

Intervention Study on Mat-Based Pilates for Posture Correction in Medical Students: A Case of Shoulder Asymmetry

Anjun Zhang

Kunming Medical University, Kunming, Yunnan, China

Abstract: Under the combined influence of intensive academic pressure and prolonged forward-leaning study posture, medical students are highly susceptible to postural problems such as shoulder asymmetry. These issues tend to occur early, are easily overlooked, and can negatively affect cervical-shoulder function, body alignment, and the physical capacity required for future clinical work. Mat-based Pilates, which emphasizes core stability, deep muscle activation, and symmetry control, has been recognized as an effective approach for improving muscular imbalances around the shoulder girdle and spine. This study recruited medical students with shoulder asymmetry and adopted a pre-test–intervention–post-test design to implement an eight-week mat-based Pilates program. Systematic assessments were conducted on acromion height difference, scapular symmetry, cranio-shoulder angle, core stability scores, and the flexibility of related muscle groups. The results show that mat-based Pilates can reduce shoulder height discrepancies, enhance scapular control and core stability, and promote improvements in postural symmetry and muscular coordination. These findings highlight the practical value of Pilates as an intervention for posture correction. This study provides a safe, low-risk, and sustainable exercise-based approach for improving shoulder asymmetry in medical students, offers a feasible model for posture-health education and targeted physical training in universities, and suggests that future research may incorporate three-dimensional posture scanning and electromyographic analysis to further explore the underlying mechanisms.

Keywords: Mat-Based Pilates; Posture Correction; Shoulder Asymmetry; Medical Students; Exercise Intervention

1. Introduction

With the rapid expansion of digital learning environments and increasing demands in medical education, medical students often maintain high-load study postures for extended periods. Frequent forward-leaning reading, laboratory operations, and prolonged use of electronic devices place continuous tension on the cervical and shoulder muscles, progressively leading to muscular imbalance. As a result, shoulder asymmetry has become one of the most common postural abnormalities in this population. Such asymmetry not only affects appearance but is closely associated with shoulder girdle instability, neck-shoulder pain, reduced respiratory efficiency, and abnormal upper-limb movement patterns. If left uncorrected, these functional deficits may worsen during future clinical practice, including physical examinations, procedural tasks, surgeries, and prolonged standing, all of which may increase fatigue accumulation and the risk of musculoskeletal injury. Although postural health should be an important component of medical education, it has not received adequate attention, and targeted interventions for shoulder asymmetry are particularly scarce. Consequently, medical students may gradually develop maladaptive postural patterns that become difficult to reverse. Pilates is known for its emphasis on core stability, body control, deep muscle activation, and symmetrical movement training, and has demonstrated considerable value in posture improvement and rehabilitation. Mat-based Pilates, which requires no equipment, has low space requirements, and features highly controllable movements, is particularly suitable for university and medical student populations. Its training philosophy focuses on activating deep stabilizers such as the transversus abdominis and multifidus, improving trunk control, and restoring shoulder girdle alignment, thoracic mobility, and muscular balance. Existing studies—both domestic and international—have widely applied Pilates for low back pain, postural deviation, and sports rehabilitation; however, research specifically targeting shoulder asymmetry in medical students remains limited. Many studies lack standardized quantitative indicators, consistent training duration, or diversified samples. Based on these gaps, the present study

selected typical shoulder asymmetry among medical students as the intervention target, designed a systematic mat-based Pilates training program, and applied multidimensional indicators such as acromion height difference, scapular symmetry, cranio-shoulder angle, and core stability to evaluate its effectiveness. The goal is to provide empirical evidence for posture-health education among medical students, to support the development of posture intervention models in universities, and to offer theoretical and practical insights for expanding the use of Pilates within medical education contexts.

2. Materials and Methods

2.1 Participants and Posture Measurement Methods

This study recruited undergraduate medical students through voluntary sign-up and preliminary screening. Initial screening was conducted via an online questionnaire and on-site postural assessment to identify individuals with noticeable acromion height differences. Inclusion criteria were: age 18–25 years, right-hand dominance, no acute or chronic shoulder injuries, no history of spinal surgery or severe structural deformities, and a minimum of 5 mm shoulder height discrepancy during pre-test assessment. Exclusion criteria included recent participation in strength training or professional posture correction, lower-limb length discrepancy affecting posture evaluation, or inability to complete the eight-week intervention[1]. All participants provided written informed consent, and the study adhered to medical ethical principles to ensure confidentiality and participant safety. Postural assessment was conducted using a digital posture evaluation system in combination with manual anatomical landmark identification to ensure accuracy and reproducibility. Prior to assessment, trained evaluators marked key anatomical points, including bilateral acromion points, inferomedial scapular angles, the C7 spinous process, and pelvic reference points. Participants stood naturally with a neutral gaze, feet shoulder-width apart, and relaxed posture[2]. A three-dimensional posture photography system and standardized front- and side-view images were used to record shoulder height, scapular position, and cranio-shoulder angle. Shoulder height difference was calculated from the vertical distance between each acromion and the floor. Scapular symmetry was assessed by measuring the horizontal distance between the inferomedial scapular angle and the spinal midline. Cranio-shoulder angle was determined based on the positional relationship between the tragus and acromion. To enhance reliability, each participant underwent repeat measurements under static conditions, and the average value was used for analysis. Inter-rater and intra-rater consistency were checked to ensure measurement reliability. All assessments were conducted under fixed lighting, consistent background, and standardized camera distance to minimize environmental interference[3].

2.2 Intervention Design and Pilates Training Protocol

This study developed an eight-week structured mat-based Pilates intervention grounded in the principles of “core stability–whole-body control–symmetry coordination.” Participants trained three times per week, with each session lasting 45–55 minutes. The program consisted of four components: warm-up, core activation, shoulder-girdle correction exercises, and full-body stretching, following a progressive intensity model that emphasized movement precision and stability[4].

As shown in Figure 1, the intervention incorporated thoracic extension, scapular stabilization exercises, the Swan, scapular control drills, and stretching movements for the neck, shoulders, and back. These exercises collectively targeted thoracic mobility, scapular retraction and depression, and activation of deep stabilizing muscles. Thoracic extension helped counteract thoracic kyphosis and anterior shoulder rounding caused by prolonged studying. Scapular stabilization emphasized downward rotation, retraction, and controlled external rotation, addressing common patterns of scapular elevation and internal rotation in individuals with shoulder asymmetry. The Swan and other spinal extension exercises strengthened the posterior kinetic chain and enhanced thoracic extension capacity. Side-lying series and scapular control movements further promoted balanced strength distribution between the left and right sides of the body. Through the coordinated action of these exercise groups, Pilates training activated the transversus abdominis, multifidus, serratus anterior, and rhomboids, strengthened core control, and improved shoulder height discrepancies caused by muscular imbalance. All training sessions were supervised by qualified Pilates instructors to ensure movement precision, appropriate load, and maximal training effectiveness[5].

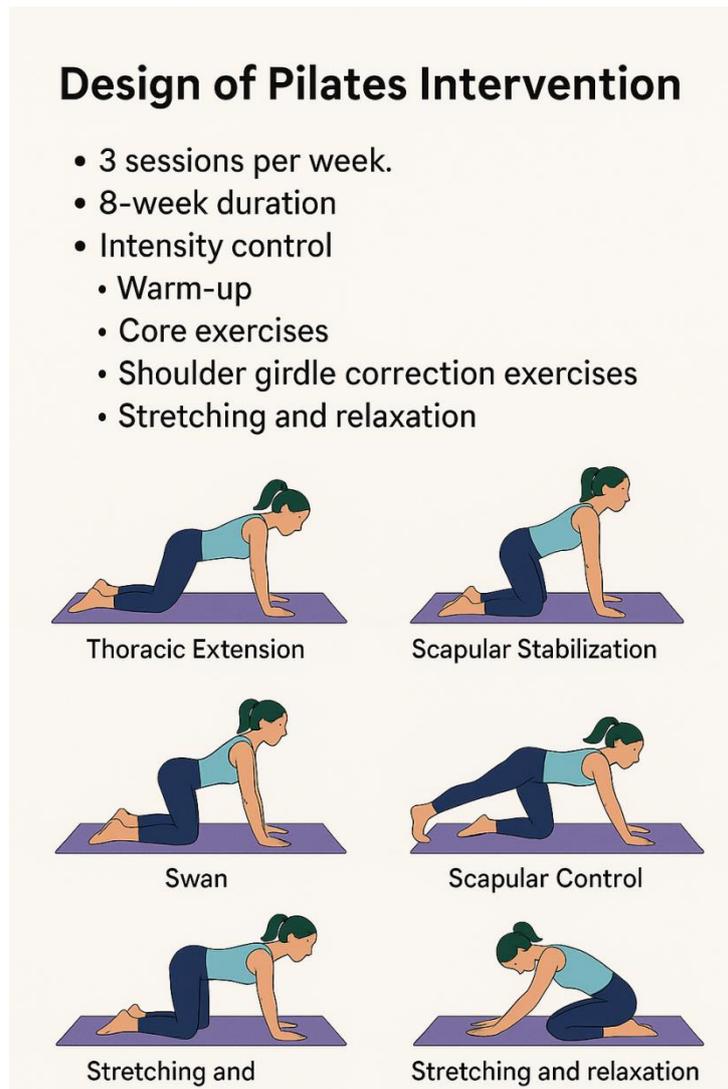


Figure 1 Design of Pilates Intervention

3. Data Collection and Indicator System

3.1 Postural and Functional Assessment Indicators

In this study, a systematic assessment framework was constructed across four dimensions—postural symmetry, shoulder-girdle stability, core control ability, and muscle flexibility—to comprehensively evaluate the effectiveness of mat-based Pilates in improving shoulder asymmetry among medical students. Postural indicators included acromion height difference, scapular symmetry, and the cranio-shoulder angle. Among these, acromion height difference served as the primary indicator of shoulder asymmetry and quantified the vertical deviation between the left and right acromion points. Scapular symmetry reflected the positional balance of the scapulae, enabling differentiation between structural and functional contributors to shoulder asymmetry. Changes in the cranio-shoulder angle were used to assess head-shoulder alignment and thoracic mobility. Functional indicators consisted of scapular stability scores, core stability scores, and flexibility measurements of relevant muscle groups. Core stability assessments focused on the activation and control of deep stabilizers such as the transversus abdominis and multifidus[6]. Flexibility evaluations examined common hypertonic muscles associated with shoulder asymmetry, including the upper trapezius, levator scapulae, and pectoralis minor, to determine whether these tight muscle groups were effectively relaxed. All indicators were measured under identical environmental conditions during pre- and post-assessments, and data collection was carried out by trained evaluators following standardized procedures to ensure reliability and comparability[7].

Table 1 Indicators for Posture and Functional Assessment

Category	Indicator	Description	Method	Data Type
Posture	Acromion Height Difference	Reflects shoulder height symmetry	Vertical distance difference of bilateral acromion points (mm)	Continuous
	Scapular Symmetry	Assesses lateral distance of scapula relative to the spine	Anatomical landmark photography	Continuous
	Cranio-Shoulder Angle	Reflects head-forward posture and thoracic alignment	Angle formed by tragus-acromion line (°)	Continuous
Function	Scapular Stability Score	Assesses scapular control ability	Standardized stability testing	Ordinal
	Core Stability Score	Evaluates activation of deep core muscles	Core control tests (plank, pelvic control, etc.)	Ordinal
	Upper Trapezius Tension	Assesses hypertonicity of common tight muscles	Manual palpation + flexibility test	Ordinal
	Pectoralis Minor Flexibility	Identifies anterior shoulder tightness	Doorway stretch / flexibility angle	Continuous

To present the assessment structure more clearly, Table 1 summarizes all postural and functional indicators, along with their corresponding measurement methods and data types, providing a foundation for subsequent results analysis.

3.2 Data Collection Procedures and Reliability Control

The data collection process adhered to principles of standardization, repeatability, and quantification to ensure the scientific rigor and reliability of all postural and functional assessments. Before formal measurement, participants were briefed with standardized instructions and prepared in a controlled environment, removing shoes and accessories, exposing shoulder and spinal landmark areas, and standing in a relaxed natural posture to minimize tension-related distortions. All assessments were conducted in the same laboratory, where lighting, background color, and floor markers remained constant to reduce external interference. During both pre- and post-tests, trained evaluators identified key anatomical landmarks such as the acromion points, inferomedial scapular angles, C7 spinous process, and tragus. High-resolution posture photography captured multiple angles to ensure complete three-dimensional posture documentation[8]. Functional assessments—including core stability tests, scapular control evaluations, and flexibility measurements—were also standardized in terms of instruction, testing tempo, and evaluator consistency to avoid procedural bias. To enhance reliability, each key postural indicator was measured twice under static conditions, with a third measurement conducted if necessary, and the mean value was used for analysis. Both intra-rater and inter-rater reliability checks were performed to confirm consistency. Measurement tools were calibrated before each assessment session, including adjustments to camera height, leveling devices, and software settings, ensuring comparability across time points. During data entry and processing, cross-checking by two independent researchers minimized human error. Furthermore, all assessments were conducted under blinded conditions; evaluators were unaware of participants' pre-test results during post-testing to avoid expectation bias. These stringent control measures ensured the accuracy, stability, and reliability of the collected data, establishing a sound basis for subsequent quantitative analysis of intervention outcomes[9].

4. Results

4.1 Postural Improvement Analysis

Following the eight-week mat-based Pilates intervention, all major postural indicators showed varying degrees of improvement. Acromion height difference, the primary indicator of shoulder asymmetry, demonstrated a consistent reduction, suggesting that the bilateral shoulder positions had become closer to a natural state of balance. Participants who exhibited pronounced lateral deviation during the pre-test showed noticeable reductions in asymmetry in the post-test, and their shoulder girdles gradually returned to a more symmetrical alignment. This improvement appears closely related to enhanced scapular adherence to the thoracic wall and improved core stability developed during

training. Similarly, measurements of the inferomedial scapular angle showed that pre-existing patterns of scapular winging, internal rotation, or excessive elevation became more stable and more centrally aligned relative to the spine, indicating improved scapular control and coordination. The cranio-shoulder angle also improved meaningfully after training. Some participants initially exhibited forward head posture and excessive cervical flexion; however, after thoracic extension drills, scapular stabilization exercises, and breathing-focused training, the cranio-shoulder angle shifted closer to a neutral range. Thoracic mobility improved, chest expansion increased, and participants were able to maintain a more natural shoulder posture during standing. Importantly, the overall postural changes reflected an interaction between structural improvement and functional enhancement. Shoulder height imbalance proved not to be correctable through simple stretching alone but required coordinated activation of deep stabilizers and improved thoracic mobility to achieve sustainable correction. Collectively, the reduction in acromion height difference, stabilization of scapular position, and normalization of cranio-shoulder angle indicate that the Pilates intervention demonstrated strong corrective potential for shoulder asymmetry in medical students. These improvements reflect the training's effectiveness in rebalancing muscle activity and reshaping trunk control mechanisms, forming the basis for subsequent functional enhancements[10].

4.2 Functional and Muscular Balance Improvements

After completing the eight-week intervention, participants exhibited marked improvements in core stability, scapular control ability, and flexibility of key muscle groups. Core stability scores showed upward trends, with participants demonstrating smoother pelvic control, better trunk stabilization, and more stable limb movements. Consistent activation of deep core stabilizers such as the transversus abdominis and multifidus provided stronger internal support, reducing compensatory shoulder movements and facilitating correction of muscular imbalances associated with shoulder asymmetry. Scapular stability indicators improved in parallel. Participants who initially displayed scapular elevation, winging, or dysfunctional rotation patterns showed reductions in these deviations following the intervention. Movement trajectories during elevation, depression, and retraction became more stable, and scapulothoracic rhythm improved, indicating effective activation of key stabilizers such as the serratus anterior, rhomboids, and lower trapezius. Improved scapular control not only enhanced shoulder girdle stability but also contributed to reductions in acromion height discrepancy. Flexibility tests revealed relaxation of hypertonic muscles including the pectoralis minor, upper trapezius, and levator scapulae. Participants demonstrated increased range of motion during cervical side flexion, thoracic expansion, and shoulder extension, accompanied by reduced tension sensations in the neck-shoulder region. The combination of enhanced flexibility and improved strength provided a dual mechanism supporting posture correction, enabling participants to sustain more balanced shoulder alignment in daily activities. Overall, the improvements in functional control and muscular balance suggest that Pilates training reshaped the cooperative relationships among shoulder-girdle muscles, promoting more even force distribution and smoother kinetic-chain function. The synergy between functional enhancement and muscular balance provided intrinsic support for correcting shoulder asymmetry. These findings demonstrate that Pilates is well suited for high-risk groups such as medical students and can support long-term postural health.

5. Discussion

5.1 Interpretation of Results and Mechanisms of Action

The findings of this study indicate that mat-based Pilates training exerts a clear positive impact on both posture and function in medical students with shoulder asymmetry. This improvement reflects the unique advantages of a Pilates training system centered on core stability and scapular control in addressing imbalances of the shoulder girdle. The reduction in acromion height difference and the stabilization of scapular position are direct manifestations of successful correction, and essentially represent a redistribution of muscular forces involving both deep stabilizing muscles and scapular control muscles. By emphasizing neutral trunk alignment, breathing control, and small-amplitude, multiplanar precision movements, Pilates training continuously activates deep core muscles such as the transversus abdominis, multifidus, pelvic floor muscles, and diaphragm. This "core-driven" movement pattern enhances thoracolumbar stability, fundamentally reducing compensatory movements of the upper body during postural control and providing a more stable foundation for restoring the three-dimensional position of the shoulder girdle. Improvement in shoulder-girdle function is another

key mechanism observed in this study. Scapular stabilization exercises, the Swan, thoracic extension drills, and quadruped core control movements in the Pilates program repeatedly engage the serratus anterior, lower trapezius, and rhomboids—muscles that are essential for scapular retraction, depression, and stabilization. Among medical students who spend long periods bent over while studying, excessive upper trapezius tension, pectoralis minor shortening, and scapular abduction are common, placing the scapula in a non-neutral position and further contributing to shoulder height asymmetry. By promoting a more natural “scapula-on-thorax” relationship, Pilates helps participants reestablish coordinated movement trajectories between scapular motion and trunk stability, thereby reducing scapular elevation and abnormal rotational patterns. Enhanced scapular control not only stabilizes the acromion position but also decreases compensatory muscle activity arising from scapular instability, making it easier to correct asymmetrical shoulder posture. Improved thoracic mobility also plays an important role in the correction of shoulder asymmetry. Prolonged forward-leaning posture in medical students often leads to thoracic stiffness and restricted rib cage expansion, which further affects shoulder girdle alignment. Thoracic extension, rotation, and mobilization exercises in Pilates help restore the physiological curvature of the thoracic spine, allowing the shoulders to be adjusted on a more appropriate postural foundation. Increased thoracic mobility provides a more balanced support base for the shoulder girdle, thereby facilitating a return of both shoulders to a neutral alignment in both static and dynamic conditions. In addition, improvements in muscle flexibility and the reestablishment of strength balance jointly constitute important intrinsic mechanisms underlying the corrective effects observed in this study. Following the intervention, tight muscles such as the pectoralis minor, upper trapezius, and levator scapulae exhibited a trend toward relaxation, so that the shoulder girdle was no longer passively pulled upward or forward. At the same time, deep stabilizing muscles that were previously weak but critical for shoulder-girdle stability gradually regained strength, enabling the shoulders to maintain a more balanced structural position through active control. The combined enhancement of flexibility and strength allowed participants to develop more stable shoulder-girdle control in daily posture, thereby reinforcing the durability of the corrective effect. In summary, the beneficial impact of Pilates on shoulder asymmetry in medical students does not arise from changes in a single muscle group, but from a multi-mechanism synergistic process driven by enhanced core stability, improved scapular control, increased thoracic mobility, and restored muscle flexibility. This integrated mechanism explains why postural changes present as gradual yet stable, and highlights Pilates, as a deep-control training approach, as having three key advantages in postural correction: sustainability, systematicity, and functional relevance.

5.2 Limitations and Directions for Future Research

Although this study demonstrates positive trends in the improvement of shoulder asymmetry among medical students following a structured Pilates intervention, several limitations in study design and implementation must be acknowledged and addressed in future research. First, the sample size was relatively small, and participants were drawn from a single institution and age group, with similar lifestyles and academic workloads. This homogeneity limits the generalizability of the findings. Students of different genders, majors, and stages of training may exhibit distinct postural characteristics and loading patterns, and future studies should therefore expand sample sources and incorporate multicenter, multi-group comparative designs to enhance the external validity of the conclusions. Second, the intervention period in this study was eight weeks. Although postural and functional improvements were observed, Pilates is fundamentally a long-term training approach based on neuromuscular control and adaptation, and the durability of postural changes requires longer follow-up periods. Future research could design interventions lasting 12 or even 24 weeks, and include follow-up assessments to examine the maintenance of corrective effects. Moreover, the assessment methods in this study primarily relied on surface anatomical landmarks, two-dimensional posture photography, and functional tests. Although these methods are widely used in clinical and research settings, they have limitations in capturing deep muscle activity patterns, scapulothoracic rhythm, and complex compensation chains. Future studies could incorporate more sophisticated measurement tools, such as three-dimensional posture scanning, electromyography (EMG), motion capture systems, or ultrasound imaging, to elucidate the specific mechanisms by which Pilates influences deep muscle activation and reorganizes movement control patterns. In addition, integrating wearable devices to monitor posture dynamically during daily study and life would help capture real-world changes in medical students' posture over time. With regard to the training protocol, this study adopted a standardized Pilates program for all participants. However, individuals differ in baseline strength, motor control ability, and the underlying causes of their postural deviations. Future research could explore individualized training prescriptions tailored to specific types of shoulder asymmetry (e.g., structural vs. functional), directions

of scapular deviation, and degrees of thoracic mobility restriction. Comparative studies between standardized and individualized protocols could further clarify the added value of personalized interventions. Furthermore, multimodal intervention strategies could be examined, combining Pilates with techniques such as myofascial release, neuromuscular re-education, breathing training, or behavioral posture management to enhance the overall effectiveness of posture correction. Overall, this study provides preliminary evidence supporting the application of Pilates in correcting shoulder asymmetry among medical students, but larger samples, longer intervention and follow-up periods, and more advanced assessment technologies are still needed to deepen theoretical understanding and broaden its practical application. Future research that integrates multimodal assessment methods, individualized training strategies, and dynamic monitoring technologies will help establish a more comprehensive, clinically relevant, and educationally meaningful system for posture-health interventions, thereby offering stronger scientific support for postural management and occupational fitness protection in university populations.

6. Conclusion

Focusing on the common issue of shoulder asymmetry in medical students, this study evaluated the effects of an eight-week mat-based Pilates intervention on posture and function. The results indicate that Pilates training effectively reduces acromion height differences, improves scapular position stability and cranio-shoulder alignment, and promotes a more symmetrical shoulder-girdle posture. Core stability, scapular control ability, and thoracic mobility all showed positive trends, while the flexibility of tight muscle groups also improved, suggesting that Pilates plays a significant role in restoring muscle balance and optimizing kinetic-chain coordination. Overall, mat-based Pilates, as a sustainable, low-risk, and easily implementable training modality, has substantial application value for correcting shoulder asymmetry in medical students. It offers a feasible pathway for posture-health education and physical intervention in universities and lays a foundation for future research on the mechanisms of Pilates and the development of individualized correction strategies.

Acknowledgement

Project No. 2014J0179, Yunnan Provincial Department of Education Scientific Research Fund Project, Title: Intervention Study on Mat-Based Pilates for Posture Correction in Medical Students: A Case of Shoulder Asymmetry, Kunming Medical University, Anjun Zhang

References

- [1] Sarıtaş, Dicle, and Pelin Pişirici. "Investigation of the effect of Pilates combined exercise program with mat and equipment on fatigue and physical self-perception in sedentary women: A randomized controlled study." *Turkish Journal of Kinesiology* 10.2 (2024): 110-118.
- [2] Koo, Jin-Eun, and Kyoung-Bin Min. "Effects of Mat and Reformer Pilates Exercise Program on Lower Extremity Edema and Stress, Depression in Pregnant Women in the Second Trimester." *The Asian Journal of Kinesiology* 27.3 (2025): 44-54.
- [3] Nageswari, C., N. Meena, and B. Thillaieaswaran. "Enhancing well-being: investigating the role of Pilates in alleviating low back pain among postmenopausal women—a scoping review." *Physical Therapy Reviews* (2025): 1-12.
- [4] Ratkovic, Tamara. "The influence of Pilates reformer exercises on non-specific lumbar pain." *Advances in Health and Exercise* 5.2 (2025): 118-127.
- [5] Nithuthorn, Chalisa, et al. "Effect of Pilates on Pain and Health-Related Quality of Life in Fibromyalgia Patients: A Systematic Review and Meta-Analysis." *Journal of Clinical Medicine* 13.23 (2024): 7447.
- [6] González, Jaime, and Alexis Ortiz. "Impact of Pilates mat-based exercises on knee kinematics during running." *Journal of bodywork and movement therapies* 33 (2023): 8-13.
- [7] Vera-Saura, Pablo, et al. "The importance of mind-body in pilates method in patients with chronic non-specific low back pain—a randomized controlled trial." *Journal of Clinical Medicine* 13.16 (2024): 4731.
- [8] Elbandrawy, Asmaa Mahmoud, et al. "Effect of kinesio taping versus tele-pilates intervention on pre-menstrual syndrome." *Bulletin of Faculty of Physical Therapy* 30.1 (2025): 57.
- [9] Opara, Józef Alfons, et al. "The Effects of Pilates in Parkinson's Disease—A Narrative Review."

Life 15.7 (2025): 1035.

[10] Taştan, Zarife, et al. "The effects of reformer pilates on postural alignment, body appreciation and social appearance anxiety in office workers." *BMC Sports Science, Medicine and Rehabilitation* 17.1 (2025): 1-9.