Complementary Therapies in Medicine 41 (2018) 130–140

Contents lists available at ScienceDirect

Complementary Therapies in Medicine

journal homepage: www.elsevier.com/locate/ctim

Pilates for women with breast cancer: A systematic review and meta-analysis

Arrate Pinto-Carral[a,*], Antonio J. Molina[b], Álvaro de Pedro[c], Carlos Ayán[c]

[a] SALBIS Research Group, Department of Nursing and Physiotherapy, Universidad de León, Spain
[b] Research Group on Gene-Environment Interactions and Health (GIIGAS), Institute of Biomedicine (IBIOMED), Universidad de León, Spain
[c] Faculty of Educational Sciences and Sports, University of Vigo, Spain

ARTICLE INFO

Keywords:
Breast cancer
Meta-analysis
Review
Women
Pain
Quality of life

ABSTRACT

Objectives: To identify and evaluate the characteristics and methodological quality of the studies that have proposed Pilates as a rehabilitation strategy for women with breast cancer and to determine its benefits on health outcomes in this population.

Methods: A systematic review and meta-analysis were conducted. Medline/PubMed, Pedro, SPORTDiscuss, Scopus and Web of Science were systematically searched up to January 2017. The methodological quality was evaluated by means of the Jadad Scale and the Quality Assessment Tool for Before–After Studies with No Control Group. Risk of bias was assessed by means of the Cochrane Collaboration's tool.

Results: Five randomized controlled trials and two un-controlled studies were selected. Four of the randomized controlled trials were pooled in the meta-analysis for effects of Pilates on shoulder range of motion, quality of life, pain, and self-reported upper extremity function. According to the findings reported in the studies analysed in the review, Pilates had a positive and significant effect on the aforementioned variables, as well as on functional status, mood, fitness and upper extremity circumference. The meta-analysis carried out showed that the effects that Pilates had on shoulder range of motion and quality of life, was not significantly greater than those resulting from other exercise programs.

Conclusions: Pilates relieves the impact of breast cancer-related symptoms. These effects are not significantly greater than those derived from the performance of other therapies, with the exception of pain and self-reported upper extremity function.

Systematic review registration number: PROSPERO CRD42018076852.

1. Introduction

Breast cancer (BC), the most prevalent cancer in women, is now considered as a form of chronic illness with longer survivorship years.[1] However, improved survival rate of BC also comes with numerous side effects from cancer and from its treatment. Indeed, it has been estimated that more than 15 million of women live with disabilities caused by this malignancy.[2] Scientific evidence has suggested that high-risk lifestyle behaviors exacerbate the health of BC survivors and increase their mortality rate; therefore, the promotion of a healthy lifestyle among this population is an important rehabilitation strategy.[3] In this regard, the performance of physical exercise has been proposed as an important form of adjuvant treatment in BC care.[4,5] Indeed, the results of multiple meta-analysis and of systematic reviews have demonstrated that in women with BC, exercise attenuates the treatment-related morbidity and optimizes the quality of survival through improvements in their physical and psychosocial state.[6]

Nevertheless, exercise adherence is still a challenge for this population[7] and further research into alternative exercise modes is required.[8] With regard to the foregoing, it has been observed that catering to exercise preferences, as well as having positive beliefs regarding the effects of the exercise therapy proposed are essential to encourage cancer survivors to engage in physical training programs.[9,10] In this context, the promotion of Pilates, a mind-body exercise approach that can be considered a complementary and alternative medicine therapy,[11] emerges as an interesting strategy for people with BC for several reasons. Firstly, because it is considered an attractive mainstream form of exercise for women.[12] Secondly, because its performance combines light-moderate intensity physical exercise with mindfulness, thus having the potential to improve both physical and psychological sequelae of BC treatment.[13] Finally, because in comparison with conventional therapeutic exercise training, Pilates offers the potential to reduce the biomechanical dysfunction that can occur as a result of cancer therapy, through improvements in body and kinesthetic

* Corresponding author at: School of Health Sciences, Avda, Astorga s/n, 24401, Ponferrada, León, Spain.
E-mail address: apinc@unileon.es (A. Pinto-Carral).

https://doi.org/10.1016/j.ctim.2018.09.011
Received 26 May 2018; Received in revised form 23 August 2018; Accepted 14 September 2018
Available online 15 September 2018
0965-2299/

awareness.[14] However, before Pilates could be established as a standard BC care treatment, the existing scientific evidence supporting its safety and efficacy should be critically reviewed, as has recently been the case for other alternative exercise therapies.[15,16]

To the author's knowledge, only one review article regarding the effects of Pilates on women with BC has been published so far.[17] This work included only randomized controlled trials (RCT) on the bases that they are considered as the gold standard for evaluation. However, the inclusion of non-RCTs when performing systematic reviews of therapeutic interventions should be considered for a number of reasons. First of all, when the number of RCT's found regarding the effects of non-pharmacological therapies is small, it is difficult to draw firm conclusions. Therefore, the inclusion of non-RCTs might be useful to get a better overview of what is known so far and to inform about future research.[18] Secondly, when reviewing the feasibility of novel therapies, non-RCTs can provide useful data to evaluate safety and to inform about the existence of adverse effects or response rates.[19] Finally, non-RCTs can include important and detailed information regarding the characteristics of the intervention that has been carried out (i.e., number and duration of sessions, Pilates modality performed, types of exercise proposed or rejected, adverse effects). Thus, they can be useful for health professionals, who are in need of basic guidelines that allow them to prescribe exercise efficiently, which is the final purpose of this persistent work. Under these circumstances, this study aims to systematically review the characteristics and methodological quality of the studies that have proposed Pilates as a rehabilitation strategy for women with BC, as well as to determine its benefits on health outcomes in this population.

2. Methods

This systematic review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[20] The selected search strategy and methods of analysis were registered at the PROSPERO database (ref: CRD42018076852).

2.1. Search strategy

Five electronic databases (Medline/PubMed, Pedro, SPORTDiscuss, Scopus and Web of Science) were searched from the inception of each database to January 2017. The following search terms, Boolean operators, and combinations were used: "Cancer" OR "Neoplasm" OR "Lymphoedema" AND "Pilates" OR "Core stability" or "Motor control".

2.2. Eligibility criteria

Studies that provided information regarding the effects of Pilates interventions on women with early to later stage (Stage O–III) BC or who had undergone BC surgery with or without adjuvant cancer therapy, were considered eligible. Studies were excluded if a) the study included cancers other than BC, unless separate data were available for the BC subgroup; b) the study used qualitative methodology; c) the full-text of the study was not available in English and d) the study was a review, a case report, a letter to the editor or an abstract from a congress.

2.3. Study selection

Two researchers screened the titles and abstracts of the identified studies for eligibility and removed all the duplicated references. Additionally, all of the full-texts of the studies that met the inclusion criteria were manually screened for any additional possibly relevant investigations. After independently reviewing the selected studies for inclusion, these were compared by both researchers to reach an agreement. Once the agreement had been reached, a full-text copy of every potentially relevant study was obtained. If it was unclear whether the study met the selection criteria, advice was sought from a third researcher and a consensus of opinion made.

2.4. Data extraction

Information on participants' characteristics, Pilates program, adverse events, drop-outs and outcomes were extracted from the original reports by one researcher and checked by a second researcher. Missing data were obtained from the study authors, whenever possible.

2.5. Quality appraisal

The methodological quality of the selected studies was assessed by one researcher. In case of doubt, advice was sought from a second researcher. The selected studies were heterogeneous in terms of study design. Therefore, two different quality appraisal tools were used. The methodological quality of the randomized controlled trials (RCT) was evaluated and summarized using the Jadad Scale[21] which is based on three criteria: description of randomization, blinding, and dropouts or withdrawals (the score ranges from 0 to 5). Risk of bias for these studies was assessed by means of the Cochrane Collaboration's tool.[22] For rating the methodological quality of the uncontrolled studies, the Quality Assessment Tool for Before–After Studies with No Control Group[23] was used. This tool assesses the risk of bias with 12 questions. These comprise the risk for different types of bias, such as selection bias, reporting bias or observer bias. Quality assessment criteria were further assessed using the Oxford Centre for Evidence-Based Medicine (CEBM) Levels of Evidence[24] for all the included studies. The CEBM, grades the methodological rigor of investigations from level 1 or grade A (systematic review of RCTs, 1a; individual RCT with narrow confidence interval, 1b) to level 5 or grade D (expert opinion).

2.6. Data analyses

A meta-analysis restricted to RCTs was intended to be carried out, provided that the same outcomes had been assessed in at least two studies in a comparable way, and pre and post data were presented for the control and Pilates groups [25,26]

For this purpose, the standardized mean differences (SMD) and their 95% CI were calculated to assess the change in the Pilates group compared to the control group, for each selected variable. The SMD is the mean divided by the standard deviation (SD), and its calculations incorporated Pilates and control groups post-intervention sample sizes, pre- and post-intervention means, and standard deviations for each of the selected outcome measures.[22]. To obtain the pooled effects, a fixed-effect model and a random-effects model according to DerSimonian & Laird[27] were performed, selecting therefore, the most adequate model for each analysis according to the heterogeneity level (random-effects model if $I^2 > 30\%$). Forest plots displaying SMD and 95% CIs were used to compare the effects between intervention and control groups. SMDs were significant when their 95% CIs excluded zero, while pooled SMD values of less than ± 0.2, or ranging from ± 0.2 to ± 0.8, or greater than ± 0.8 indicated the existence of small, medium or large effects respectively. All statistical analyses were performed using Stata 13.

3. Results

3.1. Designs and samples

Out of the 485 references initially obtained, a total of seven studies (five randomized controlled trials[28–32] and two un-controlled studies[33,34]) were finally selected (Fig. 1). Four RCTs were pooled in the meta-analysis given that they included comparable pre and post information for both the control and Pilates groups regarding the effects of Pilates on shoulder range of motion, quality of life (QOL), pain, and upper extremity function (UEF).[28,30–32]

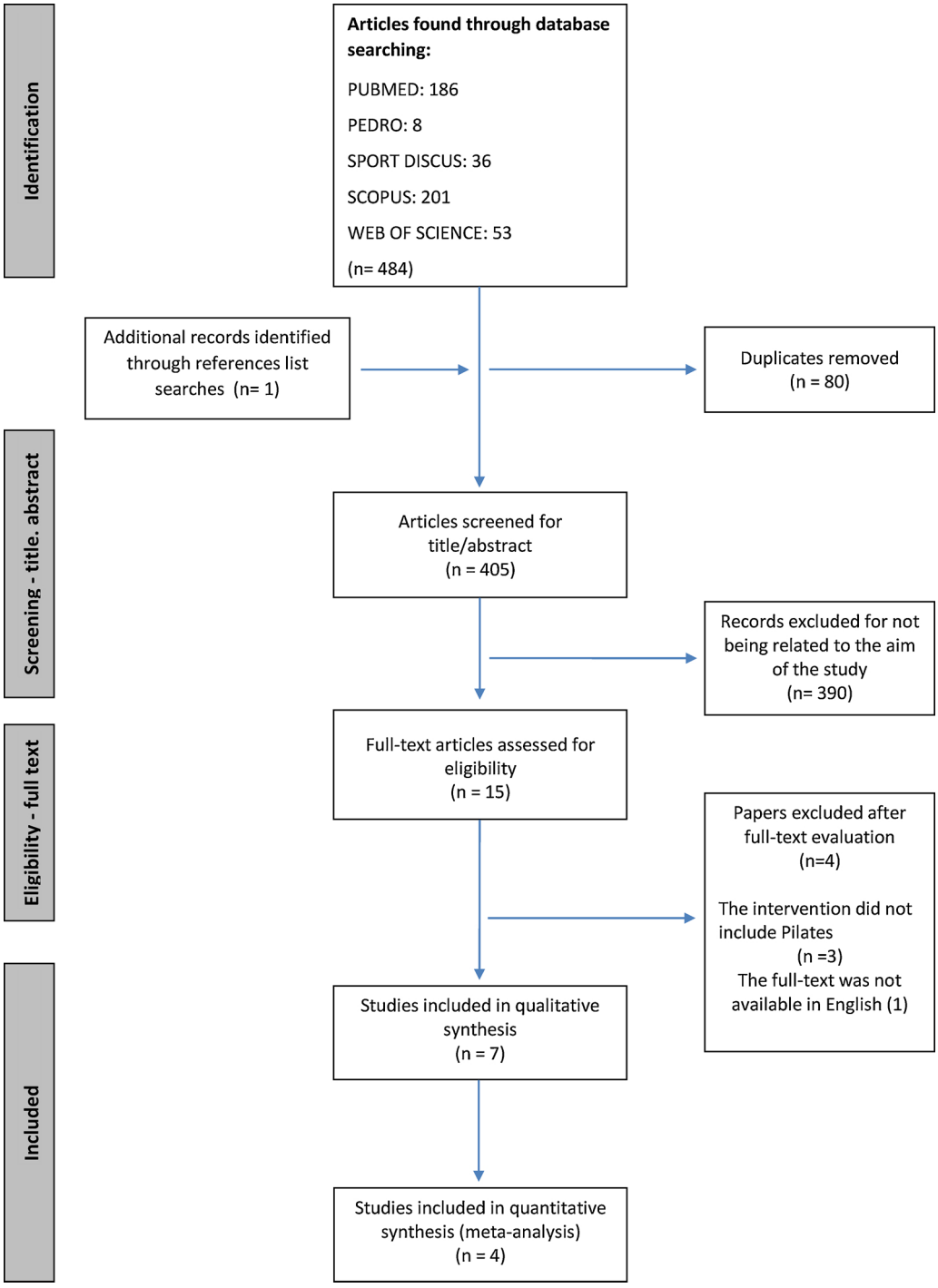

Fig. 1. Flow diagram based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement.

3.2. Critical appraisal

The results of the quality assessment of the randomized controlled trials using the Jadad scale are shown in Table 1. The highest score recorded was 3 out of 5, and was reached by three studies.[28,31,32] The highest evidence level was found in the study by Gajbhiye & Deshpande[30] (Table 1).

Table 2 shows the risk of bias assessed by the Cochrane tool. A high performance and detection risk of bias were detected in all the studies, since in none of them was it specified the existence of blinding, neither of the assessors nor of the participants. As for the attrition bias, one study presented a high risk due to an imbalance between the withdrawals of both groups, with a much higher attrition rate in the group described as the control group.[28] In two studies, the risk was rated as unclear, as the existence of withdrawals or missing data was not reported.[29,30] In the other studies, the attrition bias risk was considered low.

All the studies showed a low reporting bias risk, with the exception of the study by Zengin Alpozgen et al.,[31] in which the final values of one of the analyzed outcome variables (grip strength) were not unveiled, being showed only the p values. Selection bias risk was low for all the analyzed studies.

The assessment of the methodological quality of the uncontrolled studies is shown in Table 1.

Table 1
Quality assessment of the randomized controlled trials and uncontrolled studies.

Randomized controlled studies: Jadad scale	Randomization (0–2)					Blinding (0–2)				An account of all patients (0–1)			Total score (0–5)	Oxford level of evidence
Eyigor et al.[28]	2					0				1			3	2b
Martin et al.[29]	2					0				0			2	2b
Gajbhiye & Deshpande [30]	2					0				0			2	1b
Zengin Alpozgen et al.[31]	2					0				1			3	2b
Şener et al.[32]	2					0				1			3	2b
Uncontrolled studies: Quality Assessment Tool for Pre-Post Studies With No Control Group†	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Total score**	**Oxford level of evidence**
Keays et al.[33]	1	1	‡	1	0	1	1	0	1	0	1	§	7	4
Stan et al.[34]	1	1	‡	1	0	1	1	0	1	1	0	§	7	4

† National Heart, Lung and Blood Institute's Quality Assessment Tool for Before-After (Pre-Post) Studies With No Control Group; ‡ cannot determine; § not reported.

3.3. Interventions

All the interventions were specifically based on the performance of Mat Pilates, with the exception of two studies, in which Pilates machines were used.[29,33] Pilates sessions were carried out in a supervised manner in specialized centers, except in the study by Stan et al.,[34] in which women were offered the possibility of performing Pilates exercises at home using a DVD. Pilates interventions lasted from 3 to 12 weeks. Training sessions ranged from 40 to 60 min and were performed three times a week, except for the study by Martin et al.,[29] in which daily sessions were carried out. All Pilates-based interventions were focused on core muscle strengthening, spine flexibility and shoulder girdle range of motion. Generally, the interventions started with a learning phase in which the basic elements of Pilates (i.e. breathing, core stabilization, exercise positions) were shown. The difficulty of the Pilates exercises was gradually increased based on the participants' condition as the programs progressed.

In a total of 4 studies, the performance of Pilates was compared against other exercise interventions such as resistance training,[29] mobility exercises (kinesiotherapy)[30] or a combined training program including strength, mobility and flexibility exercises.[31]

In four studies, the participants in the Pilates exercise group were asked to perform home exercises as part of the intervention. In the study by Keays et al.[33] they were given a Pilates exercise program to perform at home once a week, while the participants in the study by Gajbhiye & Deshpande[30] were asked to perform Pilates exercises at home, but the authors did not provide further information in this regard. In the study by Sener et al.,[32] the participants carried out a daily home exercise program that included manual lymphatic drainage training and shoulder flexibility workouts. Similarly, Eyigor et al.,[28] gave the participants a lymph drainage booklet which included breathing, flexibility and range of motion exercises, that had to be performed on a daily bases. Further, all the participants in this study were encouraged to walk 20–30 minutes per day. No side effects were reported in any study, except in the one of Stan et al.[34] in which a participant experienced a decrease in shoulder mobility after treatment.

3.4. Outcomes

Table 3 shows the main findings of the studies finally analyzed.

3.4.1. Shoulder range of motion (ROM)

Four studies[31–34] assessed by means of goniometry the degrees of flexion, abduction, external rotation and internal rotation of the shoulder affected. Zengin Alpozgen et al.[31] and Sener et al.[32] found significant improvements in all the movements analyzed after the Pilates intervention. Stan et al.[34] observed significant differences in abduction and internal rotation ROM; whereas Keays et al.[33] reported significant improvements in flexion and external rotation ROM after Pilates intervention. The pooled results of the interventions included in the meta-analysis (n = 2)[31,32] (Fig. 2), showed a medium but not statistically significant effect for abduction ROM (SMD = 0.37, 95%CI − 0.03–0.78), external rotation ROM (SMD = 0.29, 95%CI − 0.30–0.84) and flexion ROM (SMD = 0.27, 95%CI − 0.30–0.84). The heterogeneity was high (I2 > 30.0%) in external rotation ROM and flexion ROM, and low in abduction ROM (I2 = 0.0%).

3.4.2. Quality of life

In the four studies that included QOL as a variable of their analysis,[28,30,32,34] a positive and significant impact was observed as a result of the practice of Pilates. The meta-analysis performed for this variable (Fig. 3) showed that the included studies (n = 3)[28,30,32] had a high statistical heterogeneity (P = 0.069; I2 = 62.6%), indicating that the random-effects model should be considered. The pooled SMD showed a greater but not statistically significant effect in the participants included in the Pilates groups 0.49 (95%CI -0.08–1.06).

3.4.3. Pain

The three studies whose sample consists of women with involvement of the upper limb[31–33] included pain as a variable of the study, finding all of them statistically significant improvements resulting from the practice of Pilates. Pooled analysis of the included studies

Table 2
Risk of bias assessed by the Cochrane Risk of Bias Tool.

Randomized controlled studies	Selection bias		Performance bias (Blinding of participants and personnel)	Detection bias (Blinding of outcome assessment)	Attrition bias (Incomplete outcome data)	Reporting bias (Selective reporting)
	Random sequence generation	Allocation concealment				
Eyigor et al.[28]	Low risk	Low risk	High risk	High risk	High risk	Low risk
Martin et al.[29]	Low risk	Low risk	High risk	High risk	Unclear risk	Low risk
Gajbhiye & Deshpande[30]	Low risk	Low risk	High risk	High risk	Unclear risk	Low risk
Zengin Alpozgen et al.[31]	Low risk	Low risk	High risk	High risk	Low risk	High risk
Şener et al.[32]	Low risk	Low risk	High risk	High risk	Low risk	Low risk

Table 3
Summary of included studies.

AUTHORS, YEAR	STUDY DESIGN	SAMPLE, mean age ± SD	INTERVENTIONS; NUMBER OF SESSIONS; DURATION; SETTING; SUPERVISION	OUTCOMES MEASURED	RESULTS	FEASIBILITY
Keays et al., 2008.[33]	Uncontrolled pilot study.	4 women (G1) who had restricted shoulder ROM† secondary to breast cancer treatments, 56.5 ± 15.0.	**G1:** 1 h Pilates exercises and home Pilates exercises (generic, whole-body exercise program: barrels, cadillac, reformer, mat and theraband), 36 sessions; 12 weeks (3 times per week); clinic and home; supervised by Pilates exercise instructor.	Shoulder ROM†: Goniometric measurement; Pain: Brief Pain Inventory − Short Form; Mood: POMS‡; UE§ function: Ad-hoc self-report questionnaire (modified from Wingate).	**Intragroup comparisons:** All participants improved the flexion and external rotation ROM† of the affected shoulder. 3 of 4 participants had no pain at the one-month follow-up. No firm conclusion could be made regarding the effects of the Pilates exercises on UE§ function and mood.	Dropouts: 0. Adherence to supervised exercises: 86%–94%. Adherence to home exercises: 33%-100%. Adverse effects: Not reported.
Eyigor et al., 2010.[28]	Randomized controlled study.	52 breast cancer survivors. **G1:** 27 women, 48.52 ± 7.62. **G2:** 25 women 49.73 ± 8.71.	**G1:** 1 h Pilates mat exercises (warm-up, one leg stretch, double leg stretch, shoulder bridge, arm opening, hundreds, clamhip twist, side kick, cool-down), information and home drainage and walking exercises; 24 sessions; 8 weeks (3 times per week); clinic and home; supervised by Pilates exercise specialist physiotherapist. **G2** (control group): Information and drainage and walking exercises; 8 weeks (once everyday); home.	Functional capacity: 6-minute walk test; Flexibility: Modified Sit and Reach Test; Fatigue: BFI¶; Depression: BDI††; QOL‡‡: European Organization for Research and Treatment of Cancer EORTC QLQ-C30 and EORTC BR23.	**Intragroup comparisons:** Significant improvements in 6-minute walk test ($p < 0.001$), BDI†† ($p = 0.01$), EORTC QLQ-C30-functional ($p = 0.03$) and EORTC BR23-functional ($p = 0.04$) scores were observed in G1. Significant improvements in 6-minute walk test were observed in G2 ($p = 0.02$). There were not significant changes in other variables (Modified Sit and Reach test, BFI¶, EORTC QLQ-C30-symptom, EORTC BR23-symptom). **Intergroup comparisons:** There were significant differences in 6-minute walk test in G1 compared with G2 ($p < 0.001$). There were not significant differences in BDI††, EORTC QLQ-C30-functional and EORTC BR23-functional scores between groups ($p > 0.05$).	Dropouts: 10 (G2). Adherence: Not reported. Adverse effects: None.
Stan et al., 2012.[34]	Uncontrolled study.	15 breast cancer survivors (G1), 49 ± 9 years.	**G1:** 45 min Pilates mat exercises (warm-up, core exercises, cool-down); 36 sessions; 12 weeks; clinic or home; supervised by Pilates certified instructor.	Active shoulder ROM†: Goniometric measurement; Neck flexibility: Goniometric active cervical ROM†; Interlimb volume discrepancy: Perometry; QOL‡‡: FACT-B§§; Mood: POMS‡; Body image: MBSRQ¶¶.	**Intragroup comparisons:** There were significant differences in abduction ($p = 0.002$) and internal rotation ROM† ($p = 0.028$), neck flexibility (rotation $p < 0.001$, flexion $p = 0.046$), interlimb volume discrepancy ($p = 0.024$), FACT-B§§ ($p = 0.001$, ES = 1.3), POMS‡ ($p = 0.001$, ES = 1.16) and MBSRQ¶¶ subscales of health evaluation ($p = 0.049$) and body area satisfaction ($p = 0.017$) after Pilates intervention. There were not significant changes in external rotation and flexion ROM†.	Dropouts (prior to intervention): 2. Adherence: 74%. Adverse effects: Not side effects were reported. One participant developed additional limitations in abduction and developed new impairments in flexion and external rotation.
Martin et al., 2013.[29]	Randomized controlled pilot study.	26 breast cancer survivors. **G1**: 8 women, 44.6. **G2**: 8 women, 47.8. **G3**: 10 women, 49.5.	**G1:** 50 min Pilates MVe Fitness Chair™ exercises (warm up, shoulder lateral raise with pump, single leg pump, mermaid, front leg pump, calf raises, two arm pump, pelvic lift, cool-down); 24 sessions; 8 weeks; clinic; supervised by expert trainers in Exercise and Sports Science. **G2:** 50 minute traditional resistance training (warm up, lateral raises, crunches, oblique crunches, ball squats, calf raises, chest press, bridge, cool down); 24 sessions; 8 weeks; clinic; supervised by expert	Muscular endurance: Combined repetitions on a standardized push up test, partial curl up test and the Dynamic Muscular Endurance Test Battery for Cancer Patients.	**Intragroup comparisons:** Muscular endurance increased significantly after intervention both in G1 ($p < 0.002$) and G2 ($p < 0.001$). **Intergroup comparisons:** There were significant differences in muscular endurance in G1 ($p < 0.002$) and G2 ($p < 0.000$) compared with control group. G2 showed a larger total gain than G1, but the difference was not significant ($p = 0.711$).	Dropouts: 0. Adherence G1: 83.3%. Adherence G2: 81.2%. Adverse effects: Not reported.

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Table 3 (*continued*)

AUTHORS, YEAR	STUDY DESIGN	SAMPLE, mean age ± SD	INTERVENTIONS; NUMBER OF SESSIONS; DURATION; SETTING; SUPERVISION	OUTCOMES MEASURED	RESULTS	FEASIBILITY
			trainers in Exercise and Sports Science. **G3** (control group): No exercise.			
Gajbhiye & Deshpande, 2013.[30]	Randomized controlled study.	30 women (G1:15; G2: 15) with unilateral breast cancer, 25–65 years.	**G1:** Pilates mat exercises (mat exercises divided into three phases); 21 sessions (2 sessions/day: morning-with assistance of therapist and evening at home); 3 weeks; clinic and home; supervised by a therapist. **G2** (control group): conventional exercises and breast prosthesis counseling; 21 sessions (2 sessions/day: morning-with assistance of therapist and evening at home); 3 weeks; clinic; supervised by a therapist.	UE§ function: Upper Extremity Functional assessment questionnaire used by Wingate. QOL‡‡: PCASEE Quality of Life Scale.	**Intragroup comparisons:** UE§ function and QOL‡‡ increased significantly after intervention both in G1 and G2 ($p < 0.001$). **Intergroup comparisons:** There were significant differences in UE§ function ($p < 0.001$) and QOL‡‡ ($p = 0.0078$) in G1 compared with G2.	Dropouts: 0. Retention rate: 100%. Adherence: Not reported. Adverse effects: Not reported.
Zengin Alpozgen et al., 2017.[31]	Randomized controlled study	57 breast cancer patients with shoulder ROM† limitation due to breast cancer treatment. **G1**: 18 women, 46.22 ± 11.19. **G2**: 18 women, 51.94 ± 8.05. **G3**: 19 women, 51.53 ± 13.81.	**G1:** 40-45 min Pilates-based mat exercises (arms opening, toy soldier, dumb waiter, chest press, cleopatra, double leg stretch, hip twist, side bend, swimming, swan dive, mermaid, corkscrew, chest stretch, arm circle, shell) and Pilates-based theraband exercises (the slice, the plough, biceps curl, triceps pull, roll up, roll up with biceps, scapula isolations, swan dive, chariot pull, triangles, abduction, diamond press, arms openings, shoulder bridge, external rotation, swimming in kneeling); 24 sessions; 8 weeks (3 times per week); clinic; supervised by a physiotherapist. **G2:** 40-45 min combined exercise program (stretching, ROM†, strengthening exercises of shoulder and breathing exercise); 24 sessions; 8 weeks (3 times per week); clinic; supervised by a physiotherapist. **G3:** exercise programme (selected according to the patient's condition through the G2 exercises); 24 sessions; 8 weeks (3 times per week); home.	Shoulder pain (motion and rest): Visual Analogue Scale. Shoulder ROM†: digital goniometric measurement. UE§ and grip Strength: Dynamometric measurement. Functional status: DASH††† questionnaire, Constant–Murley scale.	**Intragroup comparisons:** There were significant improvements in all the measurements after G1 and G2 interventions ($p < 0.05$). Significant improvements were observed in G3 in pain, flexion and abduction ROM†, flexion and abduction strength and DASH††† scores ($p < 0.05$). **Intergroup comparisons:** There were significant differences in UE§ flexion strength in G1 compared with G3 ($p = 0.019$). There were significant differences ($p < 0.05$) in internal rotation and external rotation ROM† in G2 compared with G1 and G3, and significant differences in flexion ROM† in G2 compared with G3 ($p = 0.013$). There were significant differences in Constant-Murley scores after G1 ($p = 0.003$) and G2 ($p = 0.012$) interventions compared with G3. There were no significant differences in pain, grip strength, internal rotation/external rotation/abduction strength and DASH††† between groups.	Dropouts: 1 G1 and 1 G2. Adherence: 100%. Adverse effects: None.
Şener et al., 2017.[32]	Randomized controlled study.	62 patients with lymphedema after breast cancer treatment. **G1**: 30 women, 53.17 ± 7.66. **G2**: 30 women, 54.03 ± 12.57.	**G1:** Pilates exercises concentrating on lumbopelvic stability (roll down, upper-extremity proprioceptive neuromuscular facilitation methods, dumb waiter, cleopatra, toy soldier, chester stretch, spine stretch, the saw, mermaid, oblique roll up exercises, abdominal preparation, hundreds, one-leg stretch, double-leg stretch, scissors, shoulder bridge, hip twist exercises, clam, arm openings, sidekick, lift lower, leg lift exercises, swan dive, one-leg kick and swimming exercises) and home standard lymphedema exercises (manual lymphatic drainage, wall extension, Wand exercises and skincare); 24 session; 8 weeks	Pain in the lymphedematous arm: Visual Analogue Scale. Grip strength: Dynamometric measurement. UE§ circumference. Shoulder ROM†: goniometric measurement. Anxiety: Social Appearance Anxiety Scale. QOL‡‡: European Organization for Research and Treatment of Cancer EORTC BR23. Functional status: DASH††† questionnaire.	**Intragroup comparisons:** Significant improvements ($p < 0.05$) were observed after Pilates intervention in all measurements except for external rotation ROM† and 5 and 20 cm. circumference measurements. Significant improvements ($p < 0.05$) were observed in G2 in all measurements except for grip strength, flexion and external rotation ROM† and the proximal nail fold and axilary circumference measurements. **Intergroup comparisons:** There were significant differences in Social Appearance Anxiety scale in G1	Dropouts (prior to intervention): 2 (G1). Adherence: Not reported. Adverse effects: Not reported.

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Table 3 (*continued*)

AUTHORS, YEAR	STUDY DESIGN	SAMPLE, mean age ± SD	INTERVENTIONS; NUMBER OF SESSIONS; DURATION; SETTING; SUPERVISION	OUTCOMES MEASURED	RESULTS	FEASIBILITY
			(3 times per week); clinic and home; supervised by physiotherapists. **G2** (control group): lumbopelvic stability (core stabilization) and standard lymphedema exercises (manual lymphatic drainage, skincare, shoulder exercises, extension and Wand exercises, head and neck exercises, exercises to improve shoulder girdle stability and breathing exercises); 8 weeks; home; followed up through telephone calls.		compared with G2 ($p < 0.01$). There were significant decreases in UE§ circumferences in all regions ($p < 0.05$), except for the axillary measurement, in G1 compared with G2. There were no significant differences in pain, ROM†, grip strength, QOL‡‡ and DASH††† scores between groups ($p \geq 0.05$).	

†Range of motion; ‡Profile of Mood States–Short Form; §Upper Extremity; ¶Brief Fatigue Inventory; ††Beck Depression Inventory; ‡‡Quality of Life; §§Functional Assessment of Cancer Therapy–Breast questionnaire; ¶¶Multidimensional Body-Self Relations Questionnaire; †††Disabilities of the Arm, Shoulder, and Hand.

(n = 2)[31,32] showed that Pilates was statistically more effective than the interventions proposed for the control groups in reducing pain among women with BC, showing a medium effect (SMD = −0.48, 95%CI − 0.88 to −0.07), with very low statistical heterogeneity (P = 0.974; I2 = 0.0%) (Fig. 4).

3.4.4. Upper extremity function

The effect of Pilates on the patients' self-reported UEF was evaluated in four studies using different tests (Wingate, Constant-Murley, DASH).[30–33] The pooled results of the interventions included in the meta-analysis (n = 3) [30–32] showed that Pilates was statistically more effective than the interventions proposed for the control groups in improving the functional status of the affected UE among women with BC, showing large effect (SMD = 0.94, 95%CI 0.20–1.69) (Fig. 5), with a high and significant heterogeneity (P = 0.002; I2 = 79.2%).

3.4.5. Mood

In three of the four studies that assessed the influence of Pilates on mood, statistically significant changes were observed in this respect.[28,32–34] In two studies,[28,32] the effects of Pilates on depression or anxiety, were significantly higher than those resulting from the therapies followed by other participants.

3.4.6. Physical fitness

Four studies analyzed the effects of the practice of Pilates on physical fitness. Eyigor et al.[28] observed a significant effect on the cardiorespiratory fitness of the participants who practiced Pilates. This improvement was significantly greater compared to the effects of the therapy proposed for the group described as the control group. Martin et al.[29] observed a significant improvement in muscular endurance, also compared to the control group. The practice of Pilates resulted in significant improvements in the hand-grip strength[31,32] and shoulder strength,[31] but without significant differences between groups. Regarding flexibility, no significant changes of any kind were observed.

3.4.7. Upper extremity circumference

The two studies that compared the upper limb volume before and after the treatments with Pilates,[32,34] found significant intragroup improvements in this respect. In the case of Sener et al.[32] the differences with the control group were significant, except for the axillary level.

Other variables: The practice of Pilates did not result in significant intra- or intergroup changes in terms of fatigue,[28] body image and neck flexibility.[34]

4. Discussion

In this research, the scientific evidence regarding the effectiveness of Pilates as a physical rehabilitation strategy for women with BC was examined and critically reviewed. In this regard, it is worth mentioning that in the analyzed studies the intervention and the outcomes assessments could not be blinded, and the sample size was generally small. Consequently, none of the investigations reached a Jadad score greater than three points, meaning that their methodological quality was not high.[35] In spite of this, from the analysis of the studies finally included in this review, we can extract findings of some importance.

For instance, it has been observed that adherence to exercise in women with BC is challenged by the self-perceived potential side effects, as well as by the positive beliefs related to the exercise modality selected.[10] In this regard, it should be noted that in most studies there were no withdrawals nor side effects resulting from the practice of Pilates. In addition, the levels of adherence to the proposed programs were generally high (mean adherence of 92.3%). These results indicate that Pilates is a feasible exercise modality that can be performed by patients with BC.

A second noteworthy aspect of this review is that it provides a detailed description of the interventions developed. In this context, it has

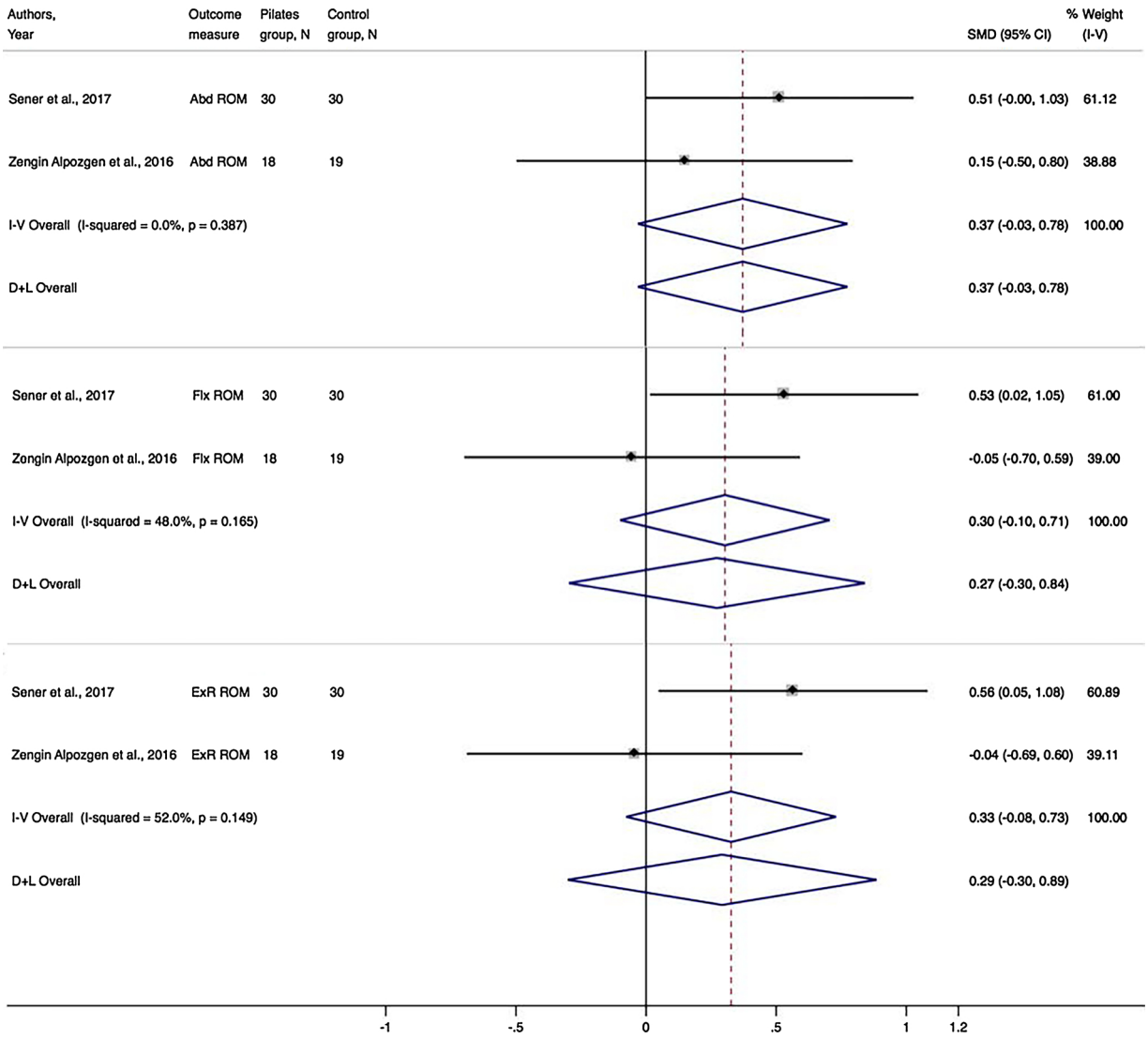

Fig. 2. Forest plots for the meta-analysis of the effect of Pilates compared with Control group on the abduction, flexion and external rotation range of motion.

been pointed out that many health-professionals show a lack of awareness regarding how to prescribe physical exercise regimens aimed at addressing individual needs at various points across the phases of cancer survivorship, as well as how to discuss exercise with people with cancer and provide a referral.[36] In relation to this, and judging by the characteristics of the interventions proposed in the analyzed studies, it

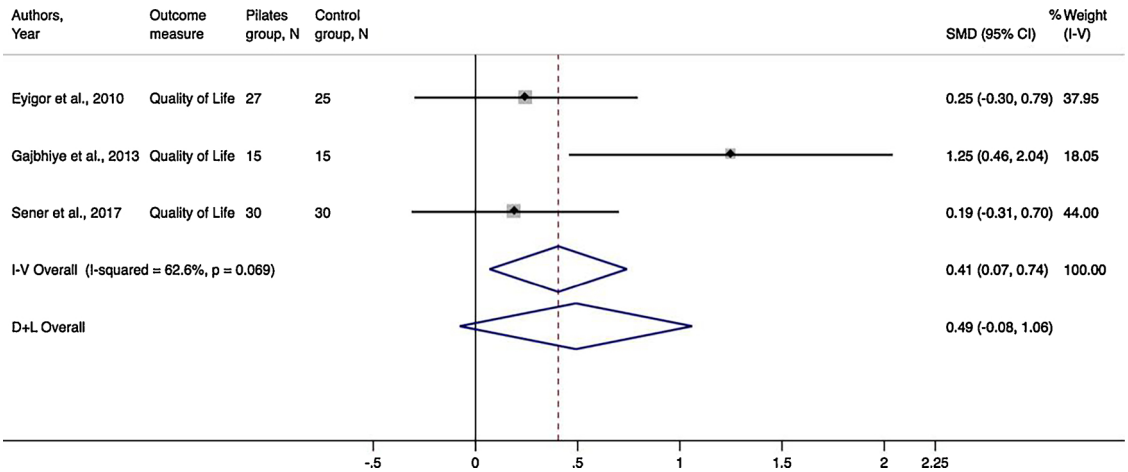

Fig. 3. Forest plot for the meta-analysis of the effect of Pilates compared with Control group on the quality of life. Abbreviations: Abd ROM, abduction range of motion; Flx ROM, flexion range of motion; ExR ROM, external rotation range of motion.

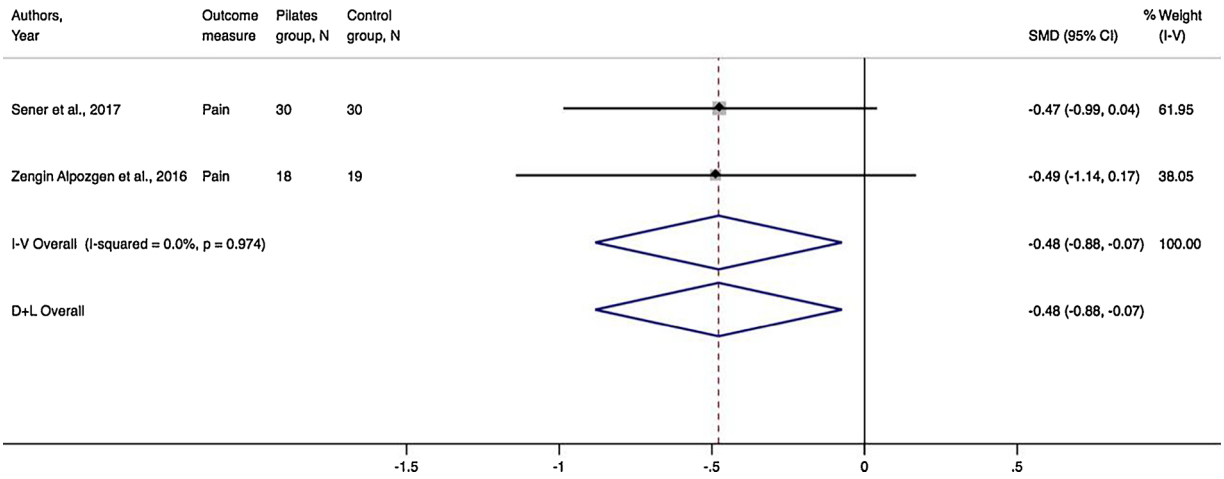

Fig. 4. Forest plot for the meta-analysis of the effect of Pilates compared with Control group on the pain.

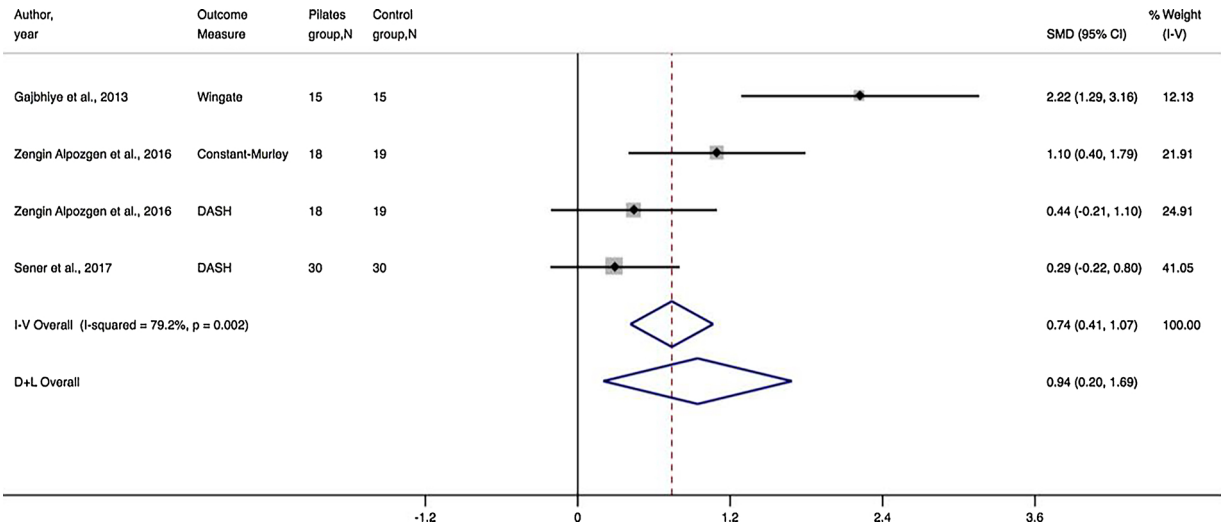

Fig. 5. Forest plot for the meta-analysis of the effect of Pilates compared with Control group on the upper extremity function.

seems that women with BC could be advised to perform 45-minute sessions of mat Pilates three times per week. The training program should be supervised by a physiotherapist and could be combined with the practice of other rehabilitation strategies (i.e. lymphatic drainage exercises, walking). These recommendations can be of help for introducing BC women to Pilates, although the heterogeneity of the revised studies prevents further elaboration regarding the design of future Pilates investigations focused on this population.

According to the findings reported in the studies analysed in the review, Pilates had a positive and significant effect on several physical (range of motion, fitness, functional status and lymphedema) and emotional (quality of life, mood, pain) parameters for women with BC. In this regard, it should be noted that the results of the meta-analysis indicated that its effects on shoulder range of motion and quality of life, was not significantly greater than those resulting from other exercise programs. Similarly, it is important to highlight the fact that the practice of Pilates had no significant effects on perceived fatigue, one of the main symptoms of this population and on which other modalities of physical exercise have demonstrated to have a positive impact. One possible explanation for this could be the short duration of the training program, since it has been suggested that exercise interventions, performed for more than 28 weeks, have a significantly greater effect on cancer-related fatigue than low-volume exercise programs.[37]

In women with BC, functional limitation of the shoulder and upper body pain have been regarded as two of the main symptoms that should be addressed by physical rehabilitation, in order to restore their quality of life (QOL).[38] In this regard, the findings of the present review are conflicting. For instance, the meta-analysis carried out on the changes observed in shoulder ROM and QOL, showed an absence of significant differences between the impact caused by Pilates and the one resulting from the other proposed therapies. These results suggest that the prescription of Pilates in women with BC may make sense for its feasibility, but its benefits are not expected to be much greater than those resulting from other exercise programs. However, the practice of Pilates was found to have significant changes in the perceived pain in women with involvement of the upper limb. This is a relevant observation, since there is no firm conclusion regarding the efficacy of exercise therapy in reducing pain related to BC treatment.[39] Similarly, Pilates was more effective than other therapies in improving self-reported UEF, which is also an interesting finding, since it has been outlined the need for information regarding the appropriate timing and content of exercise programs aimed at reducing upper-limb impairments after BC treatment.[40]

4.1. Limitations

In spite of its originality, there are a number of limitations that should be considered. Firstly, the number of studies found and their quality was low, which indicates that further research is needed in order to consolidate the scientific evidence regarding the efficacy of

Pilates in this population. Secondly, the evidence of the effect that Pilates has on the health status of women with BC was derived from a review of heterogeneous interventions. Indeed, although supervised Mat Pilates was the type of intervention most frequently carried out, two studies included the use of Pilates machines. Therefore, the exercises proposed in the reviewed studies differed in the way in which they were performed. Moreover, it should be noted that in several studies, the participants also carried out lymphatic drainage exercises and some of them practiced Pilates at home or added walking to their training schedule. In these cases, it was difficult to isolate the impact that Pilates had on the participants' health. Thirdly, considering the small number of studies included in the meta-analyses developed and their high heterogeneity, the results of said studies should be construed with caution, since these facts limit in some way the conclusions regarding the effectiveness of Pilates when compared with other therapies. In any case, it should be noted that other review papers on novel physical therapies in women with BC have considered it useful to perform meta-analyses based on the results of two studies, provided that the characteristics of the studies found allow said analyses.[16] Finallly, it should be acknowledged that only articles in the English language were included in this review, implying that an RCT about the effects of Pilates on BC women published in an Arabic dialect had to be excluded,[41] a fact that limits the findings shown herein.

5. Conclusion

Pilates can be safely prescribed to women with BC. Its practice can relieve the impact of cancer-related symptoms and improve their QOL. In comparison with other exercise interventions, Pilates seems to be especially effective for improving upper-limb pain and functionality. However, its effects on shoulder range of motion and quality of life do not appear to be greater than those resulting from other exercise programs.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors

Conflict of interest

None.

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