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REVIEW

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Effects of Pilates on health and well-being of women: a systematic review

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Abstract

Background Pilates (Contrology) is a mind–body exercise that emphasises strength, core stability, flexibility, muscle control, posture, and breathing. Pilates can be practised in a variety of methods, including using various equipment and one's own body weight on a mat. This review's objective is to assess the benefits of Pilates therapies for women with health issues, with a focus on physical and psychological health, with a focus on physical and psychosocial results.

Methodology All published Randomised controlled trials (RCTs) and comparative trials with free full text that involved female participants with medical conditions with Pilates exercises as the intervention were included. A search was conducted across 3 databases (Google Scholar, PubMed, and Cochrane Library): 10 studies—7 RCTs and 3 comparative studies, met the inclusion criteria. The Cochrane risk of bias tool was used to evaluate the quality of the methodology.

Results According to recent research, Pilates may improve quality of life while lowering pain, and disability. It may also increase flexibility, strength, mobility, respiratory rate, vital capacity, body mass index, and balance. It also helps in lowering fasting blood glucose, and HbA1c level in type 2 diabetic women and also helps in lowering the severity of temporomandibular dysfunction.

Conclusion Women with health issues who practised pilates reported improvements in physical and psychological health metrics. Additional high-quality research is necessary to determine the impact on other aspects of health and fitness.

Trial registration This systematic review was registered on PROSPERO with a registration ID CRD42022328804.

Keywords Pilates, Health-fitness, Health-condition, Well-being, Systematic review

Background

Joseph Pilates established Pilates workout in the 1920s [1]. He was born in the 1880s in Düsseldorf, Germany [2]. Pilates (Contrology) is a mind–body exercise that emphasises strength, core stability, flexibility, muscular control, posture, and breathing [3]. The key characteristic is its 8 fundamental principles: attention, control, centre, breath, fluidity, precision, routine, and isolation [2]. Pilates can be done in a variety of ways, including on a mat with just one's body weight and a variety of equipment (such as a mat, props, gym ball, foam roller, band, and pillar ring) [4–6]. The Pilates method is distinctive in that during the workout, special attention is paid to the quality, accuracy, and control of movement, as well as to breathing and sensory input [7].

Pilates requires coordinated activation of multiple muscle groups at once using a holistic approach, as opposed to standard resistance exercises that train muscles in isolation [8]. The scientific value of Pilates exercise is becoming more widely recognised as well as more well known. The physiological and psychological advantages of Pilates

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have been documented in few research, which also show gains in physical fitness [9, 10] and psychological wellbeing, quality of life, mood, depression, and anxiety [11, 12].

Few systematic reviews have investigated the impact of Pilates on health outcomes related to body composition [13, 14], breast cancer rehabilitation [15–17], physical fitness, balance, and fall prevention in seniors [10, 18–20], pelvic floor muscle function [21, 22].

The usefulness of Pilates exercises in people with chronic low back ache (LBA) has been investigated in a number of research [7, 23–32]. Pilates significantly improved pain alleviation and functional improvement in people with persistent low back ache (LBA), according to a systematic review of eight RCTs [32].

Multiple studies have looked into the benefits of Pilates for various health conditions, including breast cancer [33], fibromyalgia [14, 34], obesity [4], and multiple sclerosis [35]. According to a new study, healthy middle-aged women with sedentary jobs can improve their respiratory system, shoulder girdle, abdominal strength and endurance, and hip and shoulder joint mobility with a 12-week course of 1-h Pilates sessions performed three times per week [3]. The impact of Pilates techniques on women's health was examined through a systematic review of 13 RCTs [36].

Most of the research mentioned above included both male and female populations. In these diverse populations, the specific impact on women's health is difficult to discern, and the advantages are unclear. Also very few studies have investigated impact of Pilates on women with health issues. Exercise adherence remains a challenge for women with diseases, and more research into alternative exercise modes is needed. In light of the foregoing, it has been discovered that catering to exercise preferences, as well as having positive beliefs about the effects of the proposed exercise therapy, are critical in encouraging women with health issues to participate in physical training programmes. Pilates, a mind–body exercise approach that can be considered a complementary and alternative medicine therapy, emerges as an intriguing strategy for women for several reasons. For starters, it can be regarded as an appealing mainstream form of exercise. Second, because it combines light-moderate intensity physical exercise with mindfulness, it has the potential to improve both physical and mental health. The evidence to support the recommendation and widespread use of Pilates in women with health issues is still lacking. Prior reviews and meta-analyses have advocated the need for high-quality research on the health and wellbeing benefits of Pilates for women with and without conditions connected to their health.

The purpose of this study is to perform a systematic review of the impact of Pilates interventions on women with health-related conditions, with an emphasis on physical and psychosocial outcomes.

Methodology

Methods

Through three databases—Google Scholar, PubMed, and Cochrane Library—we did an electronic search of the literature published over the last 12 years, or from August 2010 to August 2022. Randomised controlled trials (RCTs) and comparative studies, comparing Pilates treatments to standard care or non-pharmacological treatment in healthy or sick women were included. This systematic review was registered on PROSPERO with a registration ID CRD42022328804.

Eligibility criteria

Included studies met the following eligibility requirements

1. Researches that were exclusively done on female participants (women with a health condition).
2. Articles published in a journal in period 2010–2022.
3. Free Full text article written in English language.
4. Randomised control trials and comparative studies as the study design.
5. Pilates administered as intervention.
6. Studies with full texts that looked at psychosocial outcomes, such as mental health, QOL, stress, anxiety, and depression and physical outcomes included cardio-respiratory fitness, muscle strength, endurance, flexibility, joint mobility, and body composition.
7. Researches that include Control group which may or may not have received any treatment or received some other form of treatment.
8. Aging population of women's (18–60 years old).

Excluded studies included

1. Studies that look at the impact of Pilates on pregnant women.
2. Review articles.
3. Meta-analyses.
4. Abstracts.
5. Letters to the editors.
6. Non-randomised control trials studies.
7. Case studies.
8. Cross-sectional studies.

Search strategies for identifying studies

MeSH phrases and Boolean operators were applied to library databases to improve search strategy and increase search precision. The strategy employed in

the search was [Pilates OR "Pilates training" OR "mat Pilates" OR "Pilates exercises"] AND [women OR "well-being of women" OR "women with diseases"] AND [health OR "health fitness" OR fitness OR "body composition" OR "cardiac fitness" OR "cardio pulmonary fitness" OR "bone density" OR "muscle strength" OR "muscle endurance" OR "muscle flexibility" OR "quality of life" OR "mental health" OR depression OR anxiety]. By looking through relevant articles' references, potential randomised controlled trials and comparative studies that matched the study's inclusion criteria were also reviewed. A systematic review protocol was created and reported using the recommended reporting items for systematic review protocols (PRISMA-P) statement shown in Fig. 1 [37].

PICO framework

- Population: women with a health condition.
- Intervention: Pilates training or Pilates exercises.
- Comparison/control: Control group which may or may not have received any treatment or received some other form of treatment.
- Outcome: physical and mental health measure.

Extraction and management of data

Two reviewers, AP and SK, independently extracted data on the following topics: the characteristics of the study site, the year of the study, the participants, the length of the study, the sample size, the inclusion and exclusion

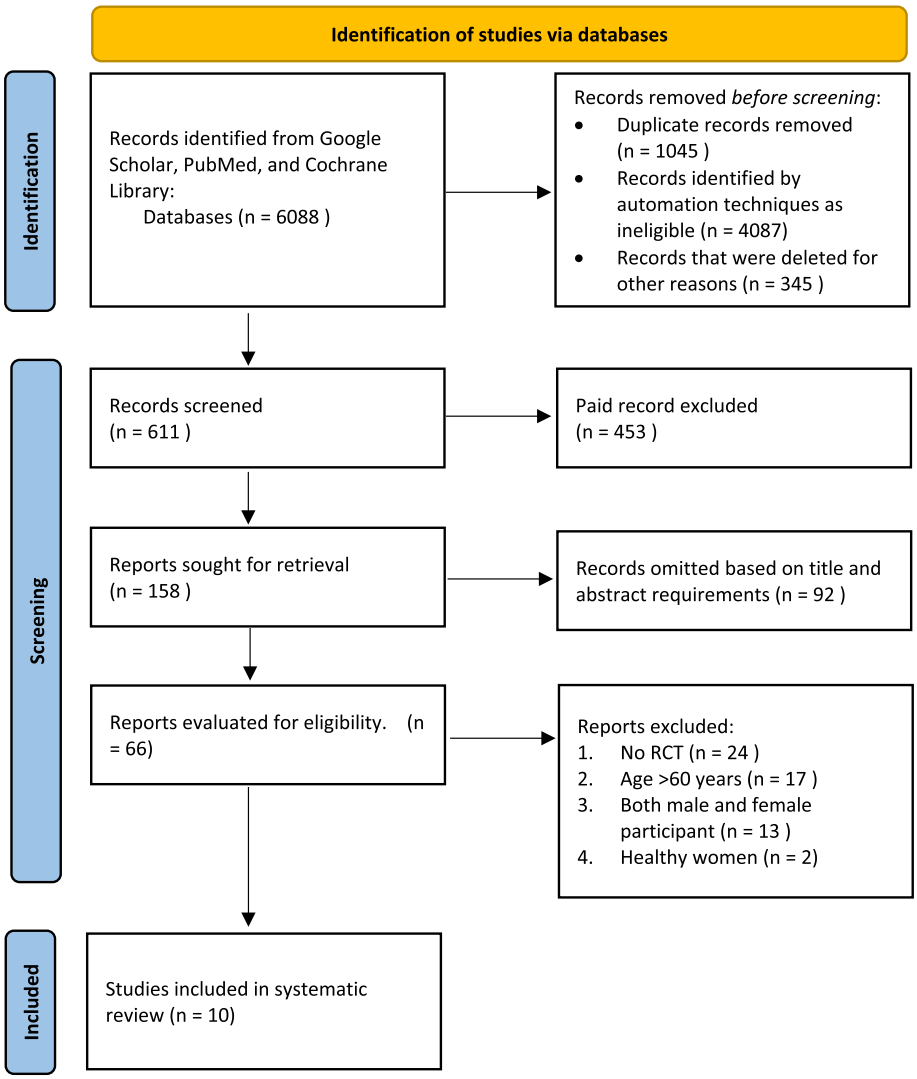

Fig. 1 PRISMA flow diagram of the study

criteria, the specifics of the intervention given to the experimental and control groups, the duration of the study, the outcome measures, and the study's findings. A third reviewer SJ, double-checked the data, and all inconsistencies were settled by consensus.

Risk of bias in individual studies

The two independent reviewers, AP and SK, evaluated the methodological quality and risk of bias in the individual research. In selected articles, the bias risk in randomised control trials and comparative studies was evaluated using the Cochrane collaboration tool. The method uses seven domains to evaluate bias risk. Three categories of bias judgement were established: (a) low risk; (b) high risk; and (c) unclear risk. The results of systematic reviews were reported in accordance with PRISMA criteria. Any disagreement over the assessment recommendation that existed between the two evaluators was settled by a third reviewer (SJ). Table 3 displays the findings of the methodological quality assessment.

Result

Study selection

In the initial literature search, 6085 titles emerged as relevant studies. After removal of duplicates and studies not fulfilling the eligibility criteria, a total of 63 unique full-text records were identified. A total of 10 studies were included in the qualitative analysis. Out of 10 studies, 7 are RCTs and 3 are comparative studies Fig. 1.

Study characteristics

Of the total of 10 studies reviewed, 3 were carried out in Iran, 2 in Korea, 2 in Brazil, 1 each in Ukraine, Egypt, and Italy. Two studies were performed on women with chronic LBA, two on women with type 2 diabetes, one each on elderly women, obese women, women with multiple sclerosis, women with breast cancer, women with fibromyalgia and women with temporomandibular dysfunction. All the 10 studies clearly mention about the number of participants in all the groups also mentioned about the inclusion and exclusion criteria for participants. Out of 10, only 3 researches mentioned that intervention given to a Pilates group by a licenced physiotherapist, professional Pilates therapist, or experienced Pilates instructor [7, 34, 38]. The exercise programme was not included in a study for any of the three groups [39]. The age range of the studied participants was not given in two studies but they mentioned about the mean age of the participants [7, 40]. In a study, Pilates exercises were conducted under two different conditions: one was normoxic (FiO2 20.9%), and the other was hypoxic (FiO2 14.5%). Pilates was performed on a mat in the majority of studies, although Pilates apparatus was utilised in a small number of studies [4].

Table 1 provides information about the study's participants and a summary of the therapies that were given to both (intervention and control group). All of the trials were carried out either at a hospital (Pilates clinic, physiotherapy department) or a medical research facility/university. In each study, there were different numbers of dropouts. The number of dropouts varied in all the studies. The research that revealed the highest number of dropouts [33], 5 from the water exercise group and 4 from the Pilates group and zero drop out from control group) followed by the two studies [4, 38]. The greatest obstacles to not finishing the study were reluctance to attend further Pilates sessions.

Table 2 presents about the intervention group characteristics (duration, frequency, total sessions), outcome measure, evaluations and result of 10 studies. Time duration for Pilates sessions ranged from 30 to 60 min, with a maximum of 144 sessions. Out of 10 studies, 9 give Pilates training for three times in a week and one study give 50 min of Pilates exercises twice per week with 2 days interval [38]. Out of 10, 8 studies evaluated their participants pre- and post-intervention. One study evaluated participants at baseline and after 6 and 12 months of intervention [33] and the last study evaluated participants at baseline and 12 weeks after randomisation [34].

Risk of bias evaluation

On seven studies, random sequence generation was done. A total of four studies did not record allocation concealment, while three study identified the danger of selection bias and all three did not report allocation concealment. Eight trials were classified as having a high risk of performance bias because they did not report on the blinding of patient personnel. Blinding of outcome assessment was not reported in 6 trials. All 10 studies reported every result and were deemed to have a minimal risk of selective reporting bias. In Table 3, the risk of bias evaluation is described in great depth.

Discussion

Ten papers were included in this systematic review to look at how Pilates affected women's health and wellness. However, generally, there was a substantial probability of bias in the eligible trials. High-quality trials examining Pilates' advantages for enhancing women's health outcomes were scarce.

Based on the studies examined, this review discovered a decrease in pain in patient with fibromyalgia [34], and chronic LBA [7, 40]. For these investigations, a Pilates intervention was contrasted with a control condition, such as continuing with one's regular everyday activities [7, 35, 38, 41, 42]. For other studies Pilates was compared to water exercises and yoga exercises [33], aquatic

Table 1 Description of study population and interventions given to groups

Author (year)/country	Diagnosis	Sample size (baseline and follow-up)	Age range/mean age	Intervention group	Control group
Kyounghwa Jung [4] (2020) Korea	Obesity	Group-1 (*N*-12) Group-2 (*N*-12) Group-3 (*N*-12) Follow-up Group-1 (*N*-10) Group-2 (*N*-10) Group-3 (*N*-12)	Age range = 34–60 years/47.5 ± 7.5 Group 1–51.6 ± 6.5 Group 2–43.8 ± 8.6 Group 3–47.2 ± 6.4	Group 2-normoxic Pilates training group (NPTG): perform Pilates training using tubing band under normoxic condition F_iO_2: 20.9% Group 3-hypoxic Pilates training group (HPTG): same as NPTG but under hypoxic condition F_iO_2: 14.5%	**Group 1-control group:** Maintained their daily life style as usual without any intervention
Antonino Patti [7] (2016) Italy	Chronic low back ache	Group-1 (*N*-19) Group-2 (*N*-19) Follow-up—100%	Group 1–41.31 ± 11.24 Group 2–41.63 ± 13.01	Group 1-Pilates matwork group: the hundred, roll-ups, single-legged circles, spine stretches, rolling like a ball, and single-legged stretches are all exercises. On a rubber mat, each exercise was carried out	**GROUP 2—CONTROL GROUP:** continue their own social interactions and routine medical care, which includes taking NSAIDs
Tetiana Odynets [33] (2019) Ukraine	Breast cancer	Group-1 (*N*-50) Group-2 (*N*-44) Group-3 (*N*-30) Follow-up Group-1 (*N*-45) Group-2 (*N*-40) Group-3 (*N*-30)	Age range = 50–60 year Group 1–58.84 ± 1.36 Group 2–59.40 ± 1.24 Group 3–59.10 ± 1.37	Group 1-Water exercise: breathing exercises and physical exercises. noodles, blades, water dumbbell were used Group 2-Pilates exercises; floor exercise that includes a warm-up, a resistance band-based main component, and a cool-down Group 3-Yoga exercise: performed as follows: a 10-min warm-up, followed by 40 min of exercise, and a 10-min cool-down (10 min)	NO
Suzy Araújo de Medeiros [34] (2020) Brazil	Fibromyalgia	Group- 1 (*N*-21) Group- 2 (*N*-21) Follow-up—100%	Age range = 18–16 years	Group 1-Mat Pilates: performed in a spacious, pleasant space with a group of up to 4 women. Exercises were conducted while adhering to all six principles	**GROUP 2—AQUATIC AEROBIC EXERCISE:** performed in a pool with a 31-degree Celsius temperature
Sayyed-Mohammad Marandi [35] (2013) Iran	Multiple sclerosis	Group-1 (*N*-19) Group-2 (*N*-19) Group-3 (*N*-19) Follow-up—100%	Age range = 20–40 years	Group 1-Pilates exercise group: encompassing stretches, strength, muscular nervous coordination, and balance exercises Group 2-Aquatic exercise group: followed by stretching, power, and endurance exercises after swimming	**GROUP 3—CONTROL GROUP: NO INTERVENTION MENTIONED**
Luiza Rampi Pivotto (2020) Brazil [38]	Temporomandibular dysfunction	Group-1 (*N*-20) Group-2 (*N*-20) Follow-up Group-1–100% Group-2 (*N*-19)	Age range = 18–35 years Group 1–29.3 ± 5.9 Group 2–28.5 ± 6.2	Group 1–Pilates group (intervention group): all study participants made use of myorelaxant plates for 15 weeks. This group made use of plates concomitantly with Pilates based exercise program for 15 weeks. There is progression of exercises in the protocol after each exercise session	Group 2–control group: Maintain their initial level of physical activity with use of Myorelaxant plates

Table 1 (continued)

Author (year)/country	Diagnosis	Sample size (baseline and follow-up)	Age range/mean age	Intervention group	Control group
Seyed Kazem Mousavi Sadati [39] (2022) Iran	Elderly women with reduced muscle strength and flexibility	Group-1 (*N*-10) Group-2 (*N*-10) Group-3 (*N*-10) Follow-up—100%	Age range = 50–60 year Group 1–52.2 ± 2.84 Group 2–54.1 ± 3.46 Group 3–54.2 ± 3.37	Group 1-Pilates exercises Group 2-Pilates exercises traband Group 3-Pilates weight training	NO
Chae-Woo Lee [40] (2014) Korea	Chronic low back ache	Group-1 (*N*-20) Group-2 (*N*-20) Follow-up—100%	Group 1–34.0 ± 3.3 Group 2–34.4 ± 3.1	Group 1-Pilates mat exercise group: Breathing, crossed arms in a spine-spinal position, arm circles, knee-over-knee twist stretches, pelvic peels, and other exercises Group 2-Pilates apparatus exercise group: Breathing, Hamstring stretch: standing tall position, straight legs. Mermaid: sit tall, one hand on foot. Arms up and down: pelvis neutral, hip flexion 90° holding hand strap etc	NO
Yasmin M. Abd El-Monim [41] (2019) Egypt	Type 2 diabetes	Group-1 (*N*-20) Group-2 (*N*-20) Follow-up–100%	Age range = 35–55 years Group 1–46.0 ± 5.15 Group 2–44.65 ± 6.31	Group 1–Pilates group (study group): an initial 7–10 min warm up phase followed by 40 min Pilates phase that consist of 5 types of exercise (bent knee, shoulder bridge, side kick front, side kick back, single leg circle), that is finally followed by 7–10 min of cool down phase. Also received regular medical treatment	Group 2–control group: received regular medical treatment with no change on their regular daily activities
Seyed Alireza Tavakoli Khormizi [42] (2017) Iran	Obese women with type 2 diabetes	Group-1 (15) Group-2 (15) Follow-up–100%	Age range = 40–60 years Group 1–51.06 ± 2.3 Group 2–51.2 ± 3.7	GROUP 1- Pilates group: an initial 5 min of stretching exercise followed by Pilates exercises (for about 50 min), cool down and return to initial status (for about 5 min)	Group 2–control group: monitoring of control group was done for 2 months on regular basis

Table 2 Description about intervention group characteristics (duration, frequency, total sessions), outcome measure, evaluations, and result

Author (year)/country	Intervention characterstics	Outcome measure	Evaluation	Result
Kyounghwa Jung [4] (2020) Korea	Duration-50 min thrice a week for 12 weeks Total sessions-36	•Body composition (height, weight, FFM, percent body fat, BMI, BMD, and BMC) •Blood pressure •Cardio metabolic markers (TC, HDL-C, LDL-C, TG, FFA, glucose, insulin, HOMA-IR, and HOMA-β) •Endothelial function (FMD), hemorheological function (erythrocyte EI and AI) •Aerobic performance (VO_2 max)	•Pre- and post-intervention	In comparison to the CON and NPTG, the HPTG significantly decreased erythrocyte deformability and aggregation, flow-mediated dilation, total cholesterol, and triglyceride levels (all p 0.05). In contrast to the CON and NPTG, the HPTG did not demonstrate improvement in other metrics
Antonino Patti [7] (2016) Italy	Duration - Group 1–50 min thrice a week for 14 weeks Total sessions-42	•Oswestry Disability Index (ODI) •Posturography	•Pre- and post-intervention	Patients in the EG showed improvements in posturography measurements with both open and closed eyes (P 0.05). Posturography in the CG showed no statistically significant changes. Over the course of the 14-week trial regimen, ODI considerably dropped in both groups. The EG experienced less discomfort to a larger extent
Tetiana Odynets [33] (2019) Ukraine	Duration-60 min thrice a week for 12 months Total session-144	•FACT-B	•Baseline •After 6 and 12 months of intervention	An enormous improvement in participants' overall quality of life was noted. Yoga was more successful at enhancing social/family wellbeing than Pilates and yoga, while water exercise intervention was more successful at enhancing emotional wellbeing and reducing side effects related to breast cancer treatment
Suzy Araújo de Medeiros [34] (2020) Brazil	Duration - Group 1–50 min twice a week for 12 weeks Group 2–40 min twice a week for 12 weeks Total session-24	•Primary–[VAS] •Secondary–[FIQ], [PSQI], [SF-36], [FABQ-BR], [PRCTS]	•Baseline •12 weeks after randomisation	Regarding pain and function, there was improvement in both groups (p 0.05). Only the mat Pilates group (p 0.05) demonstrated improvement in the FABQ questionnaire's elements of quality of life. Only the aquatic aerobic exercise group showed improvement in the PSQI and PRCTS measures (p 0.05), but no differences were seen between the groups for any of the examined variables

Table 2 (continued)

Author (year)/country	Intervention characterstics	Outcome measure	Evaluation	Result
Sayyed-Mohammad Marandi [35] (2013) Iran	Duration - Group 1–1 h thrice a week for 12 weeks Group 2–1 h thrice a week for 12 weeks	•Muscle strength (Dynamometer)	•Pre- and post-intervention	In the experimental groups, there were substantial disparities between the scores for the patients' non-dominant and dominant hands ($P < 0.05$). In multiple sclerosis sufferers, both Pilates and swimming training dramatically boost muscular strength
Luiza Rampi Pivotto [38] (2020) Brazil	Duration–50 min Twice per weeks with 2 days interval for 15 weeks Total session–30	•BackPEI-A •Computerized photogrammetry •MFIQ	•Pre- and post-intervention	The Pilates-based exercise programme had no impact on the young women with TMD's posture, postural habits, or neck and back pain. After the intervention period, only for the intervention group, there was a reduction in the graduation of TMD severity
Seyed Kazem Mousavi Sadati [39] (2022) (Iran)	Duration-60 min thrice in a week for 8 weeks Total session-24	•Body mass •Body mass index •Sit to stand test (for 30 s) •Sit and reach test static flexibility (ROM of hip flexion and hip extension)	•Pre- and post-intervention	As a result, all three groups exhibit appreciable growth as a result of exercise; nevertheless, there is no appreciable difference between the groups because no training approach is superior than another
Chae-Woo Lee [40] (2014) Korea	Duration - Group 1–50 min thrice a week for 8 weeks Group 2–50 min thrice a week for 8 weeks Total session-24	•Pain •Sway length •Sway velocity	•Pre- and post-intervention	Significant reduction in pain, sway length, and sway velocity with Pilates mat work. Pain, sway length, and sway velocity all significantly decreased throughout the Pilates apparatus workout. Compare the groups: Pilates group shows exceptional improvement in pain, sway length, and sway velocity

Table 2 (continued)

Author (year)/country	Intervention characterstics	Outcome measure		Evaluation	Result
Yasmin M. Abd El-Monim [41] (2019) Egypt	Duration–60 min Thrice in a week for 12 weeks Total session-36	•HbA1c •Blood pressure •TC •LDL •HDL	•TG •TG/HDL •Waist hip ratio	•Pre- and post-intervention	The cardio metabolic risk factors in type 2 diabetic patients were improved by specially designed Pilates exercises. Glycosylated haemoglobin, lipid profile, blood pressure (systole and distole), and waist-hip ratio all showed highly significant changes following treatment
Seyed Alireza Tavakoli Khormizi [42] (2017) Iran	Duration–60 min thrice in a week for 8 weeks Total session–24	•Fasting blood glucose (mg/dl) •HbA1c (%) •Weight (kg) •BMI (kg/cm^2)		•Pre- and post-intervention	Pilates exercise lowers fasting blood sugar and HbA1c in 2 months; however, these individuals' weight and BMI do not alter significantly. Pilates appears to help with type 2 diabetes management and improvement, the most prevalent chronic non-communicable illness in the world

FACT-B functional assessment of cancer therapy questionnaire with a specific module for breast cancer, *FFM* free fat mass, *BMI* body mass index, *BMD* bone mineral density, *BMC* bone mineral content, *TC* total cholesterol, *TG* triglyceride, *HDL-C* high-density lipoprotein cholesterol, *LDL-C* low-density lipoprotein cholesterol, *FFA* free fatty acid, *HOMA-IR* homeostatic model assessment for insulin resistance, *HOMA-β* homeostatic model assessment of β-cell function, *CON* control group, *NPTG* normoxic Pilates training group, *HPTG* hypoxic Pilates training group, *ROM* range of motion, *VAS* visual analogue scale, *FIQ* fibromyalgia impact questionnaire, *PSQI* Pittsburgh sleep quality index, *SF-36* short form 36 health survey, *FABQ-BR* fear avoidance believe questionnaire, *PRCTS* scale of catastrophic thought on pain, *BackPEI-A* Back Pain and Body Posture Evaluation Instrument for adults, *MFIQ* mandibular function impairment questionnaire, *HbA1c* Haemoglobin A1c

Table 3 Risk of bias assessment using the Cochrane risk of bias tool

S.no	Study	Random sequence generation	Allocation concealment	Blinding of participants and personnel	Blinding of outcome assessment	Incomplete outcome data	Selective reporting	Other bias
01	Jung et al. [4]	Low risk	Low risk	High risk	High risk	low risk	Low risk	Low risk
02	Patti et al. [7]	Low risk	Low risk	Unclear	Low risk	Low risk	Low risk	Low risk
03	Odynets et al. [33]	Low risk	Low risk	High risk	Low risk	Low risk	Low risk	Low risk
04	Medeiros et al. [34]	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
05	Marandi et al. [35]	Unclear	Unclear	High risk	High risk	Low risk	Low risk	High risk
06	Pivotto et al. [38]	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
07	Sadati and Behdari [39]	Unclear	High risk	High risk	High risk	Low risk	Low risk	Low risk
08	Lee et al. [40]	Unclear	High risk	High risk	High risk	Low risk	Low risk	High risk
09	Yasmin M et al. [41]	Low risk	Low risk	High risk	High risk	Low risk	Unclear	High risk
10	Khormizi and Azarniveh [42]	Low risk	unclear	High risk	High risk	Low risk	Unclear	High risk

exercises [34, 35], and in one study mat-based Pilates was compared to Pilates apparatus exercises [40]. In one study, Pilates training was compared in two different conditions: one was normoxic (FiO2 20.9%), while the other was hypoxic (FiO2 14.5%). In comparison to the control and normoxic Pilates training groups, the hypoxic Pilates training group significantly reduced diastolic blood pressure, total cholesterol and triglyceride concentrations, flow-mediated dilation, and erythrocyte deformability and aggregation (all $p < 0.05$) [4]. This demonstrates the limitations of the evidence on the effectiveness of different treatment plans or types of exercise in relieving pain.

Improvement in quality of life was found in studies investigating breast cancer [33], fibromyalgia syndrome [34], and chronic LBA [7]. Emerging evidence was found for improving BMI and lower limb flexibility in studies investigating obese women [4] and elderly women [39]. When compared to Pilates and yoga programmes, water exercises are more helpful at enhancing emotional wellbeing and reducing the side effects of breast cancer therapy, although yoga was more successful at enhancing social/family wellbeing [33]. A study investigated that the cardio metabolic risk factors in type 2 diabetic women were improved by specially designed Pilates exercises after practicing it for 12 weeks [41]. Two study demonstrate that Pilates exercises helps in lowering the HbA1c level in type 2 diabetic women [41, 42].

Pilates training improves muscle strength in multiple sclerosis suffering women [35]. One study showed reduction in the graduation of temporomandibular dysfunction severity after 15 weeks of Pilates interventions [38].

Study limitation

It's possible that limiting the eligibility requirements to women obscured data on health outcomes that had previously been discovered in mixed groups. Another drawback was that only RCTs and comparative studies were included; observational and qualitative research might have revealed further information about how to improve women's health outcomes. Only free full text that are available online were included; paid studies may provide additional findings. Only those studies were included in which women participant's age is between 18 and 60 years, elderly women > 60 years were excluded for this review; Pilates on elderly women > 60 years may provide additional benefits. Studies published in other languages were not taken into consideration, and the search was only conducted in English-language publications. We did not include the studies that examine the effect of Pilates on pregnant women.

Suggestions for future research

By including random sequence generation, allocation concealment, blinding of patients and staff, and outcome evaluation, future RCTs and comparative studies could be upgraded.

Conclusion

Pilates is commonly used by women to improve their physical and emotional health. However, there is not much data to support the claim that Pilates helps women's health. According to recent research, Pilates may improve QOL while lowering pain and disability. It may also increase flexibility, strength, mobility, respiratory rate, vital capacity, body mass index, and balance. Additional high-quality research is necessary to determine whether Pilates is useful at enhancing women's health outcomes.

Abbreviations

RCTs	Randomised controlled trial
QOL	Quality of life
LBA	Low back ache
PROSPER	The International Prospective Register of Systematic Reviews
MeSH	Medical subject heading
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
FiO_2	Fraction of inspired oxygen
TMD	Temporomandibular dysfunction
BMI	Body mass index

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Authors' contributions
Two reviewers, AP and SK, independently extracted data, a third reviewer SJ, double-checked the data, and all inconsistencies were settled by consensus. All authors read and approved the final manuscript.

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Availability of data and materials
Data will be available on reasonable request.

Declarations

Ethics approval and consent to participate
None declared.

Consent for publication
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Competing interests
The authors declare that they have no competing interests.

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