



Review Article

## Effects of Pilates on patients with chronic non-specific low back pain: a systematic review

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**Abstract.** [Purpose] To evaluate the effects of Pilates on patients with chronic low back pain through a systematic review of high-quality articles on randomized controlled trials. [Subjects and Methods] Keywords and synonyms for “Pilates” and “Chronic low back pain” were used in database searches. The databases included PubMed, Physiotherapy Evidence Database (PEDro), Medline, and the Cochrane Library. Articles involving randomized controlled trials with higher than 5 points on the PEDro scale were reviewed for suitability and inclusion. The methodological quality of the included randomized controlled trials was evaluated using the PEDro scale. Relevant information was extracted by 3 reviewers. [Results] Eight randomized controlled trial articles were included. Patients with chronic low back pain showed statistically significant improvement in pain relief and functional ability compared to patients who only performed usual or routine health care. However, other forms of exercise were similar to Pilates in the improvement of pain relief and functional capacity. [Conclusion] In patients with chronic low back pain, Pilates showed significant improvement in pain relief and functional enhancement. Other exercises showed effects similar to those of Pilates, if waist or torso movement was included and the exercises were performed for 20 cumulative hours.

**Key words:** Exercise therapy, Randomized controlled trial, Lumbar spine

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### INTRODUCTION

Low back pain (LBP) is a common disorder seen in clinical practice and is a serious problem. Nearly 75–85% of people have experienced LBP, which has large economic and social costs<sup>1–3)</sup>. According to the duration of the syndrome, LBP is either chronic or acute. European guidelines for physical therapy further divide LBP into 3 types by its mechanism as follows: specific spinal pathology, nerve root pain/radicular pain, and nonspecific LBP, with chronic nonspecific LBP as the most common statistically<sup>4)</sup>. The definitions of chronic LBP (CLBP) include pain duration in the posterior lumbar region for more than 12 weeks<sup>4)</sup> or duration of back pain greater than 7–12 weeks<sup>1)</sup>. The prevalence and high relapse rates of nonspecific CLBP often cause disability, and severely affect the quality of life.

In recent years, Pilates has been applied in patients with CLBP<sup>5–12)</sup>. Created by Joseph Pilates in the 1920s, Pilates blends Western yoga, Greek and Roman gymnastics, karate, and Zen, among others, and has developed into a series of physical and mental conditioning exercises. It is arguable whether Pilates reduces back pain and enhances the functional capabilities of nonspecific CLBP patients<sup>13–18)</sup>. Some systematic reviews have shown that when compared with a placebo or normal daily activities, Pilates relieves pain but does not reduce disability<sup>13, 14)</sup>, while others have shown that Pilates does not reduce

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disabilities and/or pain<sup>15</sup>). Still others have shown that when compared with a placebo or normal daily activities, Pilates may effectively relieve pain and reduce the degree of disability<sup>18</sup>). However, in several other systematic reviews, Pilates showed no significant differences compared with any other form of exercise<sup>14, 15, 18</sup>); in another review, Pilates effectively reduced disabilities compared with others forms of exercise<sup>13</sup>). The differences in the results of these studies may be due to the selection size of randomized controlled trial (RCT) articles, which included low-level evidence. In addition, it was found that in some systematic reviews that regardless of the existence of significant clinical heterogeneity, meta-analyses were performed and the results were misleading<sup>17</sup>).

Until now, conclusions from different research regarding the treatment effects on pain-relief and the disability for patients with LBP from Pilates and from other exercises showed significant differences<sup>7, 13-19</sup>). Little evidence has explored the recommendations for Pilates in patients with CLBP (including different forms of Pilates exercise, such as mat or equipment Pilates)<sup>20</sup>). Therefore, the purpose of the present study was to conduct a systematic review of all available studies to investigate the benefit of Pilates exercise for participants with CLBP. In addition, we compared the efficacy of Pilates with other exercise practices and further explored the best Pilates exercise design. This study only selected articles involving RCT research and that achieved greater than 5 points on the PEDro scale, in order to determine the best course of exercise based on the highest evidence levels.

## SUBJECTS AND METHODS

A literature search was undertaken using databases including PubMed, the Physiotherapy Evidence Database (PEDro), Medline, and Cochrane library within maximal date ranges of each database up until October 11, 2015. Keywords such as “Pilates”, “Chronic low back pain”, “Chronic non-specific low back pain”, “Exercise”, “Rehabilitation”, “Pain”, “Physical therapy”, and “Physiotherapy” were used in data mining without language restrictions. Selection of relevant papers was based on title and abstract. Initially, 2 reviewers independently reviewed the abstract of each article. If it was not possible to decide from the abstract whether the article was suitable for inclusion, the full text was reviewed.

After searching journals, non-RCT articles were first excluded. Then, the level of evidence was further evaluated by using the PEDro scale (<http://www.pedro.org.au/>). If not found in the PEDro database, the article was evaluated by 2 reviewers who had completed the PEDro Scale training tutorial. If the evaluation results from the 2 reviewers were different, a third reviewer who completed the PEDro Scale training tutorial was involved in the evaluation for inclusion or exclusion in the study. In the case of score disagreement or other problems, a group discussion was used to decide whether to include or exclude an article from this study. The PEDro database contains 10 items as a summary score. A summary score of 5 or 6 typically defined sufficient trial quality<sup>21</sup>). Therefore, articles with lower PEDro scores ( $\leq 5$ ) were excluded, to reduce conclusion differences due to lower-level RCTs. Articles not written in English, or that involved complicated diseases (such as scoliosis or viral infections), were also excluded.

The full text of all included RCT articles was reviewed. The following questions were investigated: (1) Pilates exercise compared with no or little intervention (such as health education; N=5); (2) Pilates exercise compared with other forms of exercise (N=2); and (3) which Pilates is the best training mode. All included RCT articles were summarized and analyzed with descriptive statistics. The author, publication year, subjects, intervention, exercise type, and outcome measures of all included articles were extracted by 2 reviewers. When possible, data were pooled and the mean between-group differences (95% confidence interval) were calculated. When necessary, the original authors of the included studies were contacted to provide additional information such as the mean between-group differences. A third reviewer validated the data using a predefined form. If the reviewers had different opinions related to article selection, data extraction, or quality assessment, a consensus was achieved through discussion.

## RESULTS

Forty articles were found through database searches. After we excluded duplicate articles (N=18), non-RCT articles, articles with a lower PEDro score ( $\leq 5$ ), and articles not written in English (N=14), a total of 8 RCT articles were included in this systematic review.

Table 1 presents the quality of included studies. The mean PEDro score of included articles was 7.5 with a range of 6–8. All studies were randomized (100%), conducted concealed allocation (100%), and had baseline comparability (100%). All studies were analyzed between-group comparisons, with reported point estimates and variability (100%). All studies didn't carry out blind subjects and blind therapist. Blind-assessors (87.5% of included articles), adequate follow-up (75% of included articles), and an intention-to-treat analysis (87.5% of included articles) were performed.

Table 2 provides the summarized information (including author, experimental design, participants, intervention, comparison, and outcome measures) for each RCT article. The ages of the experimental subjects ranged from 34–49 years of age<sup>5-11, 22</sup>). Only 1 RCT article discussed and compared Pilates and usual care/health education by age distribution<sup>5</sup>). For all other articles, the experimental and control groups showed a similar age distribution. Supervised Pilates intervention was included in most of the RCT articles, and the RCT Pilates programs lasted for 1 hour each time, 1–3 times per week for 6–12 weeks. A total of 6 weeks of exercise intervention were reported in 4 RCT articles<sup>5, 7, 11, 22</sup>), and 8 weeks in 2 RCT articles<sup>6, 9</sup>).

**Table 1.** PEDro score for included studies (n=8)

	Gladwell, V., et al. <sup>5)</sup> UK	Rydeard, R., et al. <sup>10)</sup> Canada	Miyamoto, G.C., et al. <sup>23)</sup> Brazil	K Quinn., et al. <sup>9)</sup> UK	Natour, J., et al. <sup>8)</sup> Brazil	Wajswelner, H., et al. <sup>11)</sup> Australia	Marshall, P. W., et al. <sup>6)</sup> Australia	Da Luz, M. A., Jr., et al. <sup>22)</sup> Brazil
Eligibility*	Y	Y	Y	Y	Y	Y	Y	Y
Random allocation	Y	Y	Y	Y	Y	Y	Y	Y
Concealed allocation	Y	Y	Y	Y	Y	Y	Y	Y
Baseline comparability	Y	Y	Y	Y	Y	Y	Y	Y
Blind subjects	N	N	N	N	N	N	N	N
Blind therapists	N	N	N	N	N	N	N	N
Blind assessors	Y	Y	Y	Y	Y	Y	N	Y
Adequate follow-up	N	Y	Y	N	Y	Y	Y	Y
Intention-to-treat analysis	N	Y	Y	Y	Y	Y	Y	Y
Between-group comparisons	Y	Y	Y	Y	Y	Y	Y	Y
Point estimates and variability	Y	Y	Y	Y	Y	Y	Y	Y
Total score (0–10)	6	8	8	7	8	8	7	8

PEDro: Physiotherapy Evidence Database; Y: yes; N: no  
 \*This item is not used to calculate the PEDro score

**Table 2.** Description of included studies

	Author	Design	Participant (number) Age (years)=mean (SD)	Intervention	Exercise mode (frequency or intensity)	Outcome measures
Does a Program of Pilates Improve CNSLBP <sup>5)</sup>	Gladwell, V., et al. <sup>5)</sup>	RCT	E n=25 Age (years)=36.9 (8.1)	Pilates + Drugs	Clinic: 1 hr, 1X per week for 6 weeks; Home: 30 minutes, 2X per week for 6 weeks (total: 12 hours)	RMVAS, OSWDQ, SF-12, Sports Functioning, Sit-and-reach test, Stork stand test, Symptom report, Pain diary
			C n=24 Age (years)=45.9 (8.0)	Normal activities + Drugs	6 wks	
Pilates-Based Therapeutic Exercise: Effect on Subjects With Nonspecific Chronic Low Back Pain and Functional Disability: A RCT <sup>10)</sup>	Rydeard, R., et al. <sup>10)</sup>	RCT	E n=21 Age (years)=37 (9)	Pilates (floor mat and Pilates reformer)	Clinic: 1 hr × 3 times × 4 wks; Home: 15 min (total: 13 hours)	NRS, RMDQ
			C n=18 Age (years)=34 (8)	Usual care/consultation	4 wks	
Efficacy of the Addition of Modified Pilates Exercises to a Minimal Intervention in Patients With Chronic Low Back Pain: A RCT <sup>23)</sup>	Miyamoto, G.C., et al. <sup>23)</sup>	RCT	E n=43 Age (years)=38.3 (11.4)	Pilates + Booklet	1 hr × 2 times × 6 wks (total: 12 hours)	NRS, RMDQ, Patient-Specific Functional scale, Global Perceived Effect scale, Kinesiophobia-Tampa scale, Expectancy for Improvement scale, Treatment Credibility scale
			C n=43 Age (years)=40.7 (11.8)	Booklet	6 wks	
Do patients with chronic low back pain benefit from attending Pilates classes after completing conventional physiotherapy treatment? <sup>9)</sup>	Quinn, K., et al. <sup>9)</sup>	RCT	E n=15 Age (years)=41.8 (13.8)	Pilates	Clinic: 1 hr × 1 time × 8wks Home: 15 mins × 1 time × 8 wks (total: 10 hours)	VAS, RMDQ, SAT
			C n=14 Age (years)=44.7 (12.5)	—	8 wks	

**Table 2.** Continued

	Author	Design	Participant (number) Age (years)=mean (SD)	Intervention	Exercise mode (frequency or intensity)	Outcome measures
Pilates improves pain, function and quality of life in patients with chronic low back pain: a randomized controlled trial <sup>8)</sup>	Natour, Jamil et al. <sup>8)</sup>	RCT	E n=30 Age (years)=47.8 (11.5)	NSAID + Pilates	Pilates: 50 min. × 2 times × 3 m. 50 mg sodium Diclofenac at intervals no shorter than 8 h when needed (VAS for pain more than 7 cm). (total: 24 hours)	VAS, Roland Morris questionnaire, SF-36, sit and reach test, NSAID intake
			C n=30 Age (years)=48.0 (13.0)	NSAID	50 mg sodium Diclofenac at intervals no shorter than 8 h when needed (VAS for pain more than 7 cm).	
Clinical Pilates Versus General Exercise for Chronic Low Back Pain <sup>11)</sup>	Wajswelner Henry et al. <sup>11)</sup>	RCT	E n=44 Age (years)=49.3 (14.1)	Pilates (with equipment) + Daily home program	Clinic: 1 hr × 2 times × 6 wks; Home: 1 hr × 1 time (total: 12–14 hours)	Quebec scale, NRS, Pain Self- efficacy Questionnaire, Patient- Specific Functional scale, SF-36
			C n=43 Age (years)=48.9 (16.4)	General exercise + Daily home program		
Pilates Exercise or Stationary Cycling for Chronic Nonspecific Low Back Pain: Does it Matter? <sup>6)</sup>	Marshall, P. W. et al. <sup>6)</sup>	RCT	E n=32 Age (years)=36.2 (8.2)	Pilates (mat + equipment)	1 hr × 3 times × 8 wks (total: 24 hours)	VAS, OSWDQ, Fear-Avoidance Beliefs Questionnaire, Pain Catastrophizing Scale
			C n=32 Age (years)=36.2 (6.2)	Stationary cycling		
Effectiveness of Mat Pilates or Equipment-Based Pilates Exercises in Patients With Chronic Nonspecific Low Back Pain: A Randomized Controlled Trial <sup>22)</sup>	M.A. da Luz Jr et al. <sup>22)</sup>	RCT	E n=43 Age (years)=43.5 (8.6)	Equipment-based Pilates	1 hr × 2 times × 6 wks (total: 12 hours)	NRS, RMDQ, Global Perceived Effect Scale, Tampa Scale
			C n=43 Age (years)=38.8 (9.9)	mat Pilates		

Values are n, mean (SD), or as otherwise indicated.

n: number; E: experimental group; C: control group; CLBP: chronic low back pain; CNSLBP: chronic non-specific low back pain; VAS: visual analogue scale; RCT: randomized control trial; RMDQ: Roland Morris pain rating visual analogue scale; OSWDQ: Oswestry Low-Back Pain Disability Questionnaire; NRS: numerical rating scale; RMDQ: Roland Morris Disability Questionnaire; SAT: Sahrmann Abdominal Test; SF: social functioning; NSAID: non-steroidal anti-inflammatory drug

The other 2 RCT articles used a 4-week intervention<sup>10)</sup> and a 12-week intervention<sup>8)</sup>, respectively. Additionally, in 4 of 8 articles, Pilates equipment such as a Reformer was reportedly used<sup>6, 10, 11, 22)</sup>.

For the following reasons, outcomes were not pooled into the meta-analysis. There was apparent clinical heterogeneity in the included RCT studies as shown by the conditions that were treated, frequency and duration of intervention with Pilates and other exercises, such as home exercise and education, administration of nonsteroidal anti-inflammatory drugs, use of Pilates equipment, the performance of follow-up, and evaluations of outcome measures over different periods (Table 2)<sup>18)</sup>. In addition, the test for heterogeneity showed that significant statistical heterogeneity for pain relief: pilates exercise against minimal intervention and therapeutic training ( $i^2=73%$ ,  $p=0.001$ ). Significant statistical heterogeneity was also observed when comparing improvements in functional ability with Pilates exercise versus minimal intervention and therapeutic training ( $i^2=92%$ ,  $p<0.001$ ).

Among the included articles, 5 compared the effect of Pilates and minimal intervention (such as routine care and health education) on patients with CLBP (Table 3). After 4–12 weeks of Pilates or minimal intervention, all studies showed significant statistical differences for effects on pain relief<sup>5, 8–10, 23</sup>. However, only 2 of these 5 showed that the pain relief reached minimal clinically important differences (MCID)<sup>10, 23</sup>. Compared with no treatment, achieving MCID with treatment shows some clinical benefit. The Visual Analogue Scale (VAS) score for pain relief showing an MCID in patients with CLBP was reportedly 18 mm<sup>24</sup>; the MCID on the numeric rating scale (NRS) was 2 points<sup>18</sup>. The MCID on the Roland Morris Disability Questionnaire (RMDQ) for functional capacity in patients with CLBP was 2 points<sup>8, 25</sup>. In 3 of the 5 articles, patients indicated an improvement in functional ability with significant statistical differences after 4–12 weeks of Pilates or minimal intervention<sup>8, 10, 23</sup>, but two of them achieved MCID<sup>8, 23</sup>. After 4 and 12 weeks of Pilates, some functional abilities were maintained for up to 12<sup>10</sup>) and 24 weeks<sup>8</sup>), respectively<sup>8, 10</sup>.

Among included articles, 2 RCT studies compared the effects of Pilates and other exercise types on patients with CLBP (Table 4). In 1 of these, Pilates achieved significant statistical differences in the improvement in pain relief and functional ability after an 8-week training period, when compared with other exercise (stationary cycling), but MCID was not achieved in either study<sup>6</sup>); in the other study, the outcome measures of 6 weeks of Pilates and general exercise (including stationary bike, leg stretches, upper body weights, theraband, Swiss ball, and floor exercise) were similar<sup>11</sup>).

Among the included high-quality articles, only 1 compared the effects of mat-Pilates and equipment-based exercise on patients with nonspecific CLBP (Table 5). After 6 weeks of mat-Pilates training or 6 weeks using Pilates equipment, such as the Cadillac, Reformer, Ladder Barrel, or Step-chair, patients indicated similar improvements. However, after 24 weeks, there was greater improvement in the outcomes of functional ability and kinesiophobia in patients in equipment-based Pilates groups than in patients in the mat-Pilates group<sup>22</sup>).

## DISCUSSION

This systematic review based on high-quality RCT studies provides updated evidence for the effects of Pilates on patients with nonspecific CLBP. Meta-analysis was not performed because of the clinical and statistical heterogeneity among the RCT articles<sup>18</sup>).

According to studies included in the 5 high-quality RCT articles that compared the effects of Pilates and minimal intervention in nonspecific CLBP patients, 6–12 weeks of Pilates training is better than minimal intervention in reducing pain in the short term<sup>5, 8–10, 23</sup>), and this improvement can be clinically significant<sup>10, 23</sup>). Natour et al. reported that 12 weeks of Pilates (24 total hours of training) could reduce CLBP pain for 24 weeks. Some of our included high-quality articles (40%) also indicated clinical differences in functional capacity<sup>8, 10, 23</sup>).

Equipment training was included in Pilates exercise in 2 high-quality RCT articles that compared the effects of Pilates and other types of exercise on patients with CLBP<sup>6, 11</sup>). Wajswelner et al. reported that 12–14 hours of Pilates showed no statistical superiority over therapeutic exercise in patients with CLBP<sup>11</sup>). This was consistent with the report by Pereira et al., indicating that for CLBP patients, Pilates and lumbar stabilization exercises showed similar effects on pain relief and functional enhancement<sup>15</sup>). For a longer Pilates routine (up to 24 hours), Marshall et al. found that although Pilates showed statistically superior results for pain relief and functional enhancement in patients with LBP compared with stationary cycling, however, no MCID was observed<sup>6</sup>). It is possible that Pilates and therapeutic exercise showed similar results in the report by Wajswelner et al. because both focused on the trunk (especially extension, rotation, and flexion). Marshall et al. indicated that the psychological influences on patients with LBP in the Pilates and stationary cycling groups were the same. Therefore, psychological factors should not be considered a cause for statistical differences in LBP pain relief or functional enhancement. Some researchers have reported that the relative ratio (nearly 10%) of cycling for trunk muscle recruitment is lower than the relative ratio (>50%) for specific trunk exercises for trunk muscle recruitment<sup>6, 26, 27</sup>). Hayden et al. indicated that regardless of the type of therapeutic exercise, a minimum of 20 cumulative hours of continuous training shows clinical analgesic effects and functional enhancement for nonspecific CLBP<sup>28</sup>). Therefore, in patients with LBP, training duration (dose or intensity) in addition to waist or torso training may also be a factor in the effectiveness of exercise.

Hayden et al. proposed that to alleviate pain and enhance functional capabilities, patients with LBP need to be encouraged to adhere to a minimum training period of 20 hours<sup>28</sup>). We recommend that patients with CLBP doing Pilates training should have an exercise frequency greater than 2 or 3 times a week, with each session lasting at least 1 hour, for a minimum cumulative training of 20 hours. These patients may achieve a clinical analgesic effect or enhanced functional capabilities.

One high-quality article showed that after 6 weeks of mat-Pilates training or 6 weeks using Pilates equipment (e.g., Cadillac, Reformer, Ladder Barrel, or Step-chair), patients with CLBP had similar improvements. However, disability improvement and kinesiophobia in these patients showed better and longer-lasting results (up to 24 weeks) with equipment-based Pilates than with mat-Pilates. However, only the RMDQ score achieved MCID<sup>22</sup>). The reason is that ultrasonic examination confirmed that performance of some Pilates exercises (such as the Hundred) using Pilates equipment showed thicker transverse abdominal muscles than with mat-Pilates<sup>29</sup>). This represents more transverse abdominal muscles were activated. The transverse abdominal muscles are deep, cross-joint and local core muscles. The activation of deeper muscles may exert a stiffening effect on the lumbar region to help stabilize the spinal segment<sup>29, 30</sup>). This may lead to improvement in functional activities in nonspecific CLBP patients, in part through an increase in self-confidence.

**Table 3.** Effect of Pilates exercise versus minimal intervention or usual care

Study	Outcome measure		Mean difference between groups/Exp. minus ctrl	Significance of difference between groups	Attain MCID
Gladwell, V., et al. <sup>5)</sup>	RMVAS		NA	-	-
	OSWDQ		NA	-	-
	Sports functioning		NA	-	-
	SF-12: general health		NA	-	-
	one-leg standing balance (s)		NA	-	-
	Flexibility		NA	Between groups p<0.05	NA
	Daily diary		NA	Between groups p<0.05	NA
Rydeard, R., et al. <sup>10)</sup>	RMDQ		1.2	Between groups p<0.023	-
	PNRS		5.6	p=0.002	+
Miyamoto, G.C., et al. <sup>23)</sup>	PNRS	6 wk	2.2	6-week Between groups p<0.01	+
	RMDQ	6 wk	2.7	Between groups p<0.01	+
	Patient-specific functional scale	6 wk	-0.4	-	-
	Global perceived effect scale	6 wk	-1.5	6-week follow-up Between groups p<0.01	NA
	Kinesiophobia- tampa scale	6 wk	1.6	-	-
K Quinn., et al. <sup>9)</sup>	RMDQ		1.26	-	-
	SAT		27%	-	-
	VAS: follow up		14.2 (mm)	Between groups p=0.047	-
	VAS	T45	-0.46		
		T90	-1.12	Between group p<0.001	
		T180	-1.63		
	Roland-Morris questionnaire (RM)	T45	-2.08		+
		T90	-3.80	Between group p<0.001	
		T180	-3.62		
	SF-36 physical functioning	T45	5.12		NA
		T90	8.54	Between group p=0.026	
		T180	5.83		
	vitality	T45	6.33		NA
		T90	10.58	Between group p=0.029	
		T180	5.29		
Natour, J., et al. <sup>8)</sup>	bodily pain	T45	4.25		NA
		T90	8.04	Between group p=0.030	
		T180	8.29		
	Sit-and-reach test	T45	5.63		-
		T90	6.77	-	
		T180	6.54		
	Satisfaction with treatment (Likert scale)	T45	-		-
		T90	-	-	
		T180	-		
	NSAID use	T45	-5.90		NA
		T90	-5.66	Between groups p<0.010	
		T180	-7.13		

MCID: minimal clinical importance difference; NA: not available; RMVAS: Roland Morris pain rating visual analogue scale; OSWDQ: Oswestry Low-Back Pain Disability Questionnaire; PNRS: pain numerical rating scale; RMDQ: Roland Morris Disability Questionnaire; SAT: Sahrman Abdominal Test; SF: social functioning; NSAID: non-steroidal anti-inflammatory drug; T45: 45 days after baseline; T90: 90 days after baseline; T180: 180 days after baseline

**Table 4.** Effect of Pilates exercise versus therapeutic exercise training

Study	Outcome measure		Mean difference between groups/Exp. minus ctrl.	Significance of difference between groups	Attain MCID
Wajswelner, H., et al. <sup>11)</sup>	Quebec scale	W6	-3.5		-
		W12	-0.91	-	-
		W24	-2.0		-
	PNRS	W6	-0.5		-
		W12	0.3	-	-
		W24	0.3		-
	PSFS	W6	1.0		-
		W12	0.8	-	-
		W24	-1.0		-
	SF-36 Physical function	W6	1.7	-	-
		W12	5.9	-	-
		W24	-2.9	-	-
	Role physical	W6	-0.2	-	-
		W12	-0.8	-	-
		W24	-4.3	-	-
	Bodily pain	W6	-0.8	-	-
		W12	-4.7	-	-
		W24	-3.4	-	-
	General health	W6	-2.2	-	-
		W12	-1.0	-	-
		W24	-1.5	-	-
	Vitality	W6	-0.2	-	-
		W12	-1.4	-	-
		W24	1.6	-	-
	Social functioning	W6	-3.4	-	-
		W12	2.5	-	-
		W24	4.2	-	-
	Role emotion	W6	-3.0	-	-
		W12	3.9	-	-
		W24	-5.7	-	-
Mental health	W6	-5.7	-	-	
	W12	1.8	-	-	
	W24	-4.5	-	-	
Pain self-efficacy questionnaire	W6	2.1	-	-	
	W12	1.9	-	-	
	W24	1.3	-	-	
Marshall, P. W., et al. <sup>6)</sup>	VAS	W8	1.1	Between groups p<0.05	-
		W24	0.4	-	-
	ODI	W8	6.8	Between groups p<0.05	-
		W24	4.4	-	-
	Fear-avoidance beliefs questionnaire (physical activity)	W8	2.2	-	-
		W24	-2.0	-	-
Pain catastrophizing scale	W8	2.3	-	-	
	W24	0.04	-	-	

MCID: minimal clinical importance difference; PNRS: pain numerical rating scale; PSFS: Patient-Specific Functional Scale; VAS: visual analogue scale; W6: 6 weeks after baseline; W12: 12 weeks after baseline; W24: 24 weeks after baseline; W8: 8 weeks after baseline

**Table 5.** Effect of mat Pilates exercise versus equipment-based Pilates exercise

Study	Outcome measure		Mean difference between groups/ Exp. minus ctrl	Significance of difference between groups	Attain MCID
	PNRS	W6	0.3 (-1.1 to 1.7)	-	-
		W24	-0.1 (-1.5 to 1.3)	-	-
	RMDQ	W6	-1.0 (-3.4 to 1.4)	-	-
		W24	3.0 (0.6 to 5.4)	+	+
Da Luz, M. A., Jr., et al. <sup>22)</sup>	Patient-Specific Functional Scale	W6	-0.1 (-1.1 to 0.9)	-	-
		W24	-1.1 (-2.1 to -0.1)	+	NA
	Global Perceived Effect Scale	W6	0.1 (-1.1 to 1.4)	-	-
		W24	-1.2 (-2.4 to 0.1)	-	-
	Tampa Scale for Kinesiophobia	W6	0.8 (-2.5 to 4.1)	-	-
		W24	4.9 (1.6 to 8.2)	+	NA

MCID: minimal clinical importance difference; PNRS: pain numerical rating scale; RMDQ: Roland Morris Disability Questionnaire; NA: not available; W6: 6 weeks after baseline; W24: 24 weeks after baseline

An article by Lee et al. on RCT research (not included because of its low PEDro Scale) showed different results. For businesswomen doing 8 weeks of Pilates exercise, the article showed that subjects had better balance with mat-Pilates exercise than with Pilates apparatus exercise, and were better able to reduce CLBP. Although these 2 results seem to contradict each other, they did not investigate nonspecific CLBP RMDQ, and the VAS mean differences did not achieve MCID<sup>31)</sup>. Lee et al. also did not report whether there was supervision for Pilates therapy. Without monitoring by an experienced therapist, incorrect Pilates movements could result in a lack of strenuous training of core muscles such as the transverse abdominal or abdominal oblique<sup>29)</sup>. All these may result in differences in these 2 studies.

Similar to the report by Wells et al.<sup>18)</sup>, which compared health education and Pilates, this study found that Pilates provided greater improvement for pain relief and functional ability. However, when compared with other forms of therapeutic exercise, Pilates showed similar results without MCIDs. Our research may have identified the best Pilates format and exercises. Future research may include testing parameters suggested in the Hayden article, or may determine the effectiveness of reports by Australian physical therapists that the use of Pilates exercise can achieve optimal results if performed for 3–6 months<sup>20, 28)</sup>.

Since this review only included high-quality RCT studies, there were few articles that compared the effects of Pilates intervention and other exercises on patients with CLBP, and few articles that compared the effect of mat-Pilates versus equipment-based Pilates. In some articles, the insufficiency of raw numeric data made the calculation of the mean difference between the experimental and control groups impossible. In addition, we did not restrict language in the data-mining process, but only included English language articles. This may cause a language bias. Lastly, we did not include unpublished studies, so there is likely some publication bias.

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