no major discrepancies in occupational work type exist, it can be inferred that any differences in outcomes between the groups will more likely result from the effects of the interventions themselves (WFE, PAT, or control) rather than from variations in work mechanics. Thus, the types of agricultural work represented in this study should not introduce bias or confounding effects in comparing the intervention outcomes for low back pain.

The results of our study demonstrate that both supervised, home-based PAT and WFE are effective for pain control and disability improvements in individuals with chronic LBP. While the overall improvements in pain reduction and functional outcomes were similar between the two interventions, the superior pain relief seen in the PAT group can be attributed to specific mechanisms linked to abdominal muscle training.

Pain mechanisms behind PAT and WFE effects:

Core stability and muscle imbalances

The enhanced pain relief with PAT is likely due to its focus on improving core stability, which is vital for maintaining proper spinal alignment and distributing mechanical forces evenly across the spine. Chronic LBP is often associated with muscle imbalances, particularly involving weak abdominal muscles and tight lower back muscles. These imbalances increase strain on the lumbar region, contributing to persistent pain. PAT targets these imbalances by strengthening the abdominal muscles, which act as stabilizers for the spine. Stronger core muscles reduce excessive lumbar movement and improve load distribution during daily activities, thus alleviating stress on the vertebrae and mitigating pain (Crommert et al., 2021; Luciano et al., 2020).

Additionally, the weakness of the erector spinae of the thoracic region is another critical factor in the development of lower back tension and pain. Weakness in these muscles compromises spinal support, leading to increased strain on other structures of the lower back. Over time, this tension can result in the weakening of the lower back muscles and exacerbate pain. While the strengthening of abdominal muscles through PAT may not solely resolve the issue, it plays a significant role in reducing pain by providing additional spinal support and improving overall core stability. This interaction underscores the importance of addressing both muscle groups—erector spinae and abdominals—in managing chronic LBP effectively (Crommert et al., 2021; van Dieën, et al., 2003).

The pain reduction observed with PAT in this study (51%) aligns with the outcomes reported by Bae et al. (2018), who investigated the effects of assisted device progressive abdominal training in individuals with chronic LBP. Their study documented a significant reduction in pain of approximately 50% over the 4-week intervention period, with three sessions per week. Our findings suggest that PAT may provide comparable or even superior pain relief compared to WFE, which showed a pain reduction of 38.11%.

Improved neuromuscular control

PAT likely enhances neuromuscular control of the core muscles, facilitating improved motor control and proprioception, both of which are critical for pain modulation and functional recovery. Proper activation of core muscles supports the spine during movement, minimizing compensatory postural adjustments that could otherwise exacerbate pain. These improvements in neuromuscular control contribute to better posture and spinal alignment, which in turn promote sustained pain reduction and functional restoration (Luciano et al., 2020).

Lumbar flexibility

WFE, on the other hand, primarily focuses on stretching and mobilizing the muscles and soft tissues in the lower back, pelvis, and hips, with an emphasis on reducing lumbar lordosis and promoting spinal alignment. This mechanism may explain its efficacy in alleviating lumbar tension and improving mobility, particularly in individuals with conditions such as lumbar disc pathology or sciatica (Park et al., 2024). While WFE does not directly target core strength as much as PAT, it provides significant benefits by improving flexibility and reducing stiffness in the lumbar region, contributing to pain relief.

Endorphin release

Both PAT and WFE can elicit endorphin release, a natural response to physical exercise that can help reduce pain perception and improve comfort levels in individuals with chronic LBP (Amila et al., 2021; Xu et al., 2021). This physiological response further supports the effectiveness of both interventions in mitigating pain.

Minimally Important Clinical Differences (MICD) and Duration of Intervention

The observed improvement in pain reduction and disability following a 4-week supervised, home-based program is in line with findings from previous studies conducted across various settings (Nava-Bringas et al., 2021; Sukmajaya et al., 2020; Ko, 2022; Elmahdy et al., 2022; Jeganathan et al., 2018; Bae et al., 2018). Previous research indicated that the minimally clinically relevant changes for LBP are typically considered to be a difference of

20 mm on the NRS and 10 percentage points on the MODI, or achieving at least a 30% improvement (Ostelo et al., 2008). These thresholds signify the smallest changes that are meaningful to both patients and healthcare providers, reflecting patients' perceptions of improvement or recovery, corresponding to minimal changes in their outcome scores (Sipaviciene & Pilelis, 2024). Our findings demonstrated minimally important clinically differences (MICD) of 38.11% and 51.56% on the NRS for WFE and PAT, respectively, which are consistent with previous research (Nava-Bringas et al., 2021; Sipaviciene & Pilelis, 2024). Additionally, our results revealed MICD of 19.56% and 22.44% on the MODI for WFE and PAT, respectively. While these figures are relatively lower compared to the proposed cutoff value of MICD (≥ 30%), they align with previous studies investigating MODI improvements in 4-week flexion exercise interventions, which typically range around 22.56% (Nava-Bringas et al., 2021). This discrepancy may be attributed to the relatively short duration of our study intervention. Notably, Nava-Bringas et al. (2021) demonstrated MICD of 30% after a 3-month intervention (30.81%), with further improvement observed at 6 months (39.82%). Therefore, our recommendation for future research is to employ longer intervention durations to accurately detect minimally clinically important improvements in the MODI variable.

ROM, core stability, and exercise enjoyment

Additionally, the similarity in outcomes of the two exercise interventions, in terms of ROM, core stability, and exercise enjoyment, are observed. The WFE group and the PAT group, demonstrated a statistically significant increase in ROM in all directions of lumbar spine movement compared to the pre-intervention. Additionally, the WFE and the PAT group showed a significantly greater increase in flexion, extension, lateral flexion to the right and the left compared to the control group. This may be attributed to both exercises primarily stimulating various muscles including the abdominal muscles, erector spinae, and other core stabilizers, and enhancing the mobility of the vertebral joints, allowing for greater range of motion in flexion, extension and lateral flexion movements. Furthermore, the reduction in pain also promoted increased spine mobility and flexibility. This finding is consistent with the existing literature indicating that engaging in lumbar flexion exercises has been shown to improve lumbar ROM (Cho et al., 2014; Do & Chon, 2019; Freimann et al., 2015).

In this study, both exercise intervention groups demonstrated notably elevated levels of satisfaction and enjoyment with their respective exercises (18.92% and 18.17%). This is consistent with prior researches, which similarly revealed a significant increase in enjoyment of physical activity among individuals engaging in supervised exercise modalities (14.45 – 24.03%) (Lambert et al., 2020; Noradechanunt et al., 2019; Sitges et al., 2021). Our findings suggest that either intervention could be effective in enhancing the satisfaction and enjoyment of physical activity in this population. Despite the differences in the specific exercises performed in the WFE and PAT groups, it is plausible that both interventions targeted common underlying factors contributing to physical activity enjoyment among individuals with LBP. This is evidenced by the comparable effects of both interventions in reducing pain, enhancing overall physical function, and improving mobility. Researchers suggested that satisfaction and enjoyment play a key role in the maintenance of exercise (Sitges et al., 2021). Individuals with chronic LBP are inclined to favour and engage in exercise tailored to their preferences, satisfaction, and ability with an emphasis on affordability (Nava-Bringas et al., 2021; Palazzo et al., 2016; Teo et al., 2022). Given that satisfaction and enjoyment commonly act as mediating factors in exercise engagement, it is reasonable to anticipate a similar likelihood of exercise adherence when prescribing these exercises for preventive and rehabilitation purposes in a longer-term, home-based approach.

Limitation

This study has several limitations. Firstly, the short duration of the interventions warrants further investigation into the long-term effects of exercise on pain and disability. Additionally, real-time limitations were encountered during the study, particularly during the harvesting season, when participants in all groups were actively involved in physically demanding occupational tasks. Despite our encouragement for participants to maintain their usual routines, we were unable to control for confounding variables such as activities of daily living and varying occupational demands, which may have influenced the outcomes of pain and disability. Logistically, the COVID-19 pandemic significantly impacted the study's progression, particularly in rural areas where access to participants was more challenging. Restrictions on movement, public health concerns, and limited transportation affected both the scheduling of exercise sessions. Another limitation is the lack of direct measurements of individual muscle strength and flexibility, particularly in key muscle groups such as the erector spinae, multifidus, gluteus, and abdominals, which are crucial for understanding neuromuscular adaptations related to chronic low back pain (LBP). Furthermore, we did not assess the flexibility of the hip musculature, a key component of lumbar spine mechanics, which limits our ability to fully evaluate how mechanical and occupational demands contribute to the development or alleviation of LBP through targeted interventions. Finally, there may be a selection bias as participants were those who could attend regular screening and exercise sessions in the community health promotion hospitals, likely including only highly motivated individuals, which may affect the applicability and generalizability of the findings, as not all individuals in clinical practice possess the same level of motivation to engage in exercises.

Implications for clinical practice

This study provides preliminary evidence that both supervised, home-based interventions are comparably effective in reducing pain and improving disability among individuals with chronic LBP. Although WFE and PAT have been widely used for treating chronic LBP in hospital settings for decades, our findings suggest that these exercise routines are feasible options for individuals unable to access gym facilities or conventional physical therapy settings. Additionally, these methods are cost-effective and demand minimal equipment for implementation.

Our study resonates the challenges of delivering healthcare in rural settings during the post-COVID era, where accessing daily one-on-one physical therapy sessions is difficult due to pandemic-related restrictions, changes in healthcare provision, and financial constraints. Research shows that active participation in exercise is more effective than passive treatments (Akbar & Zainuddin, 2020; Fernández-Rodríguez et al., 2022; Sipaviciene & Pilelis, 2024). Therefore, we recommend adapting rehabilitation programs to focus on home-based exercises, enabling patients to manage their rehabilitation independently and align with the evolving healthcare landscape in the new normal era.

Our results highlight the importance of prioritizing exercise interventions as first-line treatments, particularly during disruptions like the COVID-19 era or future outbreaks. This approach offers clinicians diverse options. For instance, the PAT program is suitable for those struggling with weight-bearing on the lower extremities, while WFE is ideal for low-impact exercise or correcting hyperlordosis (Park et al., 2024). WFE may be particularly beneficial for those with specific conditions like lumbar disc issues and sciatica, while PAT focuses on building core strength and stability. However, WFE has a lower risk of aggravating back pain, while PAT carries a potential risk of strain if performed incorrectly, particularly in individuals with pre-existing back issues. Both exercises can be modified for various fitness levels (Nava-Bringas et al., 2021). Furthermore, these exercise regimens offer a viable option for individuals with chronic LBP who may have limited access to exercise facilities or physical therapy settings. Additionally, they are cost-effective, easy to perform, and require minimal equipment, making them feasible for implementation at home. We advocate for using WFE or PAT exercises to assist individuals with chronic LBP who can perform exercises independently at home. Community health promotion hospitals can adapt these regimens to improve overall population health and enhance quality of life across various occupational sectors.

Implications for further research

Further investigation is required to evaluate the long-term effects, variations and progression of the exercise regimens over time on outcomes. This exploration will help determine whether exercises involving greater demands, such as increased loads, and longer follow-ups or integration into multidisciplinary treatment approaches, could lead to more substantial improvements in the variables of interest.

Future studies should incorporate detailed assessments of muscle strength and flexibility to provide a more comprehensive understanding of exercise effects on LBP. Lab-based tools, such as the Isokinetic Dynamometer, could be used to assess the maximum concentric and eccentric abdominal peak torque of relevant muscle groups. Additionally, electromyography could offer valuable insights into changes in muscle electrical activity following exercise. Future research should also consider the impact of different work-related mechanical demands, such as those found in farming, on muscle strength and flexibility, to better tailor interventions for individuals with diverse occupational backgrounds.

The exercise interventions in our study involved supervised individual home-based sessions to ensure adherence and proper execution of routines. However, maintaining compliance with exercise plans at home without supervision poses a rehabilitation challenge. Therefore, investigating the effectiveness of these exercise interventions using emerging technologies, such as online exercise sessions or other telerehabilitation, instead of face-to-face approach, may be of particular research interest in the “new normal” paradigm (Muñoz-Tomás et al., 2023)

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