



## Original Article

# Investigating the Effects of Adding Kinesio Taping to Diaphragm Strengthening Exercises on Pain, Function, Core Muscle Endurance, Agility, and Balance in Female Athletes with Chronic Non-specific Low Back Pain: A Randomized Clinical Trial Study Protocol

Sara Jafarpour<sup>1</sup>, MSc; Leila Abbasi<sup>2, 3\*</sup>, PhD; Marzieh Mohamadi<sup>2,3</sup>, PhD; Hadi Sarafraz<sup>4</sup>, PhD; Aida Karami<sup>1</sup>, MSc

<sup>1</sup> Student Research Committee, Shiraz University of Medical Sciences, Shiraz, Iran.

<sup>2</sup> Physical Therapy Department, School of Rehabilitation Sciences, Shiraz University of Medical Sciences, Shiraz, Iran.

<sup>3</sup> Orthopedic & Rehabilitation Research Center, Shiraz University of Medical Sciences, Shiraz, Iran.

<sup>4</sup> Occupational Medicine Department, Hormozgan University of Medical Sciences, Bandar Abbas, Iran.

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## ABSTRACT

**Background:** Chronic non-specific low back pain (NS-LBP) is a prevalent musculoskeletal condition affecting athletes. While core muscle strengthening is effective in managing NS-LBP, the role of the diaphragm in spinal stability is often overlooked. Kinesio taping may enhance muscle function; however, its efficacy when combined with diaphragm strengthening exercises has not been explored in female athletes with NS-LBP. This study aims to investigate the effects of adding Kinesio taping to diaphragm strengthening exercises on pain, function, core muscle endurance, agility, and balance in this population.

**Methods:** This protocol describes a single-blind randomized controlled trial that will recruit 32 female recreational athletes aged 30–50 years with chronic NS-LBP. Participants will be randomly assigned to one of two groups: diaphragm-strengthening exercises with Kinesio taping (experimental group) or diaphragm-strengthening exercises alone (control group). The intervention will be conducted over 4 weeks. Outcome measures will include: pain (Numerical Rating Scale), function (Oswestry Disability Index and Athlete Disability Index), core muscle endurance (Prone Bridge Test, Side Bridge Test, Unilateral Hip Bridge Endurance Test, Feet Elevated Side Support Test), balance (Single Leg Stance Test, Y Balance Test), and agility (Illinois Agility Test). Assessments will be performed at baseline, post-intervention, and at 2-week follow-up.

**Results:** The study will provide evidence on the effectiveness of combining Kinesio taping with diaphragm strengthening exercises in female athletes with NS-LBP.

**Conclusion:** Findings may guide clinical practice by determining whether this combined approach yields superior outcomes compared to diaphragm exercises alone.

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\*Corresponding author: Leila Abbasi; Physical Therapy Department, School of Rehabilitation Sciences, Shahid Doran Campus, Sadra Shahr Road, Fars, Iran, Email: [leabbasi@sums.ac.ir](mailto:leabbasi@sums.ac.ir)

## Introduction

Low back pain (LBP) is a common musculoskeletal condition, with prevalence rates in Iran ranging from 14.4% to 84.1%, depending on age and sex [1, 2]. Among athletes, the one-year prevalence of LBP has been reported to range between 17% and 94% [3]. When the specific cause of LBP cannot be identified, the condition is classified as non-specific low back pain (NS-LBP), which accounts for more than 90% of cases [4]. Several factors contribute to the development of LBP, with reduced lumbar stability and impaired motor control being among the most significant [5]. Strengthening the core muscles enhances endurance and plays a key role in alleviating pain and improving spinal function, particularly in the lumbar region [6].

One of the most important core muscles is the diaphragm, which functions both as a respiratory muscle and a postural stabilizer. Its contraction helps stabilize the lumbar vertebrae by increasing intra-abdominal pressure in coordination with the transverse abdominal muscle. This coordinated activity during tasks such as lifting heavy objects prevents excessive lumbar flexion and reduces the risk of injury during sports training [7].

In individuals with LBP, the mechanism of intra-abdominal pressure generation differs from that in healthy individuals [8]. Additionally, in patients with chronic LBP, the diaphragm exhibits a higher resting position, reduced excursion, and greater fatigability [4]. Reduced endurance or increased fatigability of the diaphragm is directly associated with impaired balance performance [9]. These functional differences appear to be more pronounced in women than in men, likely due to physiological differences, such as differences in respiratory tract structure and smaller chest dimensions [10, 11].

The diaphragm's postural and balance functions are closely linked to its strength and endurance [12]. Diaphragm endurance exercises enhance respiratory function, increase antioxidant capacity, improve fatigue resistance, and protect against exercise-induced oxidative stress by sustaining prolonged muscular activity, which is important for both healthy individuals and patients with respiratory conditions, including those on mechanical ventilation [13]. In contrast, diaphragm strengthening exercises focus on maximizing force output through shorter, high-intensity contractions, leading to muscle hypertrophy [14]. While both training modalities are important for respiratory health, endurance exercises primarily improve oxidative capacity and fatigue resistance, whereas strengthening exercises enhance force production [15]. Several studies have demonstrated that diaphragm exercises can effectively improve upper body stability, balance, and functional performance in athletes [12, 16].

One established method for enhancing muscle function is muscle taping. Taping not only helps optimize the length-tension relationship between actin and myosin in the muscle but also improves blood flow, enhances proprioceptive feedback, and reduces pain through indirect neurological inhibition [17–22].

The present study hypothesizes that adding Kinesio taping to diaphragm strengthening exercises will produce greater improvements in pain, function, core muscle endurance, balance, and agility in female athletes with NS-LBP compared to diaphragm strengthening exercises alone. If diaphragm taping is found to be effective in reducing pain and improving functional outcomes, athletes may benefit from a more convenient and efficient treatment, without altering their existing exercise routines and with fewer visits to physiotherapy centers. These effects may also provide long-lasting improvements in performance and spinal stability.

## Methods

### Study Design

This study is a single-blind randomized controlled clinical trial. The trial was registered with the Iranian Registry of Clinical Trials (IRCT; <https://www.irct.ir>; IRCT201909044734N5) on September 5, 2023. The study flow is illustrated in Figure 1.

Eligible participants will receive a detailed explanation of the study procedures and will be asked to read and provide written informed consent before participating. The study protocol was approved by the Ethics Committee of Shiraz University of Medical Sciences (SUMS) (Approval ID: IR.SUMS.REHAB.REC.1402.013) on July 26, 2023. All procedures will be conducted in accordance with the Declaration of Helsinki.

### Subjects

Participants with chronic non-specific low back pain (NS-LBP) will be recruited through convenience sampling via advertisements in medical centers affiliated with Shiraz University of Medical Sciences and local fitness clubs in Shiraz.

Inclusion criteria will be:

1. Female athletes aged 30–50 years.
2. Chronic LBP with a duration of at least 3 months.
3. Average pain intensity between 3 and 7 on the Numerical Rating Scale (NRS) over the past week.
4. Recreational athletes participating in bodybuilding or its sub-disciplines for 4–6 hours per week [23].
5. Disability score of 50 or less on the Oswestry Disability Index (ODI).

Exclusion criteria include:

- History of spine or rib fractures, scoliosis, or spinal surgery.
- Diagnosed with spinal canal stenosis, inflammatory back pain, or radicular pain.
- Neuromuscular or systemic conditions such as myopathy, neuropathy, multiple sclerosis, rheumatoid arthritis, or other inflammatory joint diseases.
- Respiratory conditions, including chronic bronchitis, lung cancer, chronic obstructive pulmonary disease, recent cough, or other respiratory symptoms.
- Pregnancy, diabetes, or receipt of physiotherapy within the 6 months before the study.

All measurements will be conducted at the Clinic of the School of Rehabilitation Sciences, Shiraz University of Medical Sciences, Shiraz, Iran.

*Sample Size*

Based on a previous study [16], the total sample size was calculated to be 32 participants (16 per group), considering the Numerical Rating Scale (NRS) as the primary variable. The calculation was performed with a 95% confidence interval, 90% power, and an anticipated 20% dropout rate.

*Group Assignment*

Participants will be randomly assigned to groups using block randomization with eight blocks of four, generated via online randomization software. During the first sampling session, each participant will select a non-transparent, sealed envelope prepared in advance that determines their assigned treatment group.

Enrollment, eligibility assessment, informed consent, group assignment, and intervention delivery will be performed by a trained physiotherapist. All outcome measurements will be conducted by a second physiotherapist, who will remain blinded to group allocation to minimize assessment bias.

*Intervention*

*1. Experimental Group*

On the day of baseline evaluation, diaphragmatic exercises will be taught under the supervision of a physiotherapist. Participants will also receive a training pamphlet (Table 1) with pictures detailing all exercises to facilitate home practice.

Participants in the experimental group (diaphragmatic exercises combined with Kinesio taping) will attend the clinic every 4 days for taping application. Weekly training videos will be shared via WhatsApp, Telegram, or other social platforms. Participants will perform diaphragmatic breathing exercises 5 days per week, twice daily, 10 minutes per session, following the exercise protocol outlined in Table 1 [16]. The intervention will continue for 4 weeks.

To ensure adherence, the physiotherapist will make weekly phone calls to participants. Before each taping

session, participants will shave and clean the target area. Kinesio taping will be applied as follows: the participant will raise their arms above their head and extend the trunk. The base of the tape will be attached approximately 1 inch below the xiphoid process, and the tape tail will be applied over the rib cage with 10–15% tension, extending from the abdominal area over the diaphragm toward the back. Participants will then lean forward and cross their arms to allow the physiotherapist to attach the tape from the xiphoid projection on the back toward the ribs [24].

Diaphragm taping will be performed every 4 days, with one rest day, for a total duration of 4 weeks.

*2. Control Group (Exercise Therapy)*

Participants in the control group will perform the same diaphragmatic exercises as the experimental group [16], without Kinesio taping. All exercises should be performed painlessly.

Exercise progression will be guided by patient feedback and symptom tolerance. If a participant reports increased pain at the end of a week, the progression will be postponed, and the same exercise regimen will be repeated during the following week.

*Outcome Measures*

Outcome measures will include pain, function, static and dynamic balance, core muscle endurance, and agility, assessed at baseline, post-intervention (4 weeks), and 2-week follow-up.

Pain will be measured using the Numerical Rating Scale (NRS), a horizontal line numbered 0 to 10, where 0 indicates no pain, and 10 indicates the maximum pain. The NRS has demonstrated high reliability for pain assessment [25].

Functional disability will be assessed using the Oswestry Disability Index (ODI) and the Athlete Disability Index (ADI). ODI consists of 10 sections, each scored from 0 to 5, with a reliability range of 0.75 to 0.91 [2, 27]. ADI, more specific for athletes, contains 12 sections scored from 0 to 3, with the final score reported as a percentage. ADI provides a more detailed evaluation of functional activity and sports performance compared to ODI [26].

**Table 1:** Exercise Therapy Protocol

| Weeks | Exercises  |   |
|-------|--|---|
|       | 1  | 2   |
| 1     | While lying on your back, take deep breaths and try to raise and lower your stomach without moving your shoulders or chest.  | While lying flat on your stomach, take deep breaths and try to raise and lower your stomach without moving your shoulders or chest.   |
| 2     | Repeat last week's exercise against the resistance of the Traband. *   | Repeat last week's exercise against the resistance of the Traband. *  |
| 3     | Sit on a hard chair. Bend your hips and knees to 90 degrees, then place your feet on the floor. In this position, take deep abdominal breaths without moving your shoulders and chest. | Lie on your back and bend your hips, knees, and ankles at 90 degrees. The arch of the lower back should not be separated from the ground. Do deep breathing without moving the shoulders and chest. |
| 4     | Repeat last week's exercise against the resistance of the Traband. *   | Repeat last week's exercise against the resistance of the Traband. *  |

\* Traband is placed horizontally in the thoracolumbar junction direction in breathing resistance exercises.

Tip: Do all the breathing exercises without holding your breath three times in a row, then rest for 5-10 seconds. Continue this order for 5 minutes per exercise, twice a day [16].

Core muscle endurance will be evaluated with four tests: 1) Prone Bridge Test (PBT), 2) Side Bridge Test (SBT), 3) Unilateral Hip Bridge Endurance test (UHBE), and 4) Feet Elevated Side Support test (FESS). In the Prone Bridge Test (PBT) and Side Bridge Test (SBT), the duration for which a participant can maintain weight-bearing on the hands and feet in prone and side-lying positions, respectively, without pelvic deviation, is recorded [28–30]. In the Unilateral Hip Bridge Endurance (UHBE) test, the participant performs a bridge on both legs in the crook-lying position, then repeats the movement while keeping one leg randomly elevated with the knee fully extended [31].

The Feet-Elevated Side Support (FESS) test assesses trunk muscle endurance while minimizing the influence of potential shoulder issues on performance. During the test, the participant places their feet on a 15-cm step stool, with the upper leg positioned in front. For comfort, a pillow is placed on the step stool. The participant's head and shoulders rest on the mat, and the hands are crossed over the chest [28]. The duration the participant can maintain this position is recorded for all endurance tests.

The Single Leg Stance (SLS) test and the Y Balance Test (YBT) are both highly reliable and valid for evaluating balance in patients with chronic LBP. In the SLS, the participant stands on their dominant leg, with their hands on their hips, flexing the hip and knee to 45° and 90°, respectively. The time they can maintain this position without losing balance or removing their hands from the hips is recorded [32].

In the YBT, three lines are drawn in a Y-shape with angles of 90° and 135°. The participant stands on their dominant leg at the intersection and reaches with the opposite leg as far as possible along the lines in three directions: anterior, posterior-medial, and posterior-lateral. The maximum distance achieved over three attempts, without losing balance, is recorded [33].

The Illinois Agility Test (IAGT) is a valid and straightforward method to assess athletic agility. The participant begins lying behind the starting line. Upon the whistle, they complete a five-by-ten-meter course while avoiding obstacles. The best time of the three trials is recorded [34]. For the other endurance and balance tests, the average time or distance of three trials is reported as the outcome.

#### *Data Collection and Sources*

After providing participants with detailed information about the study and obtaining informed consent, they will be randomly assigned to the intervention or control groups. Data collection will commence immediately after group allocation and continue throughout the trial until all outcome measures have been assessed. All participants are expected to complete the full study protocol, and any personal information will be kept strictly confidential. Only aggregated data will be reported in publications.

Statistical analysis will be performed using SPSS version 25, with a significance level set at  $p < 0.05$ .

Descriptive statistics will include mean, standard deviation, and frequency distributions. In contrast, inferential analyses will include the independent-samples t-test, the Mann-Whitney U test, the repeated-measures ANOVA, or the nonparametric equivalent, Friedman's test, depending on the distribution and nature of the data.

#### **Discussion**

This study protocol presents the rationale and methodology for a randomized clinical trial investigating the additive effects of Kinesio taping combined with diaphragm-strengthening exercises on pain, function, core muscle endurance, agility, and balance in female recreational athletes with chronic non-specific low back pain (NS-LBP). The rationale is based on emerging evidence that the diaphragm plays a critical role not only in respiration but also in lumbar spine stabilization [7, 8].

Individuals with chronic NS-LBP often exhibit diaphragm dysfunction, characterized by altered position, reduced excursion, and increased fatigability [4]. Such impairments may compromise core stability and postural control [9], which are crucial for athletic performance and injury prevention. By implementing a structured diaphragm strengthening program, this study aims to address these deficits. The addition of Kinesio taping is hypothesized to further enhance diaphragm function by improving proprioception, optimizing muscle length-tension relationships, and reducing pain [17–22].

This trial has the potential to provide evidence on whether the combination of Kinesio taping and diaphragm exercises produces superior outcomes compared to exercise alone. Findings may inform clinical practice by offering a practical, low-risk, and time-efficient intervention for athletes with NS-LBP, potentially improving functional performance, reducing pain, and enhancing core stability and postural control.

A major strength of this study lies in its rigorous methodological design. As a single-blind, randomized controlled trial, it effectively minimizes potential biases and enhances the internal validity of the findings. Another notable strength is the comprehensive set of outcome measures. While primary outcomes such as pain and general function are assessed using validated tools such as the NRS and ODI, the study also incorporates sport-specific metrics via the Athlete Disability Index (ADI) and objective, performance-based assessments of core muscle endurance, static and dynamic balance, and agility. This multidimensional evaluation provides a holistic

understanding of the intervention's effects, ensuring that observed changes are not only statistically significant but also clinically meaningful for an athletic population.

Furthermore, the study protocol incorporates strategies to enhance adherence and real-world applicability. The provision of illustrated exercise pamphlets, weekly instructional videos, and regular phone follow-ups is intended to support participants in correctly performing the home-based program, thereby improving compliance and maintaining the trial's internal validity.

However, several limitations should be acknowledged. First, the inability to blind participants and the treating physiotherapist to group allocation is an inherent constraint in trials involving tactile interventions such as Kinesio taping. Although the assessor remains blinded, participant expectation bias may still influence outcomes. Second, the 4-week intervention period, while adequate to detect initial improvements, may not capture long-term retention of benefits; the 2-week follow-up provides some insight, but longer-term assessment would be valuable in future studies. Finally, the exclusive focus on female recreational athletes, while addressing gender-specific gaps in the literature [10], limits the generalizability of the findings to male athletes or elite-level competitors.

The potential implications of this study are substantial. If the combined intervention proves superior, it would provide evidence for a simple, non-invasive, and cost-effective adjunct to conventional exercise therapy. Such an approach could offer clinicians a practical tool to enhance outcomes in athletes with NS-LBP, potentially reducing the number of treatment visits and allowing more consistent management within the athlete's training environment. By specifically targeting the diaphragm, this study also contributes to a paradigm shift in LBP management, highlighting the critical role of respiratory muscle function in core stability and rehabilitation.

## Conclusion

This study protocol aims to investigate the combined effects of diaphragm strengthening exercises and Kinesio taping in female athletes with chronic non-specific low back pain. Findings from this randomized clinical trial will provide valuable evidence regarding the effectiveness of this integrated approach on multiple outcomes, including pain, function, core muscle endurance, balance, and agility. If proven effective, this combined intervention could offer a practical, non-invasive treatment option that allows athletes to continue training while managing their low back pain. The results will inform clinical practice by

determining whether adding Kinesio taping to diaphragm-strengthening exercises provides superior outcomes compared with exercise alone. This knowledge will be particularly valuable for clinicians working with female athletes, addressing a significant gap in the literature regarding gender-specific therapeutic approaches for chronic non-specific low back pain in athletic populations.

## Author's contributions

SJ contributed to conceptualization, preliminary studies, proposal writing, and data collection and analysis. LA participated in conceptualization, data collection, and analysis, and final manuscript revision. AK was involved in data collection and manuscript editing. MM and HS contributed to conceptualization, proposal writing, and final manuscript revision. All authors read and approved the final manuscript.

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**Conflict of Interest:** None.

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