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The Effect of 8 Weeks of Pilates Training on Cognitive Function in Women with Chronic Low Back Pain

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Abstract

Background: *Patients with chronic low back pain (CLBP) often report memory complaints and perform poorly on memory assessments. This study aimed to investigate the effect of eight weeks of Pilates training on cognitive performance in women with CLBP.*
Methods: *Forty women aged 35–45 years with non-specific CLBP were randomly assigned to intervention (n=20) and control (n=20) groups. Data collection tools included the Kim Karad visual memory test and the Wechsler memory test. The intervention group participated in Pilates training three sessions per week for eight weeks, while the control group received no intervention. Data were analyzed using a repeated-measures T-test and ANCOVA at a significance level of P-value≤0.05.*
Results: *Results showed significant improvements in certain cognitive indices in the intervention group compared with the control group.*
Conclusions: *Pilates training can therefore be recommended as a safe and effective strategy for mental rehabilitation in women with CLBP.*

Keywords: Pilates, Cognitive performance, Chronic low back pain.
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Introduction

Chronic Low back pain (CLBP) is one of the most common musculoskeletal disorders and a leading cause of disability worldwide [1]. It is defined as pain, tension, or stiffness in the area between the lower rib margin and the inferior gluteal fold [2]. CLBP is categorized as acute (<6 weeks) or chronic (>3 months) [3]. Despite extensive research and various treatment approaches, CLBP remains a major contributor to healthcare costs and disability, with a global prevalence of approximately 6972.5 cases per 100,000 individuals [4]. Middle-aged women are particularly vulnerable due to anatomical differences, higher pain sensitivity, use of high-heeled footwear, pregnancy, and childbirth; therefore, restoring daily function and quality of life is especially important in this population [5-7]. Several modifiable risk factors—such as lifestyle, obesity, occupational demands, and psychological conditions including depression and anxiety—contribute to the development and persistence of CLBP [8]. In addition to physical symptoms, cognitive studies have shown that individuals with CLBP frequently report memory problems and exhibit poorer performance in cognitive assessments [9]. Current treatment strategies include surgery, medication, physiotherapy, and exercise therapy [10]. Although medications may cause side effects and physiotherapy often has limited long-term effectiveness, exercise therapy has emerged as a safe, non-invasive, and cost-effective option [11]. Physical activity is known to enhance cognitive functions such as memory, learning, attention, executive function, and processing speed [12-14]. Among different forms of exercise, Pilates has received considerable attention due to its combined physical and mental approach [15]. Pilates is a comprehensive physical and mental training method, incorporating approximately 500 controlled movements [16], focusing on whole-body coordination, mental concentration, rhythm, and breathing [17, 18]. Evidence suggests that Pilates can improve mental well-being, self-perception, and quality of life [19], and may enhance memory and executive functions through increased neurotrophin levels [20].

A central question that emerges is whether exercise can influence the cognitive performance of individuals with CLBP. In light of the documented cognitive impairments associated with CLBP and the growing evidence supporting the cognitive benefits of Pilates-based exercise, the present study was designed to examine the effects of a Pilates training program on cognitive functioning in women with CLBP, with the broader aim of evaluating its potential utility as a rehabilitation strategy for enhancing overall quality of life.

Materials and Methods

This quasi-experimental study employed a pre-test/post-test design with a control group. The study population included middle-aged women (35–45 years) diagnosed with CLBP by a physician. Inclusion criteria were persistent pain for more than three months and willingness to participate. Exclusion criteria were pregnancy, intolerable pain exacerbation, new injury, absence from >3 consecutive sessions, or medical conditions affecting study outcomes .Sample size was determined using G*Power (α=0.05, power=0.80, large effect size), yielding 40 participants. They were randomly assigned to intervention (n=20) and control (n=20) Groups were block-randomized based on baseline pain severity assessed using the Visual Analog Scale (VAS). Outcome assessors and data analysts were blinded to group allocation.

The intervention group completed eight weeks of Pilates training (three 60-minute sessions per week), consisting of :10 min of warm-up and stretching, 40 min of selected Pilates exercises (standing, sitting, lying; focused on back, pelvic floor, and abdominal muscles), 10 min of cool-down. In the first session, the basic principles of Pilates, including proper breathing, concentration, control, centering, precision, and flow, were taught and consistently emphasized throughout the program. Training intensity was progressively increased, respecting overload principles. Breathing coordination (inhale–exhale, ~10 seconds per repetition) was emphasized. During the intervention period, the control group continued with their daily activities, and after the study ended, in accordance with ethical guidelines and to uphold their rights, they carried out Pilates exercises for 4 weeks following the same training protocol. The assessment of the study variables was conducted at two time points: before the intervention (pre-test) and after 8 weeks of training (post-test). The instruments used in this study included the Kim Karad cognitive test and the Wechsler Intelligence Scale.

The Kim Karad visual memory test is administered using two cardboard sheets: the first sheet contains 20 squares with colored images, and the second sheet consists of 20 empty squares along with 20 small image pieces. This test is designed in three stages, sequentially assessing short-term, intermediate, and long-term memory. In the first stage, the participant observes the main sheet for one minute and then uses the image pieces to place the pictures in the correct positions on the blank sheet. At the end of this stage, the participant checks their responses against the main sheet and categorizes them: completely incorrect responses are placed on the right, while responses with the correct image but incorrect orientation (partially correct responses) are placed on the left. The second stage is conducted in the same manner; the participant observes the main sheet for another minute and again arranges the pieces. In the third stage, which assesses long-term memory, the participant must place the pieces in the correct positions without observing the main sheet again. In this stage, the examiner records all correct, partially correct, and incorrect responses. The memory score for each stage is calculated using a specific formula that accurately differentiates performance across the three response types (correct, partially correct, and incorrect). Thus, this test provides a comprehensive evaluation of visual memory across three different time intervals. It is noteworthy that the second and third stages begin immediately after the preceding stage, without any time gap. The scores obtained in these three stages correspond to short-term, intermediate, and long-term memory, respectively. In Iran, the validity and reliability of this test have also been examined, with a criterion validity coefficient of 0.50 and a reliability coefficient of 0.62, both statistically significant at the 0.01 level (Although the Kim Karad test has reported validity of 0.50 and reliability of 0.62 in Iranian populations, these values are relatively modest, which may limit the precision of cognitive assessments. Therefore, the results should be interpreted with caution, and future studies are encouraged to use instruments with higher psychometric properties) [21] . Considering the participants' conditions and the study objectives, memory assessment in this study was conducted only in two dimensions: short-term and long-term. The Kim Karad visual memory test evaluates visual memory performance across short-term, intermediate, and long-term recall stages; however, the present study focused only on the short- and long-term stages to capture the most robust and meaningful effects of the intervention, avoiding potential variability associated with intermediate recall. This selective assessment approach is consistent with prior use of the Kim Karad test in cognitive research (Figure 1).

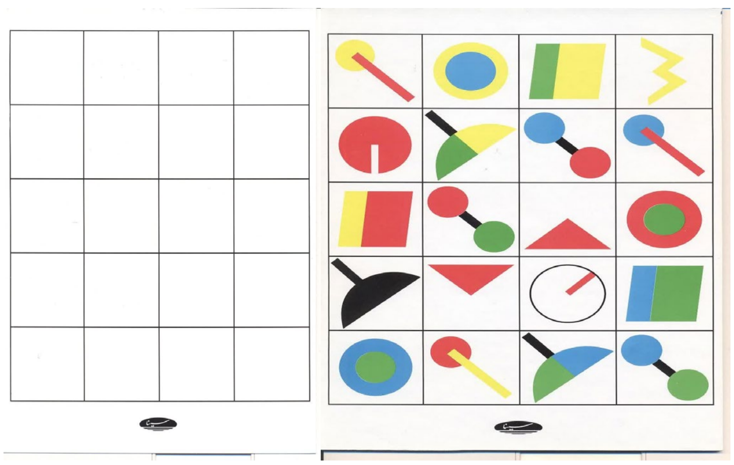

Figure 1. Kim Karad visual memory test tool

Another well-established tool for assessing memory is the Wechsler Memory Scale, which was first introduced in 1941 and is considered one of the most reliable objective methods for evaluating various dimensions of cognitive memory. This test is the result of over a decade of research on practical, immediate, and simple memory, providing valuable information for distinguishing between organic and functional memory impairments. The administration of this test allows the examination of aspects such as learning, immediate recall, concentration and attention, orientation, and long-term recall. The Wechsler test consists of seven main subscales, each measuring specific cognitive memory abilities: general awareness of daily and personal matters (6 questions), temporal and spatial orientation (5 questions), mental control (3 subtests), logical memory (retelling of two narrative texts), digit span forward and backward (two series of numbers), visual memory (four series of picture cards), and paired-associate learning (10 simple and difficult pairs). The validity and reliability of this test have been confirmed in numerous studies. Correlation coefficients between the results of this test and the Wechsler intelligence subscales have been reported to range from 0.66 to 0.83, indicating high reliability and structural consistency in assessing cognitive abilities related to memory. For these reasons, the Wechsler test is widely used in psychological research and clinical applications to evaluate memory performance across diverse populations [22]. Considering the participants' conditions and the objectives of the present study, only the dimensions of orientation and mental control were assessed using the Wechsler test. Although the Wechsler Scale encompasses multiple cognitive domains, this study focused only on orientation and mental control. The rationale for selecting these subscales was to specifically assess attentional control and working memory, which are most likely to be influenced by the intervention. Nonetheless, the exclusion of other subscales limits the generalizability of the findings, and future research should include a broader range of cognitive measures.

This article is derived from a Master's thesis approved by the Ethics Committee of Shahrood University of Technology, with the ethical code (IR.SHAHROODUT.REC.1403.039). Written informed consent was obtained from all participants prior to enrollment.

Results

Demographic variables (age, height, weight, BMI) did not significantly differ between groups (P-value≥0.05). These findings indicate that the two groups were homogeneous in terms of demographic and physical characteristics (Tables 1 and 2).

Table 1. Mean and standard deviation of age, height, weight, and BMI of participants

Group	N	Age (years)	Height (cm)	Weight (kg)	BMI
Pilates exercise	18	41.55±0.94	162.55±1.96	76.91±2.50	29.16±0.86
Control	16	45.75±2.78	161.13±0.99	77.31±3.81	30.66±1.10
Independent t-test	–	P-value=0.145 (t=1.49)	P-value=0.591 (t=−0.54)	P-value=0.932 (t=0.87)	P-value=0.287 (t=1.08)

Table 2. Results of the dependent t-test for within-group comparison

	Group	Mean difference	T	Significance level	Effect size
Short-term memory	Experimental	0.875	5.653	0.001	1.413
	Control	2.000	1.990	0.063	0.469
Long-term memory	Experimental	0.812	2.360	0.032	0.590
	Control	0.388	0.349	0.732	0.082
Orientation	Experimental	4.15	7.410	0.016	0.681
	Control	2.093	1.407	0.180	0.352
Mental control	Experimental	4.120	3.434	0.004	0.859
	Control	0.277	0.893	0.384	0.210

Within-group analysis (Dependent t-test):

• Experimental showed significant improvements in short-term memory (t=5.653, P-value=0.001 group), long-term memory (t=2.360, P-value=0.032), orientation (t=7.410, P-value=0.016), and mental control (t=3.434, P-value=0.004).

• Control group showed no significant changes.

Between-group analysis (ANCOVA):

• Significant group effects were observed for short-term memory (F=4.505, P-value=0.042, η^2=0.127), long-term memory (F=13.524, P-value=0.001, η^2=0.304), and orientation (F=13.502, P-value=0.001, η^2=0.303).

• No significant effect was found for mental control (F=0.072, P-value=0.791) (Table 3).

Table 3. Results of the analysis of covariance (ANCOVA) for comparing exercise groups

	Source of effect	Sum of squares	Df	Mean square	F	P-value	Effect size
Short-term memory	Group	26.635	1	26.635	4.505	0.042	0.127
Long-term memory	Group	109.626	1	109.626	13.524	0.001	0.304
Orientation	Group	72.703	1	72.703	13.502	0.001	0.303
Mental control	Group	0.546	1	0.546	0.072	0.791	0.002

Discussion

Eight weeks of Pilates training significantly improved cognitive performance in women with CLBP. Visual memory scores (Kim Karad test) and Wechsler subscales (orientation and mental control) improved meaningfully in the intervention group, while the control group showed no change or decline.

For instance, the mean short-term memory score on the Kim Karad test in the experimental group increased from 0.71 to 1.06, while the control group remained virtually unchanged (0.23). In terms of long-term memory, the mean score in the experimental group increased from 0.87 to 0.89, whereas the control group experienced a decrease from 0.53 to 0.46. These results indicate a positive and sustained effect of Pilates exercises on visual memory across different time intervals, emphasizing the role of regular physical activity in enhancing cognitive performance in individuals with CLBP.

In the Wechsler test, results related to orientation and mental control also demonstrated significant improvement in cognitive performance in the intervention group. The mean orientation score in the experimental group increased from 0.21 to 0.45, while in the control group it changed from 3.62 to 3.51. Additionally, in the mental control subscale, the experimental group improved from 0.35 to 0.41, whereas the control group decreased from 1.27 to 0.91. These data suggest that targeted Pilates exercises not only enhance short- and long-term memory but also strengthen cognitive abilities related to attention, focus, and mental control.

The interpretation of these results can be explained through physiological and neurological mechanisms. Pilates exercises, by combining mental focus, controlled movements, and deep breathing, can stimulate central nervous system activity and increase cerebral blood flow. Improved oxygenation and nourishment of neural cells, along with elevated levels of neurotrophins in brain regions associated with learning and memory, may enhance cognitive performance [23]. These findings are consistent with the study by Movahedi et al. (2016), which showed that Pilates exercises employing repeated mental focus can enhance cognitive and perceptual processing [24]. Rahmani et al. (2014) also reported that 8 weeks of Pilates training led to a significant improvement in cognitive status and reaction time in the post-test compared to the control group [25]. Findings by Julaei et al. (2017) demonstrated that selected Pilates exercises significantly improved short-term memory in older women [26]. Moreover, Akasheh and Shabanzadeh (2017) showed that Pilates can serve as an effective, low-cost complementary intervention for improving mental health indices [27].

Clinically, the findings are important since women with CLBP often face reduced quality of life. Cognitive improvements may enhance pain management, mental well-being, and engagement in daily life. Pilates, being low-cost, safe, and feasible in clinical or home settings, is an accessible rehabilitation strategy for this population. Although Pilates was described as a low-cost and home-feasible intervention, this claim is not directly supported by data from the present study and is based solely on the general characteristics of the exercise modality. As no cost or feasibility assessments were conducted, this point should be interpreted cautiously and warrants further investigation in future research.

Conclusion: These findings highlight the potential of Pilates to support cognitive functioning in women with CLBP, suggesting that its benefits extend beyond physical rehabilitation alone. By integrating a mind–body approach that emphasizes controlled movement and focused attention, Pilates may offer a practical strategy for addressing the interconnected physical and cognitive challenges associated with chronic pain. Incorporating this modality into rehabilitation programs could therefore contribute to more holistic and sustainable improvements in patient well-being. Specifically, engaging in Pilates three times per week at a moderate intensity may be sufficient to achieve the desired effects.

Ethical Considerations

This study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Ethical approval was obtained from the relevant institutional Ethics Committee prior to the commencement of the study. All participants were fully informed about the purpose and procedures of the study, as well as any potential benefits and risks associated with participation. Written informed consent was obtained from all participants before their inclusion in the study. Participation was entirely voluntary, and participants were informed of their right to withdraw from the study at any time without any consequences. All personal information and collected data were treated confidentially and were used solely for research purposes. Participants' identities were protected throughout the study, and no personally identifiable information was disclosed.

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Conflict of Interest

We, the authors, declare that we have no financial, personal, or any other conflicts of interest relevant to the content of this manuscript.

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