

## *Meta-Analysis of the Efficacy of Pilates Exercises in the Treatment of Non-specific Low Back Pain*

Binyu He<sup>1</sup>, Ping Jiang<sup>1</sup>, Xuanguo Zhang<sup>2,\*</sup>

<sup>1</sup>Shaanxi University of Chinese Medicine, Xiayang City, Shaanxi Province, 712000, China

<sup>2</sup>Shaanxi Provincial Hospital of Chinese Medicine, Xi'an City, Shaanxi Province, 710000, China

\*Corresponding author

**Keywords:** Pilates exercise, nonspecific low back pain, meta-analysis

**Abstract:** **Objective** to systematically evaluate the efficacy of Pilates exercises for nonspecific low back pain. **Methods** Computerized searches of CNKI, Wan fang Data, VIP and PubMed, EM base, and Web of science databases for randomized controlled trial studies on risk factors for NLBP published since the database was created until March 1, 2022. Literature extraction and risk of bias evaluation were performed independently by 2 investigators, and Meta-analysis was performed using RevMan5.4 software. **Results** A total of 14 included RCTs containing 975 patients were included. Meta-analysis results showed that in terms of relief of low back pain, VAS scores in the Pilates exercise group were statistically significant compared to other muscle group training [MD=-1.71, 95% CI (-3.86,0.45), Z=1.55, P=0.003<0.05], while compared to other exercise workouts [ MD=0.25, 95% CI (-3.72,4.21), Z=0.12, P=0.9>0.05] and medication and physical therapy [MD=-1.15, 95% CI (-2.75,0.46), Z=1.40, P=0.16>0.05] were not significantly different compared to other exercise workouts [ MD= -0.55, 95% CI (-1.16,0.06), Z=1.76, P=0.08>0.05] and routine care and missionary group [MD=-0.85, 95% CI (-1.80,0.10), Z=1.75, P=0.08>0.05] compared to other exercise [MD=-0.55, 95% CI (-1.16,0.06), Z=1.76, P=0.08>0.05]. In terms of improving low back dysfunction, the Pilates exercise group ODI scores were significantly different compared to other muscle group training [MD=-2.35, 95% CI (-4.06,-0.65), Z=2.71, P=0.007] and medication and physiotherapy [MD=-10.25, 95% CI (-11.24,-9.26), Z=20.34, P<0.00001 ] were significantly different compared to other exercise workouts, QBPDS scores in the Pilates exercise group were not statistically significant compared to other exercise workouts [MD=-1.11, 95% CI (-6.48,4.27), Z=0.40, P=0.69], RMDQ scores in the Pilates exercise group were not statistically significant compared to the usual care and mission group [MD=-1.60, 95% CI (-3.06,-0.15) Z=2.16, P=0.03] were significantly different. **Conclusion** Pilates exercises improve low back dysfunction in patients with non-specific low back pain. Pilates exercises are more effective than other muscle group training in relieving low back pain, while there is no significant difference compared to other exercise exercises, and drug and physical therapy, as well as conventional care and missionary therapy.

## 1. Introduction

Non-specific low back pain (NLBP) is one of the more common clinical disorders of the musculoskeletal system and refers to a group of symptoms associated with lower back pain and dysfunction without pathological factors or abnormal anatomical changes <sup>[1]</sup>. According to a global epidemiological survey of low back pain, the global prevalence of low back pain is 18.3% <sup>[2]</sup>, of which NLBP accounts for approximately 85% <sup>[3]</sup>. Due to the high incidence and recurrent nature of the disease, a large number of people are disabled by low back pain <sup>[4]</sup>, which seriously affects the normal work and life of patients and is gradually gaining the attention of doctors and patients <sup>[5]</sup>. As the pathogenesis of the disease is still unclear, oral analgesics, topical ointments and physiotherapy are often used to relieve local symptoms, however, according to the evidence-based guidelines of the North American Spine Society, aerobic rehabilitation has been shown to have higher evidence of recommended use than its treatment modalities <sup>[6]</sup>.

According to current research on rehabilitation interventions for NLBP, appropriate exercise has been found to have a better effect on patients' low back pain and dysfunction relief compared to other interventions <sup>[7]</sup>. The Pilates method is a widely used exercise intervention for patients with low back pain to help stabilise the lumbar pelvis and restore related muscle function <sup>[8]</sup>, and has been widely used in recent years for patients with NLBP <sup>[9-11]</sup>. Although Pilates therapy has been clinically accepted for the treatment of NLBP <sup>[12, 13]</sup>, there is still some controversy, for example, some systematic evaluations have shown that Pilates relieves pain but does not reduce disability compared to placebo or normal daily activities <sup>[14, 15]</sup>, while others have shown that Pilates does not reduce disability or pain <sup>[16]</sup>, in addition, in several other systematic evaluations it was concluded that Pilates compared to any other form of exercise <sup>[16, 17]</sup>, while some studies have concluded that there are significant differences in the treatment effects of Pilates and other exercises for patients with low back pain relief and disability <sup>[18, 19]</sup>. Therefore, the aim of this study was to investigate the effectiveness of Pilates exercise interventions for low back pain and dysfunction in NLBP patients through a systematic evaluation, with a view to guiding clinical rehabilitation treatment.

## 2. Materials and methods

### 2.1 Inclusion and exclusion criteria

#### 2.1.1 Inclusion criteria

(i) Study design: randomised controlled trial (RCT study). (ii) Study population: Patients aged 17-80 years with intermittent episodes of low back pain for no less than 3 months, regardless of gender. (iii) Intervention: The control group was given other treatment modalities than Pilates and the treatment group was given Pilates intervention, of which the sessions were of unlimited duration. (iv) Outcome indicators: Visual Analogue Scale (VAS), Numerical Rating Scale (NRS), Oswestry Low Back Pain Disability Index (ODI), Roland-Morris Disability Questionnaire (RMDQ), Quebec back pain disability scale (QBPDS).

#### 2.1.2 Exclusion criteria

(i) Non-RCT studies. (ii) Studies whose subjects did not meet the criteria. (iii) Duplicate published literature, literature with missing data. (iv) Studies in which the treatment group was a non-Pilates intervention. (v) The language of the literature was not Chinese or English.

## 2.2 Search Strategy

Computer search of CNKI, Wan fang Data, VIP and PubMed, EM base, and Web of science databases for relevant studies published from the time of database creation to March 1, 2022.

Take PubMed as an example, the search strategy is

#1 low back pain OR backache OR Non-specific low back pain OR Chronic low back pain

#2 Pilates method OR Pilates exercise

#3 #1 AND #2

## 2.3 Literature screening and data extraction

Two researchers independently searched, screened, extracted and cross-checked the literature for discussion, and consulted a third researcher in case of disagreement and made a judgment. The literature was screened by first browsing the titles and abstracts for initial screening, and then reading the full text carefully for re-screening to determine inclusion after excluding apparently irrelevant literature. Note Express 3.5.0 was used to manage the literature, remove duplicates, and create a table of relevant information using Excel 2010. The extracted content included: first author, year of publication, country, sample size, intervention, age, duration of treatment, time of assessment, and outcome evaluation index.

## 2.4 Quality evaluation

Quality evaluation was performed using the Cochrane Collaboration Network recommended systematic evaluator's manual 5.1.0 for RCT risk of bias evaluation. The seven main aspects were: randomized protocol generation, allocation concealment, blinding (subjects and treatment implementers), blinding (outcome evaluators), data completeness, selective reporting, and others. The level of risk of bias included "low risk", "high risk", and "unclear".

## 2.5 Statistical analysis

Meta-analysis was performed using Rev Man 5.3 software. The type of data in this study was a measure, so the mean difference (MD) and 95% CI were used to represent continuous variables. The included literature was analyzed by  $\chi^2$  test and I<sup>2</sup> value to test heterogeneity; if  $P > 0.10$  and  $I^2 < 50\%$ , heterogeneity between studies was considered small and a fixed-effects model was used for the combined analysis; if  $P \leq 0.10$  and  $I^2 \geq 50\%$ , heterogeneity between studies was considered significant and a random-effects model was used for the combined analysis, and sensitivity analysis could be done to explore the source of heterogeneity. If the number of included literature was comparable, funnel plots could be used to explore whether there was publication bias.

## 3. Result

### 3.1 Literature search results and general information

A total of 236 papers were searched in Chinese and English databases such as CNKI, Wan fang Data, VIP and PubMed, EM base, and Web of science, respectively, and 204 papers were obtained after using Note Express 3.5.0 to manage and remove duplicate papers, and 112 papers were obtained after reading the titles and abstracts of the papers and initial screening. After reading the titles and abstracts, 112 papers were obtained, 98 papers were deleted after further full-text reading, and 14 papers were finally included, including 4 papers in Chinese<sup>[20-23]</sup> and 10 papers in English

[24-33]. The literature screening process is shown in Figure 1, and the general information of included studies is shown in Table 1.

Table 1: General information of the included studies

Inclusion in studies	Country	Sample size(T/C)	Intervention(T/C)	Age (Y)	Treatment	Evaluation time	Evaluation Indicators
Meng Manman 2022 [20]	China	34/32	STM+ Pilates / STM	44.21±10.97/ 44.39±10.03	1M		VAS/ODI
Han Feng 2017 [21]	China	30/30	Massage + Pilates / Massage	49.7±9.14/ 49.98±9.69	2W	Before T, after T 2W ,12 W	VAS/ODI
Luo Minghui 2019 [22]	China	32/32	STM+ Pilates/ STM	3.24±11.54/ 45.16±10.37	4W		VAS/ODI
Nan Haiou 2015 [23]	China	40/40	Pilates / Education	40.21±11.16/ 41.75±10.85	2W	Concurrent	VAS
Rydeard 2006 [24]	China	21/18	Pilates / Routine	34 ±8/ 37 ±9	4W	After T 3M,6M,9M	RMDQ/NRS
Donzelli 2006 [25]	America	21/22	Back muscle training	20-65	2W	After T 1M,3M,6M	ODI/VAS
Ricci 2019 [26]	Brazil	37/37	Pilates / Running		8W	After T 8W, 6M	NRS/RMDQ
Mostagi 2015 [27]	Brazil	11/11	Pilates / General Exercise	36.1 ±9/ 34.7±8.1	8W	After T 3M	VAS/QBPDS
Cruz-Diaz 2016 [28]	Spain	57/55	Pilates + Physiotherapy / Physiotherapy	69.57±2.188/ 72.69±3.532	6W	Before T, After T 6W, 1Y	NRS/ODI
Miyamoto 2013 [29]	Brazil	43/43	Pilates / Education	38.3±11.4/ 40.7±11.8	6W	After T 6W,6M	NRS/RMDQ
Natour 2015 [30]	America	30/30	Pilates + Drugs / Drugs	47.79±11.47/ 48.08±12.98	6W	After T 3M,6M	VAS/RMDQ
Patti 2016 [31]	Italy	19/19	Pilates / Drugs	41.31±11.24/ 41.63±13.01	14W	After T	ODI
Caroline 2021 [32]	Brazil	72/72	Pilates / Running		6W	After T 6M	VAS/QBPDS
Wajswelner 2012 [33]	Australia	44/43	Pilates / General Exercise	49.3±14.1/ 48.9±16.4	6W	After 6W,12W,24 W	QBPDS/NRS

**Note** T: Treatment group, C: Control group, W: week , M: Moth, Y:Year TM: Suspension training method, VAS: Visual Analogue Scale, NRS: Numerical Rating Scale, ODI: Oswestry Low Back Pain Disability Index, RMDQ: Roland-Morris Disability Questionnaire, QBPDS: Quebec back pain disability scale.

### 3.2 Inclusion and baseline status

The 14 RCTs included included 975 patients, including 491 patients in the intervention group and 484 patients in the control group. Two of the studies did not involve information on the age of the patients [26,32], two studies did not indicate the time of assessment [20, 22], and the remaining 10 were comparable in terms of patient age, duration of treatment, time of assessment and evaluation indexes.

### 3.3 Interventions and treatment course

Of the 14 studies included, all were two-arm trials, divided into treatment and control groups.

Among them, they can be divided into 4 groups according to the intervention, namely, the efficacy of Pilates exercise versus other muscle group training [20, 22, 25]; Pilates exercise versus other sports exercises [26, 27, 32, 33]; Pilates exercise versus medication and physiotherapy [21, 28, 30, 31]; and Pilates exercise versus conventional care and preaching [23, 24, 29]. Among the 14 studies, the shortest intervention duration was 2 weeks and the longest was 14 weeks.

### 3.4 Closing indicators

Among the included studies, pain assessment was dominated by VAS and NRS, of which eight were evaluated using VAS [20-23, 25, 27, 30, 32] and five using NRS [24, 26, 28, 29, 33]. Functional impairment was evaluated using ODI, RMDQ and QBPDS, of which 6 were evaluated using ODI [20-22, 25, 28, 31], 4 were assessed using RMDQ [24, 26, 29, 30] and 3 using QBPDS scales [27, 32, 33].

### 3.5 Literature quality evaluation

Of the 14 RCTs included, seven used the random number table method [20,22,24,27,28,30,32], one used computer randomly generated serial numbers [26], and six did not specify a random method [21,23,25,29,31,33]. In terms of allocation concealment, 10 papers described it meticulously [24-33]. In terms of blinded implementation, five papers mention it [24-27,30]. four papers report the number of missed interviews and the specific reasons [24,25,28,32]. The risk of bias and the weight of each component of bias for the specific included studies are shown in Figures 2 and 3.

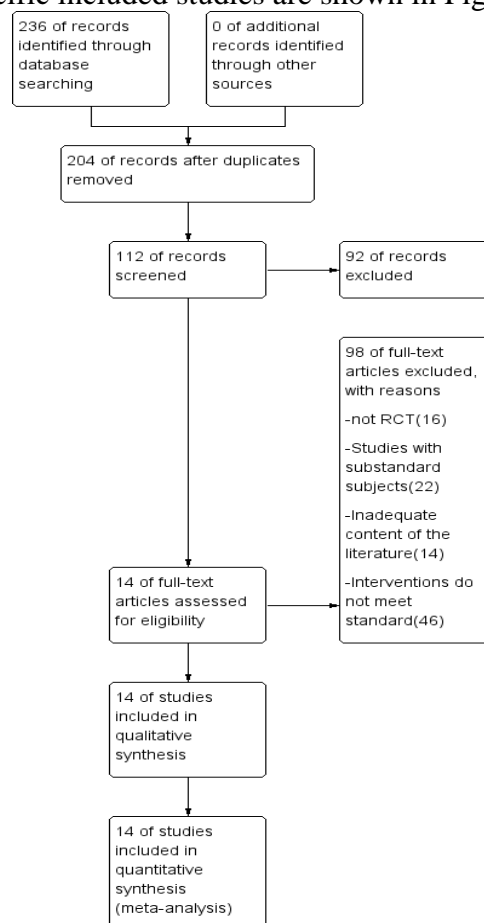


Figure 1: Literature screening process

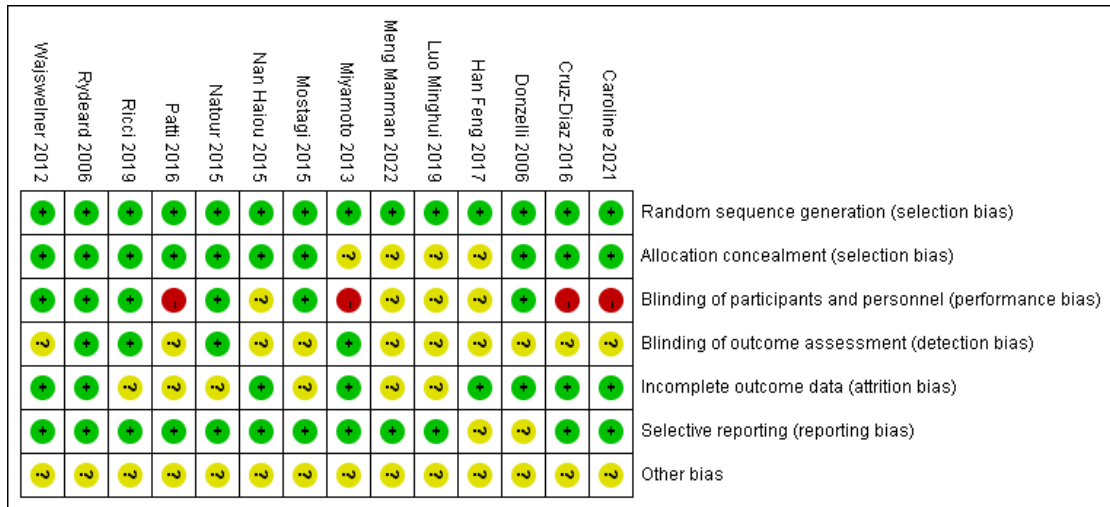


Figure 2: Risk of bias in included studies

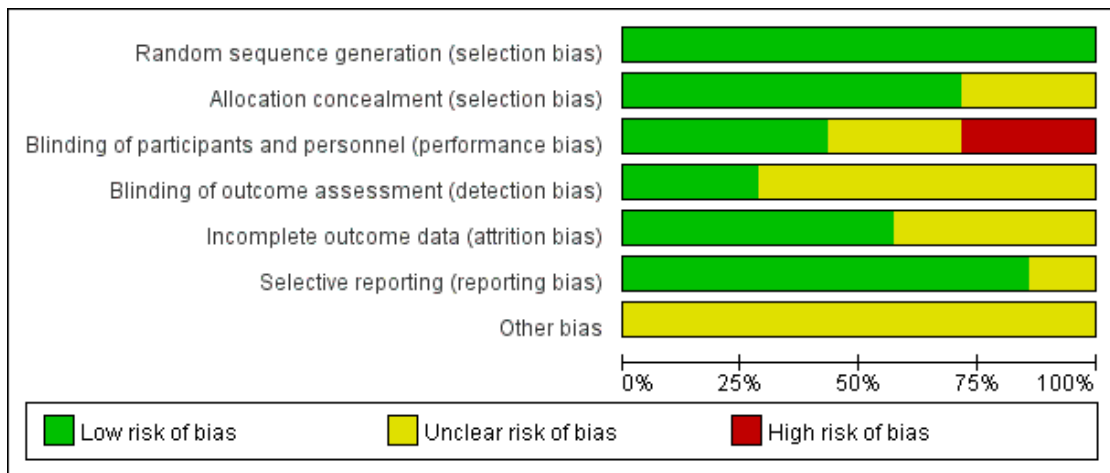


Figure 3: Bias weight of each component

### 3.6 Comparison of the efficacy of Pilates exercise with other muscle groups training

#### 3.6.1 VAS

A total of 3 studies [20, 22, 25] (173 cases) were included, and the heterogeneity test suggested significant heterogeneity between studies ( $I^2=89\%$ ,  $P=0.0001$ ), so a random-effects model analysis was used, and the combined effect size  $MD=-1.71$ , 95% CI  $(-3.86,0.45)$ ,  $Z=1.55$ ,  $P=0.003$ , suggesting that the differences were statistically significant. The results showed that the Pilates exercise group had better VAS scores than the other muscle groups trained. See Figure 4.

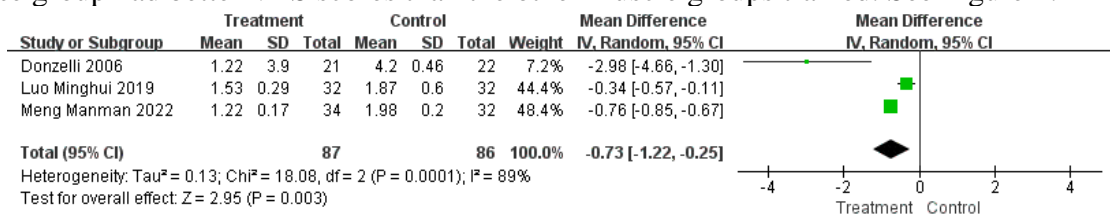


Figure 4: VAS scores of Pilates exercise with other muscle groups training

### 3.6.2 ODI

A total of 3 studies [20, 22, 25] (173 cases) were included, and the heterogeneity test suggested heterogeneity between studies ( $I^2=86\%$ ,  $P=0.0006$ ), so a random effects model analysis was used, and the combined effect size  $MD=-2.35$ , 95% CI (-4.06,-0.65),  $Z=2.71$ ,  $P=0.007$ , suggesting that the differences were statistically significant. The results showed that the Pilates exercise group had better ODI scores than the other muscle groups trained. See Figure 5.

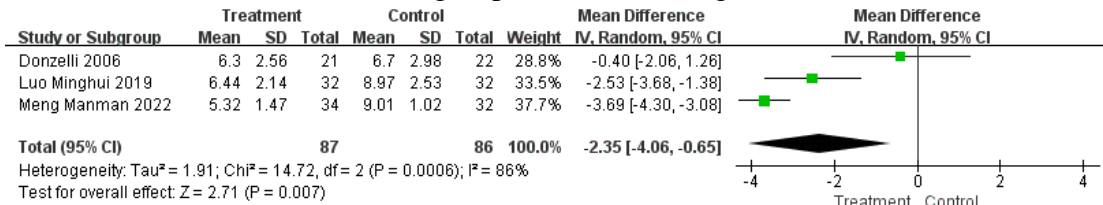


Figure 5: ODI scores of Pilates exercise with other muscle groups training

### 3.7 Pilates exercise with other sports exercise

#### 3.7.1 VAS

A total of 2 studies [27, 32] (166 cases) were included, and the heterogeneity test suggested heterogeneity between studies ( $I^2=95\%$ ,  $P<0.0001$ ), so a random-effects model analysis was used, and the combined effect size  $MD=0.25$ , 95% CI (-3.72, 4.21),  $Z=0.12$ ,  $P=0.9>0.05$ , suggesting that the differences were not statistically significant. The results showed that the VAS scores in the Pilates exercise group were not significantly different from the other exercise workout groups. See Figure 6.

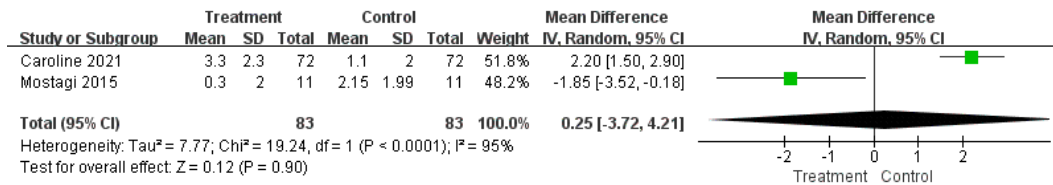


Figure 6: VAS scores of Pilates exercise with other sports exercise

#### 3.7.2 NRS

A total of 2 studies [26, 33] (161 cases) were included, and the heterogeneity test suggested no significant heterogeneity between studies ( $I^2=29\%$ ,  $P=0.23$ ), and the combined effect size  $MD=-0.55$ , 95% CI (-1.16, 0.06),  $Z=1.76$ ,  $P=0.08>0.05$ , using a fixed effects model analysis, suggesting that the differences were not statistically significant. The NRS scores in the Pilates exercise group were not considered significantly different from the other exercise exercise groups. Combining the results of VAS and NRS scores, it was concluded that there was no significant difference between Pilates exercise and other exercise workouts in terms of low back pain in NLBP patients. See Figure 7.

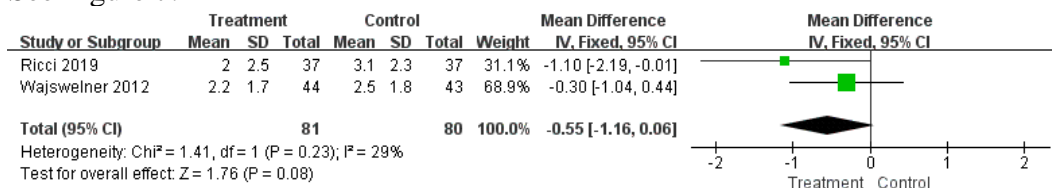


Figure 7: NRS scores of Pilates exercise with other sports exercise

### 3.7.3 QBPDS

A total of 3 studies<sup>[27, 32, 33]</sup> (253 cases) were included, and the heterogeneity test suggested that heterogeneity was seen between studies ( $I^2=69\%$ ,  $P=0.04$ ), so a random effects significant analysis was used, and the combined effect size  $MD=-1.11$ , 95% CI (-6.48,4.27),  $Z=0.40$ ,  $P=0.69>0.05$ , suggesting that the difference was not statistically significant, showing no significant difference in QBPDS scores between the Pilates exercise group and the other exercise workout groups. See Figure 8.

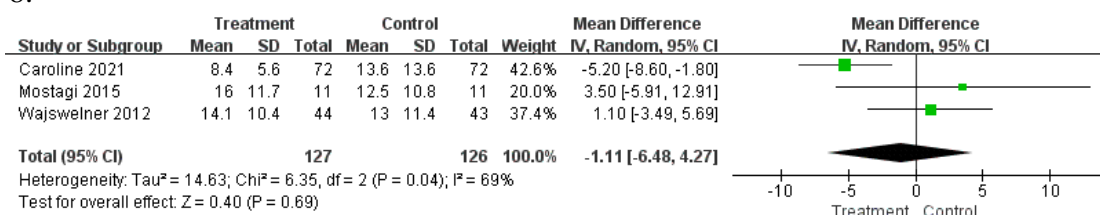


Figure 8: QBPDS scores of Pilates exercise with other sports exercise

### 3.8 Pilates exercise with medication and physical therapy

#### 3.8.1 VAS

A total of 2 studies<sup>[21, 30]</sup> (120 cases) were included, and the heterogeneity test suggested that significant heterogeneity was seen between studies ( $I^2=90\%$ ,  $P=0.001$ ), so a random effects model analysis was used, and the combined effect size  $MD=-1.15$ , 95% CI (-2.75,0.46),  $Z=1.40$ ,  $P=0.16>0.05$ , suggesting that the difference was not statistically significant, concluding that the VAS scores in the Pilates exercise group were not significantly different from the drug and physical therapy groups. See Figure 9.

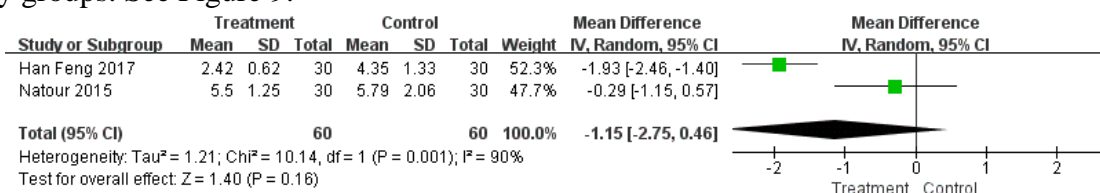


Figure 9: VAS scores of Pilates exercise with medication and physical therapy

#### 3.8.2 ODI

A total of three studies<sup>[21, 28, 31]</sup> (172 cases) were included, and the heterogeneity test suggested significant heterogeneity between studies ( $I^2=89\%$ ,  $P=0.0002$ ), and the heterogeneity analysis revealed that the overlap between the confidence intervals of Patti<sup>[31]</sup> and other studies was significantly different, so it was excluded and the remaining two studies<sup>[21, 28]</sup> (134 cases) were subjected to the heterogeneity. The results showed that there was no significant heterogeneity between the two studies ( $I^2=16\%$ ,  $P=0.27$ ), so a fixed-effects model was used to analyze the combined effect size  $MD=-10.25$ , 95% CI (-11.24,-9.26),  $Z=20.34$ ,  $P<0.00001$ , suggesting that the difference was statistically significant and that the Pilates exercise group had better ODI scores than the drug and physiotherapy groups. See Figure 10.



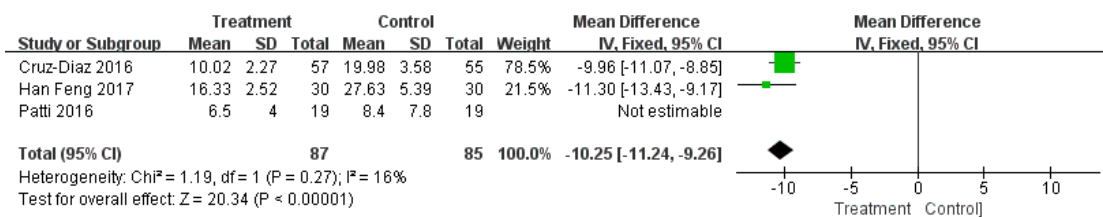


Figure 10: ODI scores of Pilates exercise with medication and physical therapy

### 3.9 Pilates exercise with routine care and awareness

#### 3.9.1 NRS

A total of 2 studies [24, 29] (125 cases) were included, and the heterogeneity test suggested no significant heterogeneity between studies ( $I^2=26\%$ ,  $P=0.25$ ), so a fixed-effects model analysis was used, and the combined effect size MD=-0.85, 95% CI (-1.80,0.10),  $Z=1.75$ ,  $P=0.08>0.05$ , suggesting that the differences were not statistically significant, showed no significant difference between NRS scores and conventional care and mission in the Pilates exercise group. See Figure 11.

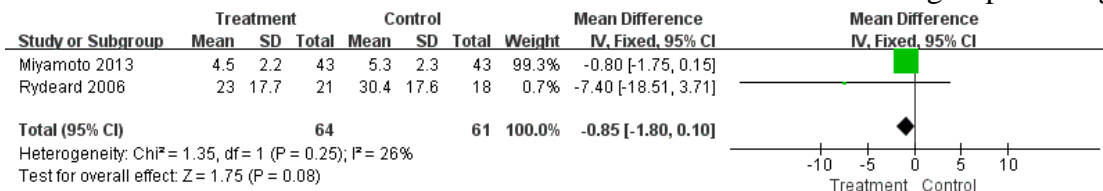


Figure 11: NRS scores of Pilates exercise with routine care and awareness

#### 3.9.2 RMDQ

A total of 2 studies [24, 29] (125 cases) were included, and the heterogeneity test suggested no significant heterogeneity between studies ( $I^2=0\%$ ,  $P=0.46$ ), so a fixed-effects model analysis was used, and the combined effect size MD=-1.60, 95% CI (-3.06,-0.15),  $Z=2.16$ ,  $P=0.03$ , suggesting that the difference was statistically significant and that the Pilates exercise group had significantly better RMDQ scores than the conventional care and missionary group. See Figure 12.

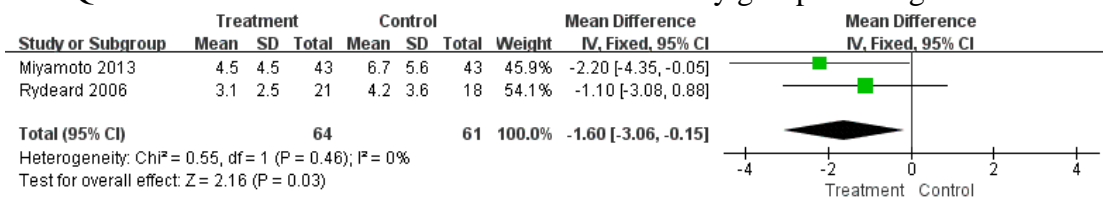


Figure 12: RMDQ scores of Pilates exercise with routine care and awareness

## 4. Discussion

Exercise interventions have been more commonly used in the treatment of patients with chronic pain and play an important role in the rehabilitation of patients with NLBP in particular [34]. In the past few years, Pilates exercises have been one of the most popular exercise programs in clinical practice [35]. In this study, we conducted a systematic evaluation of the relevant literature on the efficacy of Pilates exercise on low back pain and dysfunction in patients with NLBP, with the aim of comparing the differences in efficacy with other treatment modalities through objective evidence provided by evidence-based medicine.

The results of the systematic analysis showed that Pilates exercise was superior to other muscle group training, medication and physiotherapy, and conventional nursing preaching in improving low back dysfunction, with significant differences in the comparison of ODI and RMDQ scores, whereas there were no significant differences in the QBPDS dysfunction rating scale used compared to other exercise programs. This may be related to the use of QBPDS scores to detect changes in patients' conditions, the lack of more subtle differences, the vulnerability of the scale to cultural differences [36], the small number of included studies [27, 32, 33], and the more significant differences in the age distribution of the patients recruited. In terms of pain control in NLBP patients, the VAS scores in the Pilates exercise group were more favorable compared to other muscle group training, while there were no significant differences compared to other exercise workouts, medications and physical therapy, and the routine care mission group; the NRS scores in the Pilates exercise group were not significantly different compared to other exercise workouts and the routine care mission. Similar findings have been reported in several foreign studies, such as the lack of studies that clearly demonstrate the efficacy of specific Pilates exercise programs over other interventions in the treatment of chronic pain [37, 38], in addition, 2 systematic reviews concluded that Pilates methods did not improve pain status in patients with low back pain [39, 40], and the available evidence does not demonstrate the superiority of Pilates-based exercise over other forms of exercise to reduce pain in patients with persistent NLBP [41]. This may be related to the duration [42, 43], frequency of treatment [34], and intensity of treatment, while the duration, frequency, and intensity of Pilates exercises varied in the studies included in this paper.

Analyzing the reasons for the high heterogeneity, we believe that it may be related to patient age and baseline information as well as the duration of treatment and visits. Second, this study included 14 publications involving 975 patients, which has the drawback of small number of included publications and sample size. In addition, only the word random was mentioned in the generation of random sequences in 6 publications, without specifying the randomization scheme, and the allocation concealment and blinding methods were not specified in most of the studies when implementing the scheme, which shows that the overall quality of the included studies was not high, leading to some limitations in the argumentative nature of the Meta-analysis results.

Pilates exercise is an exercise system developed by Joseph Pilates and is a widely used rehabilitation measure in the clinical treatment of NLBP. It is able to exercise the core muscle groups [44] and enhance muscular endurance [45], thus relieving patient pain, maintaining and improving the appearance of normal activity posture, achieving body balance, increasing the range of motion and mobility of the trunk and limbs, and thus improving the quality of patient survival [46].

## 5. Prospect

In this study, the superior efficacy of Pilates exercise in improving low back dysfunction in NLBP patients has been confirmed, however, there are several limitations: first, the limited number of included literature, the inconsistent scales used, the length of treatment sessions, and the wide variation in age distribution led to high heterogeneity among the included studies, making the argument less valid; second, the occurrence of adverse events was not addressed, thus failing to In addition, Pilates exercise seems to be better at restoring lumbar dysfunction in NLBP patients, however, it has no significant advantage over other sports exercises, medication and physical therapy, and conventional care and education in terms of lumbar pain. Based on this, the following issues need to be addressed in future clinical studies: (i) Further high-quality, large-sample randomized controlled studies are needed to reduce heterogeneity and improve the validity of the results. (ii) The occurrence of adverse events should be emphasized in the studies to effectively

ensure safety during treatment. (iii) Future studies need to focus on the effectiveness of Pilates exercise compared with other exercise, medication and physical therapy, and conventional care and education in relieving low back pain. (iv) The comparison of the efficacy of Pilates exercise with other exercise exercises, medication and physical therapy, and conventional care and education in relieving patients' low back pain is needed in future studies to validate the ideas of this study.

Conflict of interest statement: All authors declare that there is no conflict of interest.

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