

REVIEW PAPER

Effects of Pilates programs on physical and mental health outcomes in women with low back pain: a systematic review

Mirjana Đukić^{1(A,B,C,D,E,F,G)}, **Radenko Matić**^{2(A,B,E)}, **Miloš Kojić**^{1(C,D)}

¹Faculty of Sport and Physical Education, University of Novi Sad, Novi Sad, Serbia

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Address for correspondence: Mirjana Đukić, Faculty of Sport and Physical Education, University of Novi Sad, Dr Zorana Đinđića 1, 21102 Novi Sad, Serbia, e-mail: mirjanadjukic05@gmail.com

ORCID: Mirjana Đukić <https://orcid.org/0009-0001-5166-032X>, Radenko Matić <https://orcid.org/0000-0002-3059-2719>, Miloš Kojić <https://orcid.org/0000-0002-4515-7664>

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Abstract

Low back pain is viewed as a public health problem. Women have a higher prevalence of low back pain than men in all age groups. Pilates is currently one of the most popular exercise methods in the world, so the aim of this review paper is to cover and consolidate the existing literature that points to the use of Pilates in women diagnosed with low back pain. Web of Science, Scopus, and PubMed databases were used for the literature review. The inclusion criteria were: the study includes women as participants, the participants were diagnosed with low back pain, a specific Pilates method was used, the participants have no other diseases and are not pregnant, the study is written in English. Based on the database search, 108 papers were identified, of which nine met all criteria and were included in the final analysis. These studies covered 445 women, with 251 women undergoing a specific type of Pilates program. The results showed that Pilates programs influenced pain reduction, improvement of muscular and functional abilities, as well as improvement of quality of life. Therefore, Pilates can be a very good way to reduce low back pain, especially in the female population.

Keywords: Pilates, low back pain, rehabilitation, women, health

Introduction

Low back pain is one of the leading causes of disability worldwide, both in high-income countries and in those with low living standards [1]. Low back pain can occur in all age categories, and it is considered that most people experience it at some point in their lives, which shows the prevalence of this condition. An increasing number of people suffer from low back pain, which is why certain authors consider it a public health problem [2].

There are different definitions that explain low back pain, but it is most often defined as a musculoskeletal disorder, characterized by pain or discomfort in the lumbar region, from the 12th rib to the lower gluteal folds [3]. According to European guidelines, there are several types of low back pain, among which are acute, subacute, chronic, recurrent, and nonspecific pain [4]. Acute low back pain is described as an episode of pain lasting less than 6 weeks, while chronic episodes are described as those lasting longer than 12 weeks. Subacute low back pain is pain that lasts from 6 to 12 weeks. Recurrent low back pain refers to pain that occurs after a period of at least 6 months without pain. Nonspecific low back pain is considered pain that is not typical. Many studies have pointed out different types of physical exercise that help reduce low back pain, such as aerobic and anaerobic exercises for core muscles [5], resistance training [6], dynamic stretching [7], as well as Pilates [8].

Pilates as a method of exercise went through different phases before becoming what we see today. The method was created by Joseph Pilates, studying ways in which exercise could help soldiers recover from war-related illnesses. Afterwards, his system was recognized by dancers, who used his program to improve their performance. After that, the founder of Pilates developed a series of exercises that are used today to improve proper posture, movement, and the muscular system [9]. There are more than 500 exercises, which include stretching and strengthening, and which are applied within the Pilates method. There are also two basic categories, namely mat exercises and apparatus exercises [10]. Pilates is based on several principles that must be respected in every session. The principles of Pilates include centering, concentration, control, precision, flow of movement, and breathing [11].

There are several systematic reviews that show the impact of different types of activities on the reduction of low back pain [12-14]. Moreover, the Pilates method today is among the most popular forms of activity practiced worldwide [15]. According to previous research, women have a higher prevalence of low back pain compared to men, and this is true across all age groups. A key role is played by the lack of estrogen, which after menopause leads to the degeneration of intervertebral discs. This process also occurs in men, but in women after the age of 50, it accelerates sharply [16]. When talking about pain sensitivity, it is important to note that women are more sensitive to chronic pain. They also often report symptoms of depression associated with pain [17]. Precisely because of this, the authors of this study consider it very important to investigate and expand the knowledge about the effects of Pilates programs in individuals with this type of pain, predominantly in the female population.

Aim of the work

The aim of this systematic review is to consolidate the literature that demonstrates the effects of Pilates programs in women diagnosed with low back pain.

Methods

Search strategy and study selection

In order to highlight the impact of Pilates on low back pain in the female population, a search of the Web of Science, Scopus, and PubMed databases was conducted for the period from January 1, 2021, to May 9, 2026, representing literature from the last 5 years. During the

search of each of the listed databases, Boolean search syntax was used, employing the operator “AND” and the keywords in English “low back pain” AND “Pilates” AND “women”. This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. All identified records were entered into a new database using EndNote software in order to remove all duplicates. The selection of studies included in this systematic review had several phases. The first phase involved reviewing databases and finding studies that matched the keywords. The first phase of the search was conducted by two independent authors (MD, RM). The second phase, also conducted by two independent authors (MD, MK), consisted of selecting studies based on reading titles and abstracts. The final selection consisted of reading the full texts. Any disagreements were resolved through discussion or consultation with the first author (MD).

Eligibility criteria

There were certain criteria that a study had to meet in order to be included in this review: (1) the sample consisted of women regardless of age; (2) the participants had diagnosed low back pain not caused by trauma; (3) a specific type of Pilates exercise was conducted; (4) the participants had no other present illnesses and were not pregnant; (5) the study was written in English. The exclusion criteria included the following: (1) Pilates was not the primary method; (2) the study represented a meta-analysis or a review article; (3) no study was available in English.

PICO framework

The PICO framework was used to form the sample of participants and to establish the research question in this systematic review, as well as to determine the criteria for the selection of studies. The PICO framework for this research was as follows:

Population: Women with low back pain.

Intervention: Pilates exercise program.

Comparison: The control group was either subjected to an exercise program or was not subjected to any program.

Outcomes: Different parameters of physical and mental health.

Data extraction and synthesis

Data extraction was carried out by two independent researchers (MĐ, MK), who entered the data from each study into a Microsoft Excel table. From each study, data were extracted on the name of the first author, year of publication, study design, and level of evidence. Regarding the sample, the data included the sample size of each study, the average age in the experimental and control groups, as well as the inclusion and exclusion criteria. Regarding the treatment, the extracted data included the type of program applied in the experimental group, the treatment conducted in the control group, and the duration and frequency of the program. Regarding the outcomes, the extracted data included information on changes in both physical and mental health of the participants after a specific Pilates treatment.

As the studies differ considerably, both in terms of the type of Pilates program used and the outcomes, meta-analysis is not possible, which is why the results of all studies were synthesized and presented descriptively.

Risk of bias

All studies included in this review were categorized according to the type of study, with eight studies being randomized controlled trials (RCT) and one being non-RCT, i.e. a case-control study. In order to perform the assessment for RCT studies, the Revised Cochrane risk-of-bias tool (RoB 2) was used, while for the non-RCT study, the Risk Of Bias In Non-Randomized Studies of Interventions (ROBINS-I) was used. According to the RoB 2 categorization, studies could be assessed as low risk of bias, some concerns, and high risk of bias. According to the ROBINS-I categorization, the study could be assessed as low risk of bias, moderate risk of bias, serious risk of bias, and critical risk of bias. The overall risk of bias was determined based on the highest level of bias in any domain. Two independent researchers (MĐ, MK) performed the assessment, while all disagreements were resolved by consensus.

Literature review results

Study selection

Figure 1 shows the study selection process. A total of 108 papers were identified through the search of three databases (Web of Science = 55, Scopus = 34, PubMed = 19). After removing

duplicates, 68 papers remained. The titles and abstracts of these 68 papers were reviewed, after which 49 papers were excluded for several reasons. The reasons for excluding the 49 papers were: (1) the study population did not include women (1 paper); (2) the study focused on pregnancy (13 papers); (3) the participants had other comorbidities besides low back pain (12 papers); (4) other methods were used instead of Pilates (5 papers); (5) review articles/meta-analyses (15 papers); healthy population without low back pain (3 papers). After reviewing titles and abstracts, 19 papers remained for further analysis. Of these 19, five did not have full text available, leaving 14 papers for detailed reading and analysis, after which five papers were excluded because they represented meta-analyses and review articles (n=1), Pilates was not the primary intervention (n=1), the participants were not only women (n=1), and two studies were not available in English (n=2). In the end, nine studies were included in the review, of which eight were RCT while one was non-RCT (case-control). In Table 1, the following is presented: the first author and the year of publication of the papers included in this review, the journal in which they were published, the study design, and the level of evidence.

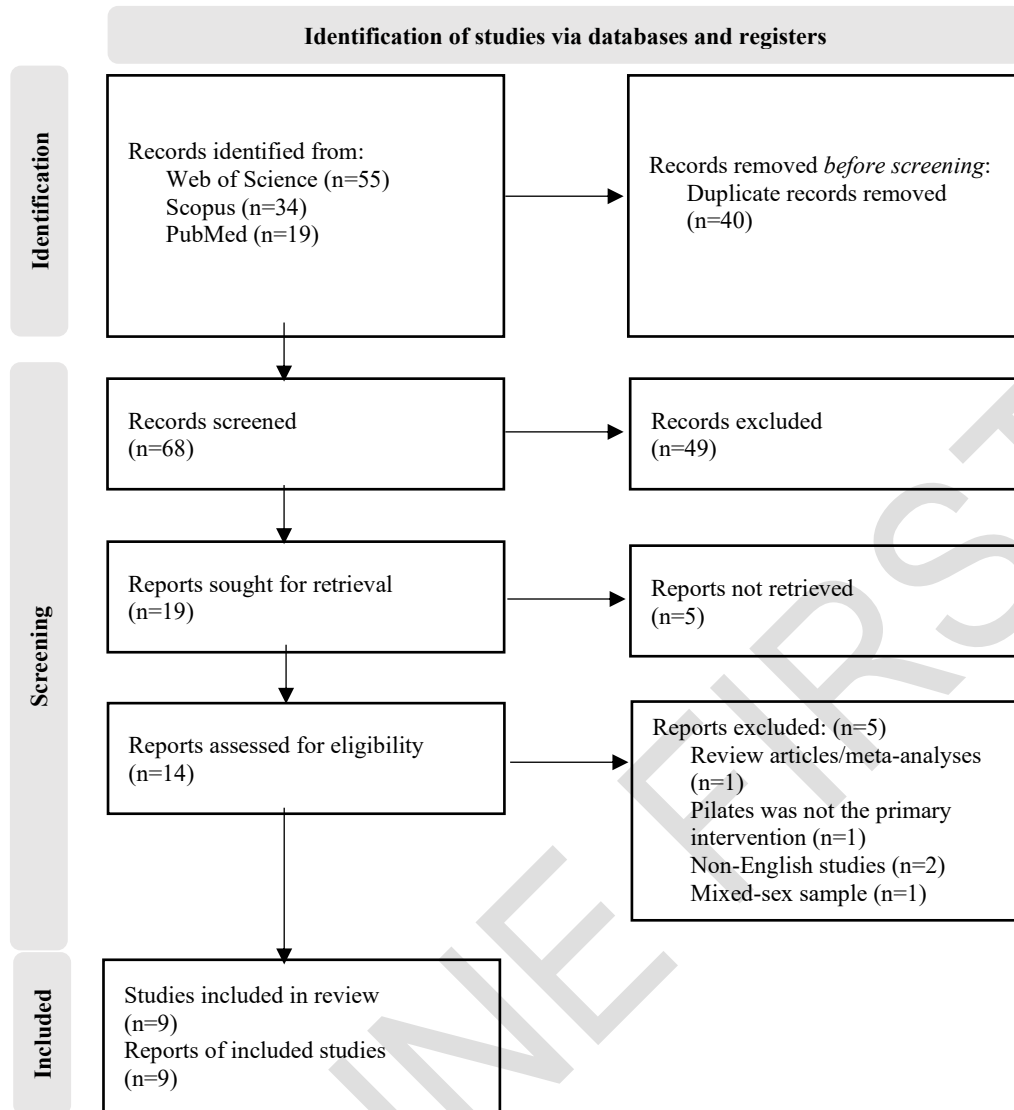


Figure 1. PRISMA flow diagram – study selection

Table 1. Characteristics of the studies

Study	Journal	Study design (level of evidence)
1. Baskan et al. [22]	<i>Annals of Clinical and Analytical Medicine (ACAM)</i>	RCT (II)
2. Batıbay et al. [18]	<i>Journal of Orthopaedic Science</i>	RCT (II)
3. Castro et al. [19]	<i>Pain Management</i>	RCT (II)
4. Ferri-Caruana et al. [20]	<i>Journal of Functional Morphology and Kinesiology</i>	RCT (II)
5. Goldberg et al. [26]	<i>Kinesiology</i>	Case-control (III)
6. Ha et al. [23]	<i>Medicine</i>	Pilot RCT (II)
7. Marotta et al. [24]	<i>Journal of Functional Morphology and Kinesiology</i>	RCT (II)
8. Nageswari and Meena [25]	<i>International Journal of Physiotherapy</i>	RCT (II)
9. Şahan et al. [21]	<i>BMC Psychology</i>	RCT (II)

Notes: RCT – randomized trial designs.

Study characteristics

In the studies included in the analysis, a total of 445 women were enrolled in the research. Of those, 251 women underwent a specific type of Pilates program. Out of the nine studies included in this systematic review, two were conducted in Türkiye, one each in India, Brazil, Spain, South Korea, and Italy, while for two studies, it was not clearly specified where they took place. Pilates protocols in five studies were conducted by physiotherapists, in two studies by Pilates instructors, in one study, it was emphasized only that the treatment was supervised, while in one study, it was not clearly stated who conducted the Pilates program. In eight out of nine studies, all participants in both the experimental and control groups had some form of low back pain, while in one study, the control group consisted of healthy women.

In each study, the authors reported the sample size, the average age of the participants, as well as the inclusion and exclusion criteria, which can be seen in Table 2. The most common reason for not including participants in the studies was pregnancy, in as many as six studies. Next, certain spinal surgery in five studies, neurological diseases in five studies, participation in other exercise programs in four studies, BMI higher than 30 kg/m² or obesity in three studies, specific therapies or use of medications in the previous 3 months in three studies. Other exclusion criteria were present in one or two studies.

Table 2. The sample of the participants in the studies

Study	Sample size	Mean age
1. Baskan et al. [22]	40	P: (n=20) 41.55±3.39; HE: (n=20) 38.95±3.96
2. Batibay et al. [18]	60	P: (n=28) 49.3±10.4; HE: (n=25) 48.4±9.3
3. Castro et al. [19]	22	Pilates without accessories (n=11) 57.18±10; Pilates with accessories (n=11) 61.45±7.54
4. Ferri-Caruana et al. [20]	96	P: (n=49) 55.5±4.6; Usual care: (n=47) 56.1±5.4
5. Goldberg et al. [26]	40	Control: (n=18) 41.63±13.46; NSCLBP: (n=22) 38.86±11.36
6. Ha et al. [23]	32	SMR+Pilates (n=16) 37.00 (6.70); P: (n=16) 34.19 (7.85)
7. Marotta et al. [24]	21	P: (n=11) 53.8±5.5; CE: (n=10) 50.8±5.3
8. Nageswari and Meena [25]	80	P: (n=15) 45-50 / (n=25) 50-56; Control: (n=13) 45-50 / (n=27) 50-56
9. Şahan et al. [21]	54	P: (n=27) 34.22±7.08; Control: (n=27) 34.81±7.15
Study	Inclusion criteria	Exclusion criteria
1. Baskan et al. [22]	Diagnosed LBP ≥8 weeks, present LBP ≥3 months	Pregnancy, radicular low back pain, spinal surgery, orthopedic and neurological diseases

2. Batibay et al. [18]	CNLBP ≥ 3 months, VAS 3-6, women 18-60 years	Malignancies, infections, inflammatory diseases, severe osteoporosis, metabolic bone diseases, pregnancy, obesity, cognitive impairment, nerve root compression, spine surgery, absence from the Pilates program more than 3 sessions in total, unfilled exercise diary for ≥ 3 days
3. Castro et al. [19]	Postmenopausal woman, NSLBP ≥ 3 months, VAS ≥ 4 , no physical exercise (3 months), medical clearance for physical activity	Hormone replacement therapy, analgesics, attendance $< 75\%$ (intervention period), participation in other exercise programs or treatments
4. Ferri-Caruana et al. [20]	Lumbar or lumbosacral pain ≥ 6 months, ODI score $> 6/50$, no back treatment ≥ 3 months	BMI > 30 kg/m ² , surgery (pelvis, spine, lower extremities), scoliosis, systemic or degenerative diseases, neurological deficits, pregnancy, hypertension
5. Goldberg et al. [26]	Adult women 21-65 years, NSCLBP, LBP > 12 weeks	Pregnancy, BMI > 30 , spine or abdominal surgery, trauma, spondyloarthropathies, neurological symptoms in the limbs, neurological diseases, participation in an ongoing physical exercise program, previous treatments or medication (last 3 months), previous experience with the Pilates method
6. Ha et al. [23]	Adult women 20-50, CLBP ≥ 12 weeks, KODI score $\geq 17\%$	LBP caused by trauma, neurological conditions involving the lower limbs (e.g., radiculopathy, peripheral neuropathy, motor deficits), lumbar disc pathology, hip, pelvic, or abdominal surgery, pelvic dysfunction (e.g. pelvic prolapse), radiation or injection treatment within the previous 3 months, pregnancy, childbirth within the previous year
7. Marotta et al. [24]	Middle-aged adult women, CNLBP, NRS > 4 , consent to discontinue pharmacological treatment, willingness to not reintroduce such treatment for the entire duration of the study	Severe cognitive impairment (MMSE < 24), inability to provide informed consent, acute worsening of back pain, pregnancy or breastfeeding, tumor pathologies, other rehabilitation or physical instrumental therapies, surgical procedures (last 6 months), allergy to adhesives used for marker placement
8. Nageswari and Meena [25]	Postmenopausal women NSLBP, outpatients from the physiotherapy department	Not reported by authors
9. Şahan et al. [21]	Female, chronic musculoskeletal pain ≥ 6 months, characteristics of pain: increasing with physical exertion and decreasing with rest, cognitive ability for understanding exercise	LBP or neck pain because of other diseases, spinal surgery (last 6 months), history of emotional problems and psychiatric disorders, an exercise or physical therapy program (last 3 months)

Notes: P – Pilates, HE – home exercise, CE – conventional exercise, SMR – self-myofascial release, LBP – low back pain, CLBP – chronic low back pain, CNLBP/NSCLBP – chronic nonspecific low back pain, NSLBP – nonspecific low back pain, VAS – Visual Analogue Scale, NRS – Numeric Rating Scale, ODI – Oswestry Disability Index, KODI – Korean Oswestry Disability Index, BMI – Body Mass Index, MMSE – mini-mentar state examination.

In Table 3, the intervention for both the experimental and control groups of participants is presented, along with the duration of the program and its frequency. In four studies, the program lasted 8 weeks, in two studies, it lasted 6 weeks, while in one study each, the programs lasted 5 and 12 weeks respectively. In three studies, the authors stated that the program was conducted through three sessions per week, while in six studies, the program was conducted through two sessions per week. The sessions lasted between 40 and 60 minutes. In two studies, the participants assigned to the control group followed a home exercise program as treatment; in two studies, conventional exercise programs were used; while in three studies, the control group did not receive any treatment but simply continued with their daily activities. In one study, the impact of a Pilates program with equipment versus without equipment was compared, so the control group was actually the group of participants who engaged in the Pilates program with equipment. Additionally, in one study, the authors compared the effects of a combination of self-myofascial release and reformer Pilates with home exercises against a program combining reformer Pilates and home exercises.

Table 3. Characteristics of the programs and main results

Study	Experimental group	Control group	Duration	Frequency
1. Baskan et al. [22]	Clinical Pilates	Home exercise	8 weeks	45 min, 3x/wk
2. Batıbay et al. [18]	Pilates mat exercise program	Home exercise	8 weeks	60 min, 3x/wk
3. Castro et al. [19]	Pilates without accessories	Pilates with elastic resistance accessories	8 weeks	50-60 min, 2x/wk
4. Ferri-Caruana et al. [20]	Pilates exercise program	No intervention	8 weeks	60 min, 2x/wk
5. Goldberg et al. [26]	Pilates program (mat + equipment)	No intervention	5 weeks	60 min, 2x/wk
6. Ha et al. [23]	Self-myofascial release combined with Reformer Pilates + home exercise program	Reformer Pilates only + home exercise program	6 weeks	P: 2x/wk /HE: 3x/wk, 15 min
7. Marotta et al. [24]	Pilates Matwork program	Conventional exercise program	4 weeks	40 min, 2x/wk
8. Nageswari and Meena [25]	Pilates exercise program	Conventional exercise program	12 weeks	50 min, 3x/wk
9. Şahan et al. [21]	Reformer Pilates	No intervention	6 weeks	45-50 min, 2x/wk
Study	Main findings			
1. Baskan et al. [22]	↓ Pain ↑ Muscle strength ↑ Balance ↑ Functional reach ↓ Disability ↔ Respiratory functionality			

2. Batibay et al. [18]	↓ Pain ↓ Disability level ↓ Depression score ↑ Physical function ↑ Spine flexibility ↑ Abdominal muscle endurance ↑ Lumbar and abdominal muscle thickness ↑ Health status
3. Castro et al. [19]	↓ LBP intensity ↓ LB Functional disability ↑ Abdominal strength (PAG) ↑ Lumbar muscle strength (PAG, PG) ↓ CK levels
4. Ferri-Caruana et al. [20]	↓ Pain intensity ↑ Functional capacity ↑ FRR asymmetry ↔ Global FRR ↔ Trunk flexion range of motion
5. Goldberg et al. [26]	↔ Pain intensity ↔ Functional ↔ Left-right TrA asymmetry ↑ TrA thickness at rest (healthy group only) ↑ TrA thickness percent change during ADIM (NSCLBP group, location C) ↓ TrA thickness percent change during ADIM (healthy group, location C)
6. Ha et al. [23]	↓ Pain intensity ↓ Disability level ↓ Muscle tone ↓ Muscle stiffness ↑ Flexibility ↑ Muscular endurance ↑ Quality of life
7. Marotta et al. [24]	↓ Pain intensity ↓ Functional disability ↑ Functional capacity ↔ Global FRR ↑ FRR protective index (Pilates group)
8. Nageswari and Meena [25]	↓ Pain ↓ Disability ↑ Lumbar flexion, extension, lateral flexion and rotation ↑ Quality of life ↑ Abdominal/back endurance
9. Şahan et al. [21]	↓ Pain intensity ↓ Pain interference in daily activities ↑ Active pain coping strategies ↑ Psychological pain beliefs ↓ Kinesiophobia ↓ Fatigue ↑ Sleep quality ↔ Organic pain beliefs ↔ Passive coping strategies

Notes: P – Pilates, HE – home exercise, PAG – Pilates with accessories, PG – Pilates without accessories, LBP – low back pain, FRR – flexion-relaxation ration, TrA – transversus abdominis, CK – Creatine kinase, ADIM – abdominal drawing-in maneuver, NSCLBP – nonspecific chronic low back pain, ↓ – Significant increase, ↑ – significant decrease, ↔ – no changes.

Risk of bias

For the assessment of methodological quality of RCT studies, RoB 2 was used, while for non-RCT studies, ROBINS-I was used.

Randomized controlled trials

In the assessment of RCT studies, it was determined that four studies [18-21] were assessed as having low risk of bias, while four studies [22-25] were assessed as having some concerns. Some concerns were most often identified in domain (D4) Measurement of the outcome, and in one study [25], also in domain (D2) Deviations from intended interventions. A detailed overview of Risk of Bias for RCT studies (RoB 2) is presented in Table 4.

Table 4. Risk of Bias for RCT studies (RoB 2)

Study	D1	D2	D3	D4	D5	Overall
Baskan et al. [22]	L	L	L	SC	L	Some concerns
Batibay et al. [18]	L	L	L	L	L	Low risk
Castro et al. [19]	L	L	L	L	L	Low risk
Ferri-Caruana et al. [20]	L	L	L	L	L	Low risk
Ha et al. [23]	L	L	L	SC	L	Some concerns
Marotta et al. [24]	L	L	L	SC	L	Some concerns
Nageswari and Meena [25]	L	SC	L	SC	L	Some concerns
Şahan et al. [21]	L	L	L	L	L	Low risk

Notes: D1 – randomization process, D2 – deviations from intended interventions, D3 – missing outcome data, D4 – measurement of the outcome, D5 – selection of the reported result, L – low, SC – some concerns.

Non-randomized study

The only non-randomized study [26] was assessed using the ROBINS-I tool. In domain (D1) Confounding, a serious risk was identified, while in the other domains (D2, D3, D4, D5, D6, D7), low risk was identified. As a serious risk was identified in one domain, the overall assessment for this study was serious risk. A detailed overview of Risk of Bias for non-RCT studies (ROBINS-I) is presented in Table 5.

Table 5. Risk of Bias for non-RCT studies (ROBINS-I)

Study	D1	D2	D3	D4	D5	D6	D7	Overall
Goldberg et al. [26]	S	L	L	L	L	L	L	Serious risk

Notes: D1 – confounding, D2 – selection of participants, D3 – classification of interventions, D4 – deviations from intended interventions, D5 – missing data, D6 – measurement of outcomes, D7 – selection of the reported result, L – low, S – serious.

Effects of interventions

Pain intensity

In the studies included in this review, the parameter of pain intensity was assessed based on specific scales. In the majority of studies [18-20,22,23,26], this parameter was assessed using the Visual Analogue Scale (VAS). In the other studies, one of the following scales was used: Numeric Rating Scale (NRS) [24], Numeric Pain Rating Scale (NPRS) [25], and Brief Pain Inventory (BPI) [21]. In eight out of nine studies, a reduction in pain intensity was observed after a specific Pilates program. Baskan et al. [22] recorded a significant reduction in pain in the Pilates group (from 5.34 ± 2.5 to 1.28 ± 1.6), while in the group that exercised at home, the intensity of pain did not change (from 5.7 ± 1.76 to 5.7 ± 1.9). Similar results were shown in the study by Batibay et al. [18], where the Pilates group had significantly lower pain values (3.0 ± 1.5) compared to the group that exercised at home (4.6 ± 1.8). Comparing Pilates with elastic resistance accessories and Pilates without accessories, Castro et al. [19] indicated a reduction in pain intensity in both groups, with a reduction of 3.64 points in the Pilates group (PG) and 3.07 points in the Pilates with accessories group (PAG). The study by Ferri-Caruana et al. [20], which compared the group of participants who did Pilates and the control group without intervention, also indicated a reduction in pain in the Pilates group by 30% (from 5.9 ± 1.8 to 4.1 ± 1.3), while in the control group, there was no significant reduction (from 5.7 ± 1.8 to 5.5 ± 1.6). Similar results were indicated by Sahan et al. [21], where in the Pilates group, a change in pain intensity was recorded (from 6.18 ± 2.01 to 3.77 ± 1.98), while in the control group, there was none (from 5.25 ± 1.63 to 5.11 ± 1.55). However, Goldberg et al. [26] did not record a statistically significant reduction in pain (from 3.64 ± 2.42 to 3.1 ± 2.18). In the study by Ha et al. [23], the group of participants who applied only Pilates (from 5.75 ± 0.93 to 2.81 ± 0.75), as well as the group that applied both Pilates and self-myofascial release (from 5.69 ± 0.70 to 2.94 ± 0.57), achieved significant reductions in pain intensity. Comparing conventional exercise programs and Pilates, a reduction in pain was also indicated in the study by Nageswari and

Meena [25], from 7.2 ± 0.75 to 4.7 ± 0.85 in the Pilates group, while in the control group, it decreased from 6.97 ± 0.96 to 5.85 ± 0.72 . Lower pain intensity (1.65 ± 1.03) was observed after four weeks in the Pilates group compared to the group that did the conventional exercise program (2.9 ± 0.738) in the study by Marotta et al. [24].

Functional ability

For the assessment of functional ability, different questionnaires were used. In the majority of studies [18,22,24,25], the Oswestry Disability Index (ODI) was used. In the Ha et al. study [23], the Korean version of the Oswestry Disability Index (KODI) was used. In two studies [19,26], the Roland-Morris Disability Questionnaire (RMDQ) was used to assess functional disability. In addition to ODI, in two studies [18,24], the Quebec Disability Scale (QDS) or Quebec Back Pain Disability Scale (QBPDS) was used as an additional measure. One study [20] used the Low Back Outcome Score (LBOS), and one [21] used the Brief Pain Inventory (BPI) with a focus on the impact of pain on general activities. The ODI/KODI score assesses the impact of pain on daily activities. A decrease in the value of this score was determined in five studies [18,22-25], while the most significant decrease was in the study that compared a mat Pilates program with a conventional exercise program for low back pain [24]. Comparing the Pilates program and the home exercise program, Baskan et al. [22] indicated a reduction in disability score in the Pilates group (from 26.4 ± 14.06 to 6.2 ± 6.8), while in the other group, it remained unchanged (from 26.4 ± 13.7 to 26.1 ± 13.08). In the study by Batibay et al. [18], however, a reduction was observed in both groups, in the Pilates group from 27.9 ± 6.4 to 21.4 ± 5.9 , and in the group that applied home exercise from 30.9 ± 8.8 to 27.3 ± 9.0 . On the QBPDS, in the study by Marotta et al. [24], an improvement of 20.34 points was observed in the Pilates group, with an improvement of the ODI by 19.67 also noted. In the study by Nageswari and Meena [25], the results of the ODI score were in favor of the Pilates group (from 32.5 ± 3.02 to 23.87 ± 4.24) compared to the control group (from 33.9 ± 3.09 to 27.30 ± 2.37). Ha et al. [23] nevertheless determined that a greater reduction in the KODI score was observed in the group that combined self-myofascial release with Reformer Pilates (by 5.83%). In the study by Goldberg et al. [26], the parameters of the RMDQ score did not change significantly (from 4.54 ± 3.9 to 3.95 ± 3.86).

Neuromuscular parameters and muscle morphology

Ultrasound measurements provided results of changes in muscle structure after specific Pilates programs. One study [18] indicated an increase in the thickness of the transversus abdominis muscle (from 3.1 ± 0.7 mm to 3.5 ± 0.8 mm), while another [26] showed no change at rest but an increase in muscle thickness during contraction. In the first mentioned study [18], an increase in the thickness of the lumbar multifidus (from 25.4 ± 3.5 mm to 26.4 ± 3.4 mm), as well as the rectus abdominis ($15.6 \pm 8.6\%$), internal ($24.4 \pm 5.2\%$), and external obliques ($21.8 \pm 14.3\%$), was also indicated. Electromyography was used in two studies [20,24] to determine the phenomenon of flexion relaxation (FRP). In one study [24], it was indicated that the group that underwent a Pilates program (9.96 ± 1.316) exceeded the threshold value (≥ 9.5) of the Flexion-Relaxation Ratio coefficient (FRR), while in the other, an increase in asymmetry in muscle activation was observed (11%) [20]. In the study that compared a Pilates program and a Pilates program with self-myofascial release, in both cases, a change was observed in the form of reduced muscle tone (Right Erector Spinae: sMFR-RP group (from 18.94 to 17.75 Hz); Reformer Pilates (RP) group (from 17.35 to 17.16 Hz); Left Erector Spinae: sMFR-RP group (from 19.36 to 17.20 Hz); RP group (from 19.39 to 17.99 Hz)) and stiffness (sMFR-RP group: right rectus abdominis (2.00%); left rectus abdominis (2.04%); right erector spinae (1.68%); left erector spinae (1.51%)) [23]. Certain functional tests indicated improvements in muscle endurance in two studies [18,25], as well as improvements in muscle strength ($p \leq 0.05$) in one study [22]. Batibay et al. [18] indicated an increase from 16.6 ± 5.3 to 22.6 ± 5.5 repetitions in the sit-up test in the Pilates group, while in the group that did the home exercise program, an increase was determined from 16.3 ± 4.4 to 19.2 ± 4.5 repetitions. In the Krause-Weber test, an increase was observed from 6.10 ± 0.96 to 8.47 ± 0.94 points in the Pilates group, and in the group that did the conventional exercise program, an increase from 6.30 ± 3.09 to 7.32 ± 2.37 points was observed [25]. Castro et al. [19], comparing Pilates with accessories and Pilates without accessories, indicated changes in muscle strength, taking into account lumbar strength (PG: from 3.09 to 3.82; PAG: from 3.18 to 3.91) and abdominal strength (PG: from 3.55 to 4.00; PAG: from 3.27 to 4.09). In one study [19], it was shown that Pilates with accessories significantly reduces the level of creatine kinase (from 111.82 U/L to 67.36 U/L).

Quality of life and psychological factors

Different questionnaires were used to assess quality of life (36-Item Short Form Health Survey (SF-36), EuroQol 5-Dimension 5-Level (EQ-5D-5L), Menopause-Specific Quality of Life Questionnaire (MENQOL)), with improvements recorded in three studies [18,23,25]. Nageswari and Meena [25] confirmed a significant reduction in the MENQOL questionnaire score in the Pilates group (from 50.87 ± 7.53 to 37.85 ± 5.57), which indicates an improvement in quality of life. Ha et al. [23] indicated a reduction in the EQ-5D-5L score, i.e. an improvement in quality of life in the group that applied Pilates (from 9.44 ± 1.86 to 6.75 ± 1.13), as well as in the group that applied self-myofascial release combined with Reformer Pilates (from 9.50 ± 1.79 to 6.63 ± 1.15). Batibay et al. [18] indicated a reduction in depression in the Pilates group from 13.3 ± 7.5 to 7.0 ± 5.7 , compared to the home exercise group (from 12.4 ± 7.2 to 10.2 ± 6.1), while Sahan et al. [21] confirmed a reduction in fear of movement in the Pilates group from 39.74 ± 4.04 to 36.55 ± 3.95 , and in the control group, from 39.62 ± 3.38 to 39.74 ± 3.42 . The results also indicated an improvement in sleep (from 6.8 ± 2.41 to 4.70 ± 2.74), as well as an increase in the use of active strategies for coping with pain (distraction: from 6.62 ± 2.00 to 7.70 ± 2.079 ; pain transformation: from 3.55 ± 1.62 to 4.29 ± 2.01 ; comforting thinking: from 6.29 ± 1.79 to 7.29 ± 2.12) [21].

Discussion of the review results

The aim of this systematic review was to highlight the effects of different Pilates programs on physical and mental health in women diagnosed with some form of low back pain. The main findings indicated a reduction in the intensity of low back pain, improved functional ability, enhancement of neuromuscular control and muscle morphology, as well as an improvement in quality of life.

Low back pain is a very common occurrence among women. According to the results obtained in the studies included in this review, different Pilates programs influence the reduction of pain intensity. Castro et al. [19] and Baskan et al. [22] pointed out a change in the VAS score of 3 points, which represents the Minimal Clinically Important Difference (MCID), showing that this change is not only statistically significant but also indicates a reduction in pain intensity that enables better and easier everyday activities in patients. In one of the nine studies, such a result was not achieved, with the authors Goldberg et al. [26] citing as reasons the short duration of the program, the low level of initial functional parameters, as well as the

enthusiasm of the participants. The reduction in pain intensity is associated with morphological changes that occurred after the Pilates program. Batibay et al. [18] and Goldberg et al. [26] indicated an increase in the thickness of the transversus abdominis and multifidus muscles, which enables better stability of the spinal column and reduces pain intensity.

Marotta et al. [24] found improvements in the FRR coefficient, indicating that the Pilates program has an effect on normalizing muscle function, i.e. their relaxation in a certain position. Ferri-Caruana et al. [20] also pointed out asymmetric improvement in the FRR coefficient, emphasizing that more time is needed to achieve symmetrical adaptation or that this may serve to protect the painful side. The study by Ha et al. [23] indicates a reduction in muscle stiffness and tone, showing that the Pilates program effectively contributes to easier movement.

Women in menopause face a large number of symptoms that make normal functioning more difficult. Castro et al. [19] pointed out a reduction in creatine kinase levels after the Pilates program, especially after Pilates with equipment. This shows that Pilates also contributes to reducing damage to the musculoskeletal system. Therefore, the authors of this study recommend a Pilates program in order to slow down the reduction of muscle mass and strength, as well as to alleviate the degeneration of intervertebral discs, which occur due to the lack of estrogen. Nageswari and Meena [25] also consider Pilates programs important in the prevention of postmenopausal symptoms, as they reduce pain and increase mobility.

Many studies have pointed out the importance of Pilates programs for mental health. Batibay et al. [18] indicated a reduction in depression, which they associate with group exercise, influencing socialization as well as motivation and mood. Sahan et al. [21] confirmed that Pilates on the reformer improves the mental health of patients and also leads to a reduction in fear of movement, which is very important for patients with low back pain that limits them. It is also important to note that the Pilates program in this study influenced the adoption of active pain coping strategies, which is significant in gaining the belief that there is personal control over health.

It is very important to compare Pilates with other exercise methods, which the authors of the studies included in this review also emphasized. Two studies compared the Pilates program with a home exercise program. Batibay et al. [18] and Baskan et al. [22] concluded that the Pilates program is better in reducing pain intensity, improving muscle strength, balance, and flexibility compared to home exercises. It is also pointed out that the presence of a professional leading the Pilates program is important for the correct execution of movements, as well as group exercise, which increases motivation. Two studies compared the Pilates program with conventional exercise programs for low back pain. Nageswari and Meena [25]

concluded that the Pilates program contributed to a greater reduction in pain intensity and functional disability, as well as better improvement in range of motion and muscle endurance, compared to the conventional exercise program. On the other hand, Marotta et al. [24] pointed out more effective improvement in quality of life in the group that conducted the Pilates program, as well as improvement in the FRR coefficient, indicating that Pilates is a better method for normalizing muscle activity. There are more than 500 exercises, which include stretching and strengthening and which are applied within the Pilates method. Therefore, there are different variations of the Pilates method. The study by Castro et al. [19] compared the effects of Pilates with and without accessories. The results showed that both groups achieved improvement in pain reduction and reduction of functional disability, but Pilates with accessories had a better effect on physiological responses. Ha et al. [23] compared the effect of a myofascial release program combined with a Pilates program and a standalone Pilates program in women with chronic low back pain. The results showed a significant reduction in pain in both groups of participants, as well as a decrease in muscle tone of the rectus abdominis and erector spinae muscles, while improvement in muscle stiffness was observed in the group that combined the two programs. Flexibility as well as muscle endurance increased in both groups, but the flexibility parameter showed a greater positive change in the group of participants who applied the combined program. These results show that Pilates is significant in increasing all measured parameters but that additional techniques such as the myofascial release program can be added to achieve even better results.

There is a wide range of literature dealing with the assessment of the effects of the Pilates method on low back pain, but there is a very small number of studies that include only the female population. This systematic review included only studies in which women were taken as the sample of respondents. Studies that, in addition to subjective assessments in the form of questionnaires, also used objective measuring instruments such as ultrasound, electromyography, biochemical markers, were also included, thereby obtaining more precise and objective results. The quality of each study was analyzed using adequate validation: RoB 2 and ROBINS-I tools. This systematic review also includes studies that, in addition to the effects of Pilates on physical health, dealt with the effects on mental health. In this systematic review, certain limitations are also present, such as the small sample size in the included studies, as well as the short follow-up period and the absence of an examination of the long-term effects of the program. Due to the large differences between the studies, it was not possible to perform a meta-analysis, so the results were synthesized only descriptively. Most of the studies were

also conducted in specific regions, which may be related to different lifestyles and cultural factors.

Conclusions

This systematic review presented the effects of Pilates programs on the physical and mental health of women diagnosed with low back pain. The significance of the Pilates program is reflected in the reduction of pain intensity, the increase of functional abilities, the improvement of neuromuscular control and muscle morphology, as well as the improvement of certain physiological parameters. The Pilates method also proved to be a good way to improve overall quality of life, reduce symptoms of depression, and improve sleep. Compared to other exercise methods, Pilates proved to be more effective. In future research, it is necessary to increase the sample size of respondents in order to obtain the effects of Pilates on a wider population, as well as to monitor the effects of the program in the long term and to standardize the protocols in terms of intensity, duration, and frequency. In further research, it is also necessary to use objective measuring instruments more frequently.

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