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REVIEW ARTICLE

Effects of Pilates exercises on idiopathic scoliosis: a scoping review of the literature

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Abstract

Purpose Scoliosis is a deformity involving changes in three planes. These changes include lateral curvature in the frontal plane, changes in physiological thoracic kyphosis and lumbar lordosis angles in the sagittal plane, and rotation of the vertebrae in the transverse plane. The aim of this scoping review was to review and summarize the available literature to determine whether Pilates exercises are an effective treatment for scoliosis.

Methods The Cochrane Library (reviews, protocols, trials), PubMed, Web of Science, Ovid, Scopus, PEDro, Medline, CINAHL (EBSCO), ProQuest, and Google Scholar electronic databases were used to search for published articles from inception to February 2022. All the searches included English language studies. Keywords were determined as "scoliosis and Pilates" or "idiopathic scoliosis and Pilates", "curve and Pilates", "spinal deformity and Pilates."

Results Seven studies were included; one study was a meta-analysis study, three studies compared Pilates and Schroth exercises, and three applied Pilates exercises in combined therapy. The studies included in this review used outcome measurements of Cobb angle, ATR, chest expansion, SRS-22r, posture assessment, weight distribution, and psychological factors such as depression.

Conclusions The results of this review suggest that the level of evidence regarding the effect of Pilates exercises on scoliosis-related deformity is very limited. Pilates exercises can be applied to reduce asymmetrical posture in individuals with mild scoliosis with reduced growth potential and progression risk.

Keywords Scoliosis · Spine · Pilates · Exercise

Introduction

Lateral curvatures of the spine measured more than 10° according to the Cobb method on standing radiography are defined as "scoliosis". Curvatures less than 10° are considered physiological curvatures [1, 2]. Although the diagnosis is made by evaluation in a single plane, scoliosis is a deformity that includes changes in three planes.

These changes include lateral curvature in the frontal plane, changes in physiological thoracic kyphosis and lumbar lordosis angles in the sagittal plane, and rotation of the vertebrae in the transverse plane [1, 2]. Less frequently, there may be an increase in physiological sagittal curvatures in some cases. Some researchers consider that changes in the sagittal plane (flat back) occur first, and accordingly, lateral curvatures occur in the frontal plane secondarily [3, 4].

Scoliosis is an idiopathic form in more than 80% of cases, especially in adolescence when growth is rapid. Therefore, the most common type of scoliosis encountered in the clinic is "adolescent idiopathic scoliosis" (AIS). The prevalence of AIS has been reported in the literature in a wide range from 1.6 to 15% in different studies. These different results may be due to differences in the methodological characteristics of the studies, such as methods of evaluation and diagnosis and the age groups included [5, 6].

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Scoliosis treatment is traditionally determined by the degree of Cobb angle. Current treatment approaches include scoliosis-specific exercises if the Cobb angle is between 15° and 25°, brace treatment in addition to these exercise programs if the Cobb angle is between 20° and 40°, and surgical treatments for angles > 40°–50° [6]. The risk of curvature progression must be calculated to decide on the appropriate treatment option. The risk of progression can be calculated with the formula developed by Lonstein and Carlson. This formula includes Cobb angle, Risser sign (assessment of bone maturation over the iliac apophysis), and chronological age [7, 8].

Weiss and The International Society on Scoliosis Orthopedic and Rehabilitation Treatment (SOSORT) committee reported which treatment should be applied according to the risk of progression from age 6 to adulthood [8, 9].

According to the guidelines published by SOSORT professionals in 2006 and 2011, scoliosis treatment according to the risk of progression includes observation, scoliosis-specific exercise methods, intensive rehabilitation in which scoliosis-specific exercises are applied in patient centers, and brace treatment [9, 10].

The Pilates method was developed by Joseph Pilates in the early twentieth century and has been used by dancers for many years. There is strong evidence that the traditional Pilates method improves flexibility and dynamic balance in healthy individuals and moderate evidence that it improves muscle endurance [11–13].

Pilates exercises focus on the core muscles, defined as the "Powerhouse". This exercise system, which includes open and closed kinetic chain exercises, aims to provide both stability and mobility. Exercises involve concentric and eccentric contractions, so muscles are activated statically and dynamically. A relationship is established between mind and body, and it is aimed to achieve motor relearning. Correct breathing is important. Exercises can be adapted to different patient populations by physiotherapists and are known as Clinical Pilates exercises [13].

This exercise system has eight basic principles of concentration, breathing, focusing on the power (core) muscles, control of the muscles, stability in maintaining the activity, fluidity in the movement, providing body awareness, and routine continuation of the exercises.

The muscles primarily focused on in the clinical Pilates exercise system are the diaphragm, transversus abdominis, multifidus, and pelvic floor muscles, which are called the stability cylinders. In addition, longitudinal, anterior, and posterior oblique and lateral muscular bands contribute to stability [13].

In recent years, clinicians on websites and social media accounts have frequently recommended clinical Pilates exercises to individuals with scoliosis. Lack of treatment or lack of the proper treatment approach may result in the progression of the curvature, especially in growing children [5, 7]. Therefore, it is highly important to identify and clarify the effects of Pilates exercises on scoliosis treatment outcomes. The aims of this review were to (1) present the characteristics of studies on scoliosis and Pilates, (2) identify the effects of Pilates exercise on the Cobb and ATR angles which determine the curvature status, (3) identify the effects of Pilates exercises on other treatment outcomes of scoliosis treatment, (4) present the results of comparisons of Pilates exercises with other exercise methods.

Materials and methods

Design

Scoping reviews, also known as mapping reviews, are commonly used for "reconnaissance" to clarify a topic's working definitions and conceptual boundaries. Scoping reviews are beneficial where literature has not yet been extensively studied or exhibits a complex or heterogeneous nature that is not amenable to a more precise systematic review [14]. Although this study had been designed as a meta-analysis study, it was decided to be applied as a scoping review type due to the lack of RCT studies.

Search strategy

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist was used to standardize the search strategy. Two independent researchers reviewed relevant published articles on Pilates exercises in adolescent idiopathic scoliosis and scoliosis. Researchers independently screened the search results by reading the titles and abstracts. The results were first checked for duplicates. Full texts of the potentially relevant studies were obtained and independently assessed for inclusion. In case of discrepancies between authors, the articles were discussed between the three researchers of the study. The Cochrane Library (reviews, protocols, trials), PubMed, Web of Science, Ovid, Scopus, PEDro, Medline, CINAHL (EBSCO), ProQuest, and Google Scholar electronic databases were used to search for published articles from inception to February 2022. All the searches included English language studies.

Selection of the studies

Keywords were determined as "scoliosis and Pilates" or "idiopathic scoliosis and Pilates," "curve and Pilates," "spinal deformity and Pilates."

Inclusion criteria

- Studies that sampled participants with idiopathic scoliosis
- Studies that sampled participants diagnosed with radiographic assessment
- Studies that contained interventions including Pilates exercises
- Studies that contained Cobb angle, angle of rotation, or other outcome measurements data

Exclusion criteria

- Studies that sampled participants with < 10° Cobb angle
- Studies that were not available in English or Turkish
- Conference abstracts and thesis
- Case report studies

Study designs and levels of evidence

The designs and levels of evidence of the studies were assessed by the first and second reviewer independently according to the Center of Evidence-Based Medicine in Oxford guidelines for therapeutic studies [15]. Systematic reviews of randomized controlled trials (RCTs) and RCTs with narrow confidence intervals were classified as Level I, lesser quality RCTs and prospective controlled studies were classified as Level II, retrospective controlled studies were classified as Level III, and uncontrolled studies were classified as Level IV.

Results

Descriptive data

Two researchers identified 63 potentially relevant articles through different electronic databases (Fig. 1), and 29 duplicates were eliminated. After evaluating titles and abstracts, 13 articles were excluded. Next, 19 full texts were reviewed, and the researchers could not reach the full text of one article. Finally, seven studies were included in this scoping review [16–22].

The study characteristics are summarized in Table 1. The seven studies that met the inclusion criteria were published between 2016 and 2021 and were conducted in four countries. Three studies were from Korea [20–22] and two from Kosovo [17, 19]. Three studies [20–22] were randomized controlled studies with level II evidence, and three studies [17–19] were uncontrolled studies with level IV evidence. The most recent study was a meta-analysis of RCTs with level I evidence [16]. The ten RCT articles included in the meta-analysis of RCTs research are examined deeply. The

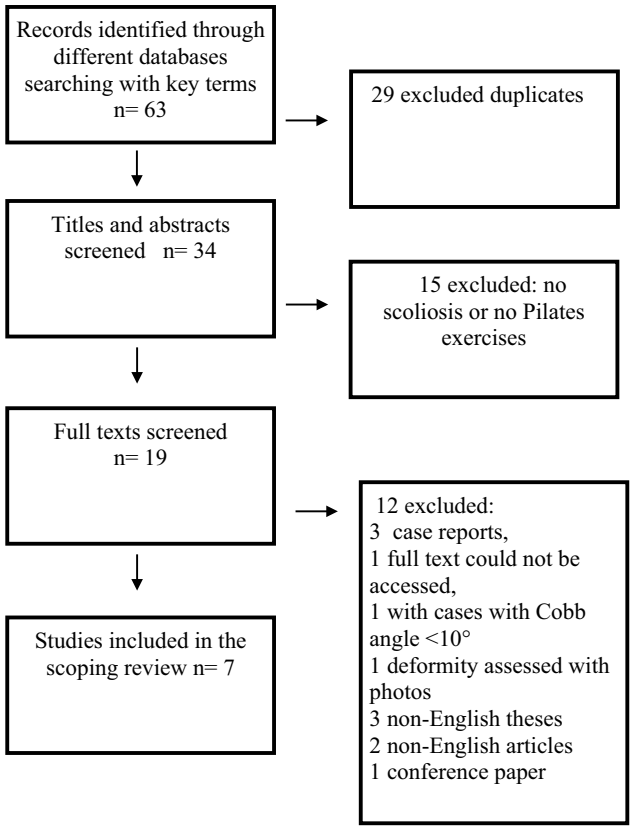

Fig. 1 Flow chart of study evaluation and selection process

Tang (*Tang R, Jiang J, Zhong Q,* et al. *(2019) The rehabilitation effect of Pilates combined with Schroth training system for scoliosis. Contemp Med. 25:176–8*) and Li (*Li X, Song L, Guo H (2020) Pilates for correction of scoliosis in college students. J Shanxi Datong Univ*) publications included in the study by Gou et al. [16] were not available on the internet sources. The pre-treatment mean Cobb angle values were less than 10 degrees in the studies by de Araujo 2012 [23] and de Araujo 2010 [24]. In the studies of Bipin [25] and Mehdi [26], the diagnosis of scoliosis was made by clinical evaluation. Pilates exercises were not applied in the study by Monticone [27] et al. Therefore, these studies were not included in the current scoping review. Three RCTs [19, 21, 22] included in the Gou et al. [16] study are included in this scoping review.

The meta-analysis included 359 participants and 191 participants were included in other studies (Table 1). Gender characteristics were not presented for some of the studies included in the meta-analysis study [16]. Other studies included in this scoping review included 142 females (74.3%) and 49 males.

Participants were aged between 13.1 and 22.7 years in the included studies. The RCT meta-analysis study included patients aged 7–70 years. However, some studies included in

Table 1 Characteristics of the studies in this review

Authors	Year	Country	Methodology	Sample Size	Mean age of the participants	Mean Cobb angle	Intervention	Outcomes
Gou et al. (16)	2021	China	Meta-analysis of RCT's	$n=359$ (10 RCTs)	NR	NR	Pilates exercises (and other interventions)	Cobb angle ATR Pain Trunk ROM SRS-22
Rrecaj-Malaj et al. (17)	2020	Kosovo	Uncontrolled study	$n=69$	13.4 years	Brace group:21.9 Non-bracegroup:14.1	Schroth and Pilates exercises were performed over 24 weeks and consisted of 2 periods of 2-week treatment regimens	Cobb angle, ATR, Chest expansion, SRS-22r
Aly et al. (18)	2019	Egypt	Uncontrolled study	$n=10$	14.6 years	36	Participants underwent an integrated exercise program consisting of Schroth exercises, manual therapy, myofascial release, core stability exercises, Yoga and Pilates for 6 months with an average of 2 sessions per week	Posture Screen mobile software
HwangBo (19)	2018	Korea	Randomized Controlled study	$n=16$	21 years	Schroth group: 18.9 Pilates group: 19	Schroth + Pilates exercise group performed Pilates exercise using Schroth breathing, and a Pilates exercise group performed Pilates exercise using lateral breathing for three times per week for 12 weeks	Cobb angle, ATR, Chest expansion ability
Rrecaj-Malaj et al. (20)	2018	Kosovo	Uncontrolled study	$n=56$	13.1 years	17.2	Schroth and Pilates exercises were performed five days per week for 3 months	SRS-22r
Kim and HwangBo (21)	2016	Korea	Randomized Controlled study	$n=24$	15.4 years	Schroth group: 23.6 Pilates group: 24	One group received Schroth exercises and another group received Pilates exercises three times a week for 12 weeks	Cobb angle Weight distribution (%)
HwangBo (22)	2016	Korea	Randomized Controlled study	$n=16$	18.5 years	Schroth group: 22 Pilates group: 21.2	One group received Schroth exercises and another group received Pilates exercises three times a week for 12 weeks	Beck depression inventoty, Self-esteem inventory, Body-esteem scale

ATR angle of trunk rotation, *NR* non-reported

the meta-analysis did not report the mean age of the patients, so an average value cannot be given for the study by Gou et al. [16].

Adolescents were included in four studies, and the mean ages were reported as 13.1, 13.4, 14.6, and 15.4 years. None of the included studies provided information on the bone development of participants, such as Risser or Sanders staging methods.

Intervention

Two of the included studies [17, 19] evaluated the effects of Pilates + Schroth exercises in an uncontrolled group. In one study [17], exercises were performed over 24 weeks and consisted of 2 periods of 2-week treatment regimens, and participants followed the same home program for ten weeks after treatment. The treatment regime consisted of 60 min of daily exercises. Another uncontrolled study [18] by Aly et al. investigated the effects of combined therapy, including Schroth + Pilates + Yoga + core stability exercises, manual therapy, and myofascial release. Researchers [18] applied the treatment program for six months with an average of two 120 min-sessions per week.

In two [21, 22] of the three randomized controlled trials included in the study, the authors compared the effects of Schroth and Pilates exercises applied three times a week for 12 weeks. In another RCT study by HwangBo [19], one Pilates exercise group performed Pilates exercise using Schroth breathing, and another Pilates exercise group performed Pilates exercise using lateral breathing three times per week for 12 weeks. In these three RCT studies [19, 21, 22], it was stated that a treatment session lasted 60 min.

In the two studies by Rrecaj-Malaj et al. [19, 20] reported that 19 children (33.9%) and 18 (26.1%) children, respectively, were wearing a brace in addition to the exercise program.

Outcome measurements

The studies included in this review used outcome measures of Cobb angle, ATR, chest expansion, SRS-22r, posture assessment, weight distribution, and psychological factors such as depression.

Three studies [17, 19, 21] examined the pre-post treatment Cobb angle values, which are still the gold standard for measuring deformity. Rrecaj-Malaj et al. [17] reported that the Cobb angle was significantly reduced in children whose growth continued both in the groups wearing and not wearing a brace after the treatment program.

HwangBo [19] reported that the Cobb angle decreased in both groups after treatment, but this improvement was more significant in the Schroth + Pilates group.

Kim and HwangBo [21] presented Cobb angle improvement in two treatment groups, although they stated that changes in the Schroth group were significant.

Two studies [17, 19] examined the pre–post treatment angle of trunk rotation values and reported improvement after the treatment. HwangBo [19] stated that between-group comparison after the exercise showed that Schroth + Pilates group improvements in the angle of trunk rotation were more significant than those of the Pilates group.

Improvements in measurement results were reported in two studies [17, 19] that evaluated chest expansion after treatment programs. HwangBo [19] stated that between-group comparisons after the exercise showed that the Schroth + Pilates group improvements in chest expansion values were more significant than those of the Pilates group as with other measurement results.

Only two studies evaluated the quality of life, both by Rrecaj-Malaj et al. [17, 20]. The SRS-22r version was used in both studies, but the authors did not specify a valid and reliable study for the Albanian language and wrote that a certified translator translated it.

Posture assessment was performed with Posture Screen mobile software in a study by Aly et al. [18]. Improvements were reported in head shift, head tilt, shoulder shift, shoulder tilt, T1-T4 tilt, and shift, T4–T8 tilt and shift, T8–T12 tilt and shift.

Weight distribution was assessed in a study by Kim and HwangBo [21], and no significant difference was found in the Pilates treatment group, but the Schroth treatment group showed significant changes.

Only one study by HwangBo [22] investigated the psychological factors including depression, self-esteem, and body-esteem with the Beck Depression Scale, self-esteem inventory, and body-esteem scale. The author suggested that Pilates exercises had a positive psychological effect on patients with scoliosis, but the comparison between the Schroth and Pilates groups showed that Schroth exercise was more effective than Pilates.

Conclusion

This scoping review study aimed to review and summarize the available literature to determine whether Pilates exercises are an effective treatment for scoliosis. A total of six original research studies [17–22] and a meta-analysis [16] were included and analyzed. Three RCTs [19, 21, 22] included in the Gou et al. [16] study were included in this scoping review. There was no study with high methodological quality. There were three randomized controlled studies [19, 21, 22], and three [17, 18, 20] were uncontrolled studies. Cobb angle changes, an indicator of deformity, were reported in three studies [17, 19, 21].

The results of the included studies [19, 21, 22] suggest that Pilates exercises may improve Cobb angle, ATR, chest expansion values, and the psychological status of patients with mild to moderate scoliosis. However, these three studies also reported that Schroth exercises, which are scoliosis-specific, are more effective than Pilates exercises in improving Cobb angle, ATR, chest expansion, and psychological status [19, 21, 22]. In addition, HwangBo reported in the article that the Cobb angle in the group performing Pilates exercises was 21.20° before treatment and 18.73° after treatment and the improvement was 3.57°. However, the difference is 2.47 and this value shows that the Cobb angle is stabilized according to SOSORT guidelines [28] Importantly, the average age of the included individuals was above 18 years and they had no growth potential and therefore no risk of progression [21].

No study could be found that compared Pilates exercises with a control group (as a waiting list, regular activities). The other three studies applied Pilates exercises with other exercises and interventions. The authors reported that different combined therapy models, including Pilates and Schroth exercises and other interventions, effectively improve Cobb angle, ATR, quality of life, and posture [17, 18, 20].

The meta-analysis [16] study in this review reported that "Pilates exercises may reduce Cobb angle and trunk rotation, relieve pain, increase trunk ROM, and improve QoL for patients with scoliosis. Due to the poor quality of the evidence, however, these results should be interpreted with caution". As noted by the authors, the results of these studies should be interpreted with caution, because in some of the studies included in this meta-analysis, the diagnosis of scoliosis was made with clinical evaluations such as photographs, not by a specialist physician and radiographic evaluation.

In the study by Gou et al. [16], which the authors evaluated as high methodological quality (10/10) study [23] according to the PEDro scale [29], the ages of the participants were 18 – 25 years, and the mean Cobb angle was 7°. In addition, Gou et al. [16] stated that the studies included in the meta-analysis were of average-fair quality according to the PEDro scale (5.3/10).

Studies examining the natural history of scoliosis have shown that scoliosis progresses in growing adolescents who do not receive appropriate and necessary treatment management [5, 7, 30]. Both the studies which sampled growing participants were included in this review. The average age of the participants was 13.1 years [20] and 13.4 years [17], and it was stated that children with an average Cobb angle of 20° used braces in addition to exercise therapy.

When the participants in the other included studies [18, 19, 21, 22] were analyzed according to the mean age, it was seen that growth was largely completed, and the risk of curvature progression decreased [30]. The generally accepted belief has been that curves that reach 50° are likely to progress into adulthood, progressing at a rate of 1° per year, mainly based on Iowa studies [31].

The adolescent period is the second period of life when growth is rapid, and therefore, deformity progression is more probable [7, 30]. It is accepted that adolescent idiopathic scoliosis progresses within a self-sustaining biomechanical process involving symmetrical growth of vertebrae and the spine evolving during the growth spurt [30]. The primary goal of adolescent idiopathic scoliosis treatment is to stop progression and improve the curvature. Conservative scoliosis treatment is based on physiotherapy and rehabilitation methods and brace treatment [6, 32]. As scoliosis is a 3D deformity with deviation in all three planes, treatment should address deformity in 3 planes. Scoliosis-specific exercises are recommended by scoliosis professionals to be able to achieve treatment goals [6, 10, 32–34].

In this sense, researchers and clinicians should consider scoliosis as a three-dimensional deformity [5], but Pilates exercises do not include exercise mechanisms to correct curvature in three planes [13]. Activation of upper cervical flexion and deep neck flexors is required within the "head and neck placement", one of the key elements of clinical Pilates exercises. This key element may not suit many individuals with scoliosis as their cervical lordosis is reduced. Conversely, the cervical extensors may need to be activated. Similarly, serratus anterior, upper, and lower trapezius contraction is requested in the "shoulder placement" key element in the clinical Pilates exercise system [13]. This key element is also not suitable for many individuals with reduced physiological kyphosis angle and will limit the correction of rotation deformity.

The changes in the spine and the musculoskeletal structure of each individual with scoliosis are unique. Therefore, a clinician specializing in scoliosis rehabilitation should first make a detailed evaluation and create a rehabilitation program according to the evaluation results. Techniques with a high level of evidence regarding the corrective effect of the content of the exercise program on the curvatures should be selected, because when the duration and costs of the exercise programs are considered, results such as the inadequacy of the therapeutic effect of an application that is not based on evidence or the inability to prevent progression may also pose ethical problems.

The inclusion of studies involving cases diagnosed with scoliosis by X-ray evaluation can be considered the strength of this study. The review was limited to papers published in the English and Turkish languages, so it is possible that other potentially relevant studies were omitted.

In summary, the level of evidence regarding the effect of Pilates exercises on scoliosis-related deformity is limited. Pilates exercises can reduce asymmetrical posture in individuals with small scoliosis angles with reduced growth potential and a low risk of progression.

The long-term effects of applied Pilates exercises are unknown. The studies included in this review did not include long-term follow-up for growing adolescents. Another important point is that the same authors mostly carried out research on Pilates and scoliosis. It is important to obtain and present similar results by different researchers to obtain reliable interpretations. Studies with high methodological quality with control groups are needed to demonstrate the effectiveness of this exercise method.

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Declarations

Conflict of interest The authors have no relevant financial or non-financial interests to disclose.

Ethics approval This is a review study; therefore ethical approval was not sought.

Consent to participate Not applicable.

Consent for publication All authors whose names appear on the submission. (1) made substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data; or the creation of new software used in the work; (2) drafted the work or revised it critically for important intellectual content; (3) approved the version to be published; and (4) agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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