Effectiveness of Pilates exercise for managing chronic non-specific low back pain: a Systematic Review with Meta-analysis

Antonino Patti[1], Jane S. Thornton[2], Valerio Giustino[1*], Patrik Drid[3], Antonio Paoli[4], Jenna M. Schulz[6,7]., Antonio Palma[1,5], Antonino Bianco[1]

[1] Sport and Exercise Sciences Research Unit, Department of Psychology, Educational Science and Human Movement, University of Palermo, Palermo, Italy

[2] Western Centre for Public Health and Family Medicine, University of Western Ontario Schulich School of Medicine and Dentistry, London, ON, Canada

[3] Faculty of Sport and Physical Education, University of Novi Sad, Novi Sad, Serbia

[4] Department of Biomedical Sciences, University of Padua, Padua, Italy

[5] Regional Sports School of Italian National Olympic Committee (CONI) Sicilia, Palermo, Italy

[6] School of Physical Therapy, Faculty of Health Sciences, University of Western Ontario, London, Canada

[7] Bone and Joint Institute, University of Western Ontario, London, Canada

[*]Corresponding author:

Valerio Giustino

ADDRESS: Via Giovanni Pascoli, 6, 90144, Palermo, Italy

E-MAIL: valerio.giustino@unipa.it

ORCID: 0000-0002-4575-8021

https://www.unipa.it/persone/docenti/g/valerio.giustino

Abstract

Purpose

Low back pain (LBP) is the most frequently reported musculoskeletal disorder and represents one of the highest patient burdens in healthcare. This systematic review and meta-analysis aimed to investigate the effectiveness of Pilates exercise for managing low back pain (LBP).

Materials and methods

A Systematic review with meta-analysis was conducted. Data sources: MEDLINE-NLM and MEDLINE-EBSCO. We also searched on Scopus Elsevier, Cochrane, DOAJ, SciELO, PEDro, and PLOS ONE databases. Randomized controlled trials (RCTs) evaluating LBP in which the primary treatment was based on Pilates exercise compared with no exercise, or non-specific exercise.

Results

The search returned 1566 records of which 36 articles were included in this systematic review and 17 in the meta-analysis. Twenty-two studies compared the effects of the Pilates exercise versus no exercise and 13 studies examined the effects of Pilates exercise versus non-specific exercise. Studies showed that Pilates had a positive effect on the perception of LBP vs no exercise (SMD= -0.80, 95%; p<0.00001) and non-specific exercise (SMD= -2.36, 95%, p=0.02).

Conclusions

Pilates exercise can decrease LBP compared to no exercise and non-specific exercise. General practitioners should consider Pilates exercise as an effective strategy to manage LBP and counteract the growing health.

Trail Registration: PROSPERO registration number: CRD42022308387.

Keywords: Pilates exercise, Pilates method, low back pain, body posture, physical exercise, health promotion, systematic review, meta-analysis.

Introduction

Low back pain (LBP) is the most frequently reported musculoskeletal disorder and represents one of the highest patient burdens in healthcare. Almost 80% of the population will suffer from LBP In in their lifetime, causing it can limitations in the performance of normal daily activities of daily living and prolonged absences from work [1]. LBP is a common clinical presentation encountered by general practitioners [1]. Indeed, many with LBP seek initial care from their general practitioner, [2] creating a significant and ongoing workload for the healthcare system. There is therefore a need for identifying effective management strategies to use in the primary healthcare setting. Chronic non-specific LBP is defined as back pain localized below the costal margin and above the inferior gluteal folds, with or without leg pain and nerve involvement [3]. LBP can be further classified according to symptom duration: acute (less than 4 weeks), subacute (over 4 weeks and up to 12 weeks), and chronic (longer than 12 weeks) [4]. Pain can originate from mechanical, neuropathic, and secondary causes. Pilates is a “method” of sequential exercises in which body and mind are closely linked, developed to correct muscle imbalances, improve body posture, and increase fitness levels. Each of them is linked and built on the previous exercise in order to strengthen the body and acquire a greater awareness of the mind-body relationship [5,6]. In 2015 our research unit conducted a systematic review to examine the effects of Pilates exercise in chronic LBP [7]. In this study, we found that the applied Pilates protocols were vague and often undefined, and the homogeneity of the intervention group/control group was not optimal. They demonstrated that Pilates “helps” in the treatment of chronic pain, but it was not yet clear exactly which factors or types of exercises may be responsible for such improvements. The data in the literature suggest that Pilates improves the functionality of the diaphragm, the transverse muscle, and all respiratory muscles [8]. This systematic review aims to update the evidence on this topic and evaluate whether the scientific rigor on the application of Pilates exercise in these participants has improved after seven years. To achieve this, we performed a comprehensive systematic review and meta-analysis with the aim of examining the benefits of Pilates exercise on LBP assessed using pain rating scales and comparing Pilates exercise with no exercise or with non-specific exercise. To define non-specific exercise, we followed the study by Hayden, J. A. et al [9]. The authors showed that some types of workouts were more effective than others and also demonstrated that Pilates and McKenzie therapy were more effective than other types of exercise. We analyzed the results of all randomized controlled trials (RCTs) published after 2000 that met our inclusion criteria.

Methods

Protocol and registration

This systematic review and meta-analysis, registered in PROSPERO (CRD42022308387) (https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42022308387), adopted the points reported in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement [10].

We considered studies that assessed the benefits of Pilates exercise on LBP perception using multiple scales. Some studies were not included in the meta-analysis due to the discrepancy in the scales used. Hence, we analyzed the following scales in the meta-analysis: Visual Analogue Scale (VAS), Numeric Rating Scale (NRS), Oswestry Disability Index (OLBPDQ), Roland-Morris scale (RMS), Borg, Quebec Back Pain Questionnaire, Pain Self-efficacy Questionnaire (PSEQ), SF-36v2, McGill Pain Questionnaire (MPQ). Additionally, since some studies have investigated the effects of Pilates exercise versus no exercise or non-specific exercise, we carried out a separate meta-analysis.

Eligibility Criteria

Only randomized controlled trials (RCTs) including participants with LBP in which pain was evaluated were included, and in which the primary treatment was based on Pilates exercise versus no exercise, or non-specific exercise. To be included in this systematic review, studies had to meet the following criteria: (1) published in the English language; (2) published in full text, so that the methodological quality of the studies could be assessed together with the results; (3) achieved a

PEDro summary score ≥4 [11,12]; (4) used outcome measures with appropriate psychometric qualities that evaluated pain and/or functional ability in people with LBP; that is, Visual Analogue Scale (VAS), Numeric Rating Scale (NRS), Oswestry Disability Index (OLBPDQ) [13], Roland-Morris scale (RMS) [14], Borg [15], Quebec Back Pain Questionnaire [16], Pain Self-efficacy Questionnaire (PSEQ) [17], SF-36v2 [18], McGill Pain Questionnaire (MPQ) [19]; (5) used Pilates exercise a treatment. We excluded: (1) RCTs with outcomes for pain that did not have sufficient responsiveness, validity, or reliability (only validated and standardized pain assessment scales); [20] (2) studies in which exercises were described as "motor control" or "lumbar stabilization" were not sufficient to be included in the Pilates exercise as this method can include other features besides motor control and lumbar stabilization [6]; (3) abstracts were excluded [21].

Search Strategy and Keywords

Publications were selected based on a literature search ranging from 2000 to 2022. The following databases were used: MEDLINE-NLM and MEDLINE-EBSCO. We also searched on Scopus Elsevier, Cochrane, DOAJ, SciELO, PEDro, and PLOS ONE databases.

The search strategy included the use of the terms "Pilates", "Low Back Pain", "exercise", "motor control", "core", in the title, abstract, and keywords, and the removal of "Low" in "Back Pain" did not identify any additional studies.

Study record

The search results were uploaded into EndNote 20 software (Clarivate Analytics, Jersey, UK) and duplicates were removed. Two independent investigators (AP and VG) conducted the literature search, screened the titles and the abstracts for relevance of the studies based on the inclusion criteria of this systematic review, and performed the synthesis as follows: Study design; Sample (n); Pain measure; Intervention; Main results on pain perception.

Any cases of disagreement between the two investigators were resolved through discussion and the consent of a third investigator (AB). The screening process was summarized in the PRISMA flow diagram (Fig. 1). A table was created to extract relevant study data using a Microsoft Excel spreadsheet (Microsoft Corp, Redmond, Washington).

Primary outcome

The primary outcome measure was pain intensity measured after the end of the intervention [22] through Visual Analogue Scale (VAS), Numeric Rating Scale (NRS), Oswestry Disability Index (OLBPDQ), Roland-Morris scale (RMS), Borg, Quebec Back Pain Questionnaire, Pain Self-efficacy Questionnaire (PSEQ), SF-36v2, McGill Pain Questionnaire (MPQ).

Risk of bias assessment and quality assessment

The methodological quality of the included studies was evaluated using the PEDro (Physiotherapy any evidence Database) scale, which is a validated tool for assessing the risk of bias of RCTs [11], and is commonly used in literature [23]. Only studies with a summary score ≥4 were included in this systematic review (Table 1). Moreover, we also evaluated the risk of bias of the studies using the Cochrane risk of bias tool which is present in the RevMan 5.3 software [24-26]. We used the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) framework to assess the certainty of the evidence in the systematic review. We used the GRADE profiler (GRADEpro GDT) to create a summary of the findings table (Table 2) [26-28]. We justified all decisions to downgrade or upgrade the quality of studies using footnotes and made comments to aid readers' understanding of the review where necessary, in accordance with Section 4.3 of the Cochrane Handbook for Systematic Reviews of Intervention. The evidence was graded as having ‘high’, ‘moderate’, ‘low’, or ‘very low’ certainty. Five factors were considered to grade the certainty of evidence: risk of bias, inconsistency, indirectness, imprecision, and other considerations.

Data collection and analysis

Data was collected and analyzed by AP, VG, and AB using RevMan 5.3 software. Standardized mean difference (SMD) was calculated and used in the meta-analysis. Studies that did not report the mean and standard deviation before and after the exercise were not excluded from the meta-analysis. The standardized mean difference is a statistical value to measure the same outcome that has been measured in various ways and/or different times. This allows to express the size of the intervention effect. Inconsistency or statistical heterogeneity of the studies was evaluated by calculating the Chi^2 and I^2 tests. The heterogeneity of the studies was evaluated by calculating the I^2 value. It can be assumed that I^2 values of 25%, 50%, and 75% reflect small, moderate, and large degrees of heterogeneity. If $I^2 \leq 50\%$ studies were considered homogeneous and the fixed effect model was used, if $I^2 > 50\%$ the random effect model was used. A p-value <0.05 was considered statistically significant. We used the pooled relative risk [and confidence intervals (CI:95%)], and the standard mean difference (SMD) (and CI) to analyze continuous outcomes. Cohen´s classification was used for the interpretation of effect sizes with SMD: SMD ≥ 0.2 small effect, SMD ≥ 0.5 moderate effect size and SMD ≥ 0.8 large effect size [29].

Results

Study identification and study characteristics

Our search yielded 1566 articles. Nine hundred and thirty articles were excluded based on title and abstract, and 297 duplicate records were removed. Full-text articles were screened for relevance and 36 RCTs met our eligibility criteria. Therefore, 36 studies (n=2030 participants) were included (Fig. 1)[10]. Eighteen RCTs (n=292 participants) were included in the meta-analysis. We analyzed the effect of Pilates exercise by taking the values of the most common and validated pain perception scales as a reference. Most of the included studies had similar populations regarding age (18-75 years). The studies had similar LBP characteristics (Table 3). The mean Pilates exercise period was 6.86±6 weeks. However, in the included studies there was a great diversity in the amount and types of exercises in the Pilates method. Table 3 provides a summary of the studies included in the review. Studies ranged from 15 [30] to 222 [31,32] participants. The included studies were published over 15 years from 2006 to 2021. Regarding the measured outcome, 12 studies used the VAS [33-44], 8 studies used the OLBPDQ [34,36,39,41,43,45-47], 8 studies used the Roland-Morris scale (RMS) [33,34,37,42,44,45,48,49], 5 studies the NRS-10 [30,46,50-53], one study the NRS-100 [54], one study used the Borg, 2 studies used the Pain Self-efficacy questionnaire (PSEQ) [50,55], 2 studies used the SF-36v2 [49,56], and 2 studies the McGill Pain Questionnaire (MPQ) [49,57]. Moreover, 22 studies compared the effects of Pilates exercise versus no exercise [32,33,35,37-39,41-47,49,51,53,56-61], and 13 studies examined the effects of Pilates exercise versus non-specific exercise [30,34,36,40,48,50,54,55,62-66]. One study analyzed the effect of different weekly frequencies of Pilates exercise [31].

Risk of bias studies and quality assessment

Although the risk of bias was identified to different levels in all included studies in the meta-analysis, the Cochrane risk of bias tool showed that most studies were classified at low risk of bias. Furthermore, data collectors and/or participants were not blinded, or the authors did not describe it (performance bias) (Fig. 2). The PEDro scale ranged from 4/10 to 8/10 with 21/36 RCTs achieving “moderate to high” quality scores (>6/10). The PEDro scale mean score of the studies was 6.05/10. The lowest scores for the included studies were achieved in items 5 and 6 (blinding of participants and therapist). Blinding of outcome measures was thought to be sufficient (“low” risk) [67]. Furthermore, GRADE was used to evaluate the risk of bias and certainty of the evidence, respectively.

Meta-analysis

The meta-analysis included data from Pilates exercises at the beginning and at the end of the intervention. Follow-up results were not included in the analysis because they were not present in all studies or had different, and therefore not comparable, follow-up periods. To evaluate the perception of pain we analyzed the results of the VAS, NRS-10, RMS, and OLBPDQ scales because they were present in multiple included studies and allowed an analysis of the intervention effect. The analyses were conducted by comparing: a) Pilates versus no exercise (Fig. 3); b) Pilates versus non-specific exercise (Fig. 4).

Synthesis of results

As shown in Fig. 3, Pilates exercise revealed an effect in most studies. The ranked forest plot of the intervention effect identifies that, compared with no exercise, Pilates exercise had the largest effect size. The studies that used VAS showed a high heterogeneity between studies (I^2=89%) and the random-effect model showed that Pilates had a beneficial effect on the perception of LBP [SMD= -0.94, 95% CI (-1.70, -0.17), p=0.02] (Fig. 3). The studies that used NRS-10 (I^2=39%) in the random-effect model showed that the difference was statistically significant [SMD= -1.11, 95% CI (--1.51, -0.71), p<0.00001] (Fig. 3). This was also the case in studies that used RMS (I^2=86%) as the random-effect model indicated that the intervention had a favorable trend although not statistically significant [SMD= -0.68, 95% CI (-1.38, 0.01), p=0.05] (Fig. 3). Studies that used the OLBPDQ indicated homogeneity (I^2=35%), and the random-effect model was used. These studies showed that Pilates had a beneficial effect on the perception of pain and the difference was statistically significant [SMD= -0.66, 95% CI (-0.99, -0.33), p<0.00001] (Fig. 3). Similarly, the analysis between Pilates and non-specific exercise showed a statistically significant difference (I^2=92%) [MD= -2.36, 95% CI (-4.42, -0.30), p=0.02] (Fig. 3). VAS was used in these studies. Total analysis showed that Pilates had a positive effect on the perception of LBP vs no exercise (SMD= -0.80, 95%; p<0.00001) and non-specific exercise (SMD= -2.36, 95%, p=0.02).

Discussion

This systematic review found that Pilates exercise can improve the perception of LBP compared to no exercise and non-specific exercise, as measured by the most used standardized pain scales. This is the second systematic review conducted by our research unit, eight years after the first [7]. The results confirm the conclusions we showed in the previous study, but in this study, as shown in the GRADE Summary Table (Table 2), we measure the effect of Pilates and note that there is greater scientific rigor in conducting research on this topic. In 2014, our systematic review showed that there was no homogeneity in terms of the control group and intervention group or intervention. Since 2015 there have been 22 additional studies. In the studies analyzed, the mean duration of the intervention was 6.86 weeks, which allowed us to evaluate the effect of Pilates exercise over the short- to medium-term. However, a limitation of these studies that remains today is the lack of long-term follow-up. The Visual Analogue Scale (VAS) was the most commonly used scale to evaluate LBP, and in these studies, Pilates exercise improves the perception of LBP both compared to control groups that did not perform exercise and compared to groups that carried out the non-specific exercise. Lumbar stabilization has a positive effect on LBP but not all types of exercise work [68]. Physical training that strengthens the transverse and multifidus muscles increase spinal stability, neuromuscular control and decreases LBP [69]. An interesting study by Cruz-Díaz et al showed the effects of Pilates on women with LBP[46]. The sample analyzed consisted of 101 participants and the duration of the intervention was of 6 weeks. The authors analyzed Pilates exercise combined with physiotherapy compared with only physiotherapy (MD= -2.74, 95% CI (-3.86, -1.62). The results suggested that Pilates in addition to physiotherapy is more effective than physiotherapy alone ($p<0.001$)[46]. Moreover, in 2020, Poncela-Skupien et al showed that six weeks of Pilates combined with therapeutic exercise versus therapeutic exercise alone can reduce pain and improve postural alignment in children[40]. Our meta-analysis indicated that Pilates exercise improves LBP compared to no exercise; results which were significant in studies that used VAS and OLBPDQ. Studies employing NRS-10 and RMS showed a positive effect of Pilates exercise but only with a significant difference in NRS-10 (p=0.00001 and p=0.05; Fig. 3). The same positive trend was found in the analysis that compared Pilates exercise with non-specific exercise, in line with the literature (Fig. 4) [70,71]. In addition, our analysis showed that all studies presented a high risk in the blinding of participants and personnel. Probst et al. described that the participants (patient or practitioner) who know the effect of a specific intervention in advance may perceive an enhanced treatment effect [72].

In conclusion, our analysis indicated that Pilates can improve the perception of LBP and this could be attributed to improved neuromuscular and balance control[47]. Pilates exercise is undoubtedly a functional strategy. There is a great waste of health care resources, career costs, and lost productivity that represents a significant burden to the worldwide economy. In addition, repeated investigations, diagnoses and treatment strategies that are often ineffective and can result in chronic pain and decrease the cost-effectiveness of low back chronic pain management interventions. To manage the demand of patients with LBP and counteract the growing health and social burden of LBP and the associated rate of disability, the healthcare provider can consider Pilates exercise as an effective strategy in the short- to medium-term.

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Figure Legends

Fig. 1. PRISMA Flow diagram of the studies included.

Fig. 2. Risk of Bias assessment.

Fig. 3. Meta-analysis of pain intensity between Pilates exercise and Control group. CI, confidence interval; SD, standard deviation; SMD, standard mean difference

Fig. 4. Meta-analysis of pain intensity between Pilates exercise and non-specific exercise. CI, confidence interval; SD, standard deviation; SMD, standard mean difference