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Review Article

Core Stabilization Exercises vs. Schroth's Three Dimensional Exercises to Treat Adolescent Idiopathic Scoliosis: A Systematic Review

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Abstract

Background: Adolescent idiopathic scoliosis (AIS) is one of the most prevalent spinal abnormalities, appearing far into puberty. Schroth's exercises (SE) and core-stabilization exercises (CE) have become very prominent among the specialized and general methods to scoliosis treatment. However, their effects are still unclear and there is insufficient evidence of superiority between them. Therefore, we aimed to evaluate and compare the effectiveness of these methods on Cobb angles (CA) in AIS.

Methods: A systematic review was performed on SE and CE papers. The databases included PubMed, Scopus, MEDLINE, Cochrane Library, CINAHL, and Google Scholar from January 2005 to June 2022. The physiotherapy evidence database (PEDro) scale assessed the quality and provided internal validity and the statistical information of the papers.

Results: After screening 410 papers, nine papers (SE=5, CE=3 and SE vs. CE=1), with 339 participants, were admitted for review (PEDro=6). Among them, three (SE=moderate evidence) and two papers (CE=limited evidence) reported clinically significant reductions in CA>5°, alone or compared to control or other exercise methods, while only one paper (very limited evidence) showed the relative superiority of SE (-7.16°) compared to CE (-3.27°). However, three papers did not show clinically significant results (CA<5°).

Conclusion: Moderate and limited evidence suggests that both SE and CE can effectively improve CA, respectively. There is very limited evidence to suggest that SE is more effective than CE in treating AIS. Thus, the definitive answers to the questions, especially concerning the superiority between these two methods, remained unclear. Further high-quality studies must be conducted in the future.

Keywords: Systematic review; Scoliosis; Exercise therapy; Core stabilization; Schroth method

Introduction

Scoliosis is known as a complex three-dimensional (3D) deformity of the spine, meaning the vertebrae of the spine not only deviate laterally, but also rotate anteriorly and

posteriorly (1). Adolescent idiopathic scoliosis (AIS) accounts for about 80% of all types of scoliosis and its prevalence is approximately 0.47-5.2% (adolescent 10 to 18 yr) (2). This condition may lead to an improper trunk appearance (3), respiratory disorders (4), poor quality of life (QoL) (1), back pain and even osteoporosis (5).

A person with scoliosis is diagnosed if the degree of Cobb angles (CA) on the frontal plane is ≥10° (3). Ignoring this issue, especially around the age of growth spurts, can lead to worsening of the person's condition. However, unfortunately, some doctors still ignore mild scoliosis and advise the AIS to wait and see what occurs (6). Hence, the primary goal of managing AIS is to prevent the progression of curvature, followed by correcting it (5).

Different invasive and non-invasive strategies have been proposed for the treatment of these patients depending on the severity of the deformity (usually, surgery and corrective exercises with braces for greater and less than 45°, respectively) (7), but the surgical procedure, in addition to potential risks, causes fear and anxiety in scoliotic adolescents (8, 9). Conversely, wearing braces for a long time without exercise causes muscle weakness, rigidity, development of a flat back, and even the adolescents' unwillingness to continue the treatment process (9). Consequently, corrective exercises are the primary and most suitable choice before alternative methods for remedying AIS (1, 10, 11). Meanwhile, Schroth exercises (SE) (among scoliosis-specific exercises) (7) and core-stabilization exercises (CE) (among general exercises) (1) have become more prominent than other exercise methods due to their promising results (1, 7).

Katharina Schroth in Germany created the Schroth techniques in 1921 (12). The primary function of this method is to eliminate muscle imbalances by strengthening and stretching soft tissues, which is done by using breathing and self-correction techniques in front of the mirror along with other equipment such as wall-bars, sticks, and Swiss balls (5). In fact, the main basis of correction in the Schroth method is according to the type and number of arches created in a scoliotic person so that the trunk areas are separated into three or four hypothetical blocks (10). The focus on the correction of these blocks is by applying different active and passive forces (such as lateral shift, compression and rotation) by the specialist and the patient (12, 13).

Manohar Panjabi developed the theory of spinal stability in 1992 in the United States. According to him, strengthening the passive spinal column, active spinal muscles, and neural control unit all together can form a stable spine structure, while defects in any of these subsystems can lead to spinal deformities and pain (14). Hence, researchers and therapists in different countries of the world have designed exercises (such as Pilates, yoga and core stability) based on this theory, which is used not only to correct spinal deformities (1, 15, 16) but also to treat low back pain and even improve performance and prevent injuries in athletes (17, 18). The focus of core-stabilization exercises (CE) is to reinforce the muscles of the core area of the body, such as para-spinal, multifidus, oblique and anterior abdominal and gluteal (3, 18).

Despite extensive review in this field (1, 5, 7, 15, 19, 20), there is still no convincing evidence on the effectiveness of these two exercise approaches in general and the superiority of one of them in particular (1, 7, 19, 21).

In a recent review, the beneficial role of core-based exercises in reducing CA were reported, however, the authors' focus was on all core-based exercise methods (such as Pilates, yoga, etc.), not specifically CE as well as all people with scoliosis (not limited to AIS) (1). On the other hand, in the latest review for SE, it was confirmed with moderate evidence that SE could be effective in reducing the curvature of AIS, but a very limited number of studies (four studies in total) was analyzed in this review (7). Furthermore, at the time of writing this manuscript, there was no review in which these two exercise approaches had been compared.

Therefore, considering the publication of newer papers by 2022, conducting this review was necessary in order to answer the following questions:

Q1. What is the level of evidence that SE and CE are effective in treating AIS?
Q2. What are the disadvantages and benefits of each exercise method?
Q3. Which of the two exercise methods is superior?
In fact, the main goals of the current review were to initially evaluate the effectiveness of SE and CE and then, for the first time, to compare them with each other on the reduction of CA in AIS. The authors hypothesize that both methods show objective improvement on AIS (1, 7), and based on clinical observations, SE provides superior outcomes compared to CE (7).

Methods

This is a systematic review designed according to the protocol recommended by the Preferred Reporting Items for Systematic Reviews and Meta-Analyzes (PRISMA) by searching information in databases including PubMed, Scopus, MEDLINE, Cochrane Library, CINAHL and Google Scholar from 2005 to June 29, 2022 (22), registered in the PROSPERO database (NO. CRD42022329874).
Key terms including "adolescent", or "Juvenile", and "scoliosis" or "idiopathic scoliosis", and "corrective exercise", or "physiotherapy", or "core stabilization", or "core strengthening", or "scoliosis specific exercise", or "Schroth", and "Cobb angles" were used, limited to English-language studies. The papers analyzed from all databases were cross-checked by two reviewers independently (AK and HM). This revision process involved checking titles and abstracts first, and if they comply with the inclusion criteria, full texts were received. Two other reviewers (MG and MA) discussed any conflicts with respect to accepting full-text papers until agreement was accomplished.

Inclusion criteria

Inclusion criteria were limited to the PICO items (23) of population (AIS 10-18 years old), interventions (existence of one of the Schroth or core stability exercises), comparison (an exercise group with a control group (CON), an exercise group with its own before and after data, an exercise group with another exercise groups), and outcome (The primary variable of CA with or without the secondary variable such as QoL, angle of trunk rotation, etc.). In the design of the present study (such as randomized controlled trial (RCT) or any other design study), training courses and the amount of CA, no limitations were considered in the papers.

Exclusion criteria

The papers, in which the study populations were inflicted with disorders and abnormalities (such as osteoporosis and genu varum, respectively), in addition to idiopathic scoliosis, and the use of other interventions (such as surgery, massage, manipulation, and kinesio tape), were excluded from the study. It should be noted that the papers that used a combination of SE and CE approaches (such as Schroth and Pilates) in a group in their training interventions were also excluded, while no restrictions were considered on the use of braces (1).

Assessment of methodological quality

Two independent reviewers (AK and MG) assessed the quality of the papers using the Physiotherapy Evidence Database (PEDro) scale (24). This scale has 11 choices, a positive response to each item is considered as a positive point, while the response to the first item is not considered a point. Scores within the ranges of 0–4, 5–7, and 8-10 were considered low, moderate, and high, respectively (Table 1) (5, 24).

Assessment of Level of Evidence

The level of evidence was determined based on the Cochrane Back Review Group by two reviewers independently (MA and HM), and classified into five levels. These levels include level 1 or strong (consistent outcomes between several high-quality RCTs (PEDro≥8)), level 2a or moderate (a high and/or several moderate-quality RCTs (PEDro=5-7)), level 2b (a moderate and/or a few low-quality RCTs or Non-RCTs),

level 3a or limited (multiple low to moderate-quality RCTs and/or Non-RCTs), level 3b (a low-quality RCT and/or Non-RCT (PEDro≤4), level 4 or conflicting (contradictory outcomes among several RCTs and/or Non-RCTs), and finally level 5 or no proof (no RCT or non-RCT) (25).

Results

A total of 410 papers were obtained from six databases in the initial search. Then, 132 irrelevant and 37 duplicate papers were removed after screening their titles and abstracts. Eventually, nine papers including 339 participants with valid result data were allowed to enter this review (Fig. 1).

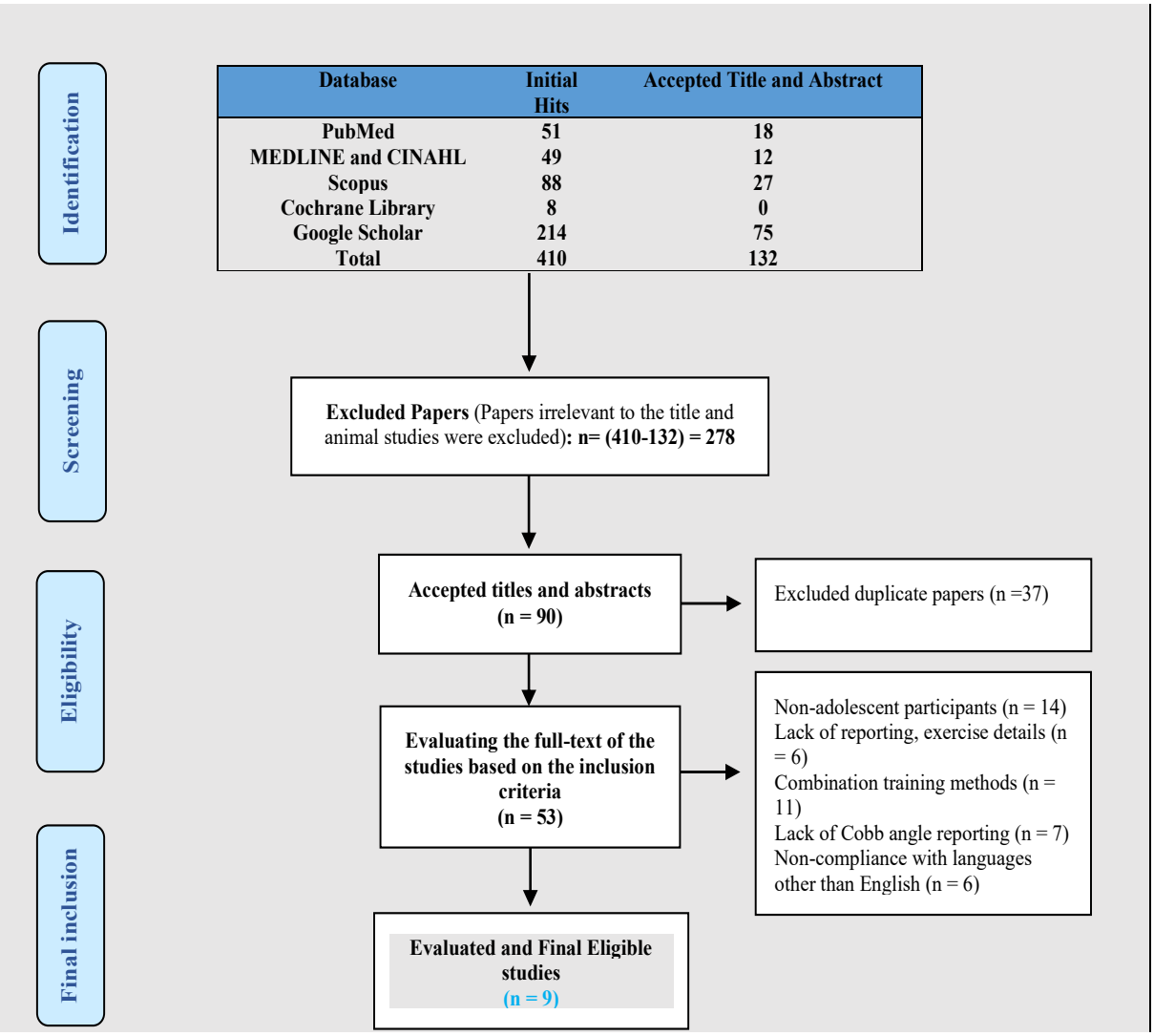

Fig. 1: PRISMA flow diagram of this study

Level of evidence and appraisal quality

Six RCTs (54%) were of moderate (26-30) to high-quality (31), while three non-RCTs (27%; prospective or re-prospective) had low (32, 33) to moderate-quality (34). This means that the ranking of scores on the PEDro scale was classified from 3 to 9, and the overall average of these scores is 6, which indicates the moderate-quality

of papers (26-34). Specifically, the averages of the scores for the SE (26, 29-32, 34) and CE (27-29, 33) papers are 6 and 6.25, respectively (Table 1).

Table 1: Assessing the quality level of the studies based on PEDro scale

Authors	*Exercise*	*Score*	*Quality and design of study*	*1.Eligibility*	*2.Random allocation*	*3.Concealed allocation*	*4.Baseline measure*	*5.Blind subjects*	*6.Blind therapist*	*7.Blind assessor*	*8.Adequate follow up*	*9.Intention to treat*	*10.Between group*	*11. Point Estimate of Variability*
Otman et al. (2005) (32)	SE	3	Low non-RCT	Yes	No	No	Yes	No	No	No	Yes	No	No	Yes
Kuru et al. (2016) (26)	SE	6	Moderate RCT	Yes	Yes	Yes	Yes	No	No	No	Yes	No	Yes	Yes
Schreiber et al. (2016) (31)	SE	8	Strong RCT	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Ko and Kang. (2017) (33)	CE	4	Low non-RCT	Yes	No	No	Yes	No	No	No	Yes	No	Yes	Yes
Kwan et al. (2017) (34)	SE	5	Moderate non-RCT	Yes	No	No	Yes	No	No	Yes	Yes	No	Yes	Yes
Gür et al. (2017) (27)	CE	7	Moderate RCT	Yes	Yes	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes
Yagci et al. (2019) (28)	CE	7	Moderate RCT	Yes	Yes	No	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Kocaman et al. (2021) (29)	SE and CE	7	Moderate RCT	Yes	Yes	Yes	Yes	No	No	Yes	Yes	No	Yes	Yes
Mohamed and Yousef. (2021) (30)	SE	7	Moderate RCT	Yes	Yes	Yes	Yes	Yes	No	No	Yes	No	Yes	Yes

Abbreviations: RCT=Randomized Controlled Trial, SE=Schroth Exercises, CE=Core-Stabilization Exercises

Characteristics of included papers

Six as well as four papers adopted the SE (26, 29-32, 34) and CE (27-29, 33), respectively, in one of which both of the exercise types were tested (29). In particular, in four RCTs, SE was compared with the CON (SE in clinic vs. SE at home as CON (26) and, SE+ standard of care vs. standard of care as CON) (31), CE (29) as well as proprioceptive neuromuscular facilitation (PNF) techniques (30). Furthermore, in two non-RCTs, one SE paper was compared with its own before and after data in one exercise group (32), and in the other with no intervention or CON (34) (Table 1, 2).

Four papers (three RCTs and one non-RCT) adopted the CE. They were compared with the Scientific Exercise Approach to Scoliosis (SEAS) (28) and SE (29), as well as no intervention or CON (27, 33), respectively (Table 1, 2). Four papers evaluated CA between 10° to 30° (29, 30, 32, 33), and five other papers evaluated degrees between 25° to 50° (26-28, 31, 34) (Table 2).

The research period for CE papers was from ten to sixteen weeks (27-29, 33), while for SE, this duration was from eight weeks to one year (26, 29-32, 34), and in all of them, two to three training sessions were performed per week. Moreover, three papers did not separate the effect of braces and exercises (27, 28, 31), one paper accurately identified the effect of braces and exercises (34), and the other five papers did not use braces (26, 29, 30, 32, 33) (Table 2).

Table 2: Summary of Included Studies (Sample, Intervention, Outcome Measures, Result)

Author and year	*Cobb angles and Risser*	*Participant*	*Treatment length*	*Intervention*	*Outcomes measured*	*Results*
Otman et al. (2005) (32)	20°-35° RS=NR	(N=50)	6 weeks (Inpatient), 6 months, and one year (outpatient).	(SE)	CA Vital capacity Muscle strength	The CA decreased from 26° to 23.45°, 19.25° and 17.85° after 1.5, 6, and 12 months, respectively (P<0.01).
Kuru et al. (2016) (26)	10°-60° RS=0-3	(N=45, three groups, 15 in each)	6, 12, and 24 weeks.	(SE in clinic) (SE at home or CON)	CA ATR Waist asymmetry Maximum hump QoL	The CA (-2.53°; P=0.003) significantly reduced, in the SE in the clinic compared to the CON.
Schreiber et al. (2016) (31)	10°-45° RS=0-5	(N=50, two groups, 25 in each)	6 months, (Inpatient and outpatient).	(SE + standard of care) (Standard of care or CON) (Brace in both groups)	CA	The SE had a significantly smaller largest curve than CON (-3.5°, 95% CI -1.1° to -5.9°, p=0.006).
Ko and Kang. (2017) (33)	10°–20° RS=NR	(N=29, two groups, 15 in CE and 14 in CON)	12 weeks (Inpatient).	(CE) (CON)	CA Flexibility lumbar muscle strength	The CE had a significant reduction in the CA (15.20° to 14.77°) (P<0.001).
Kwan et al. (2017) (34)	25°-40° RS=0-2	(N=48, two groups, 24 in each)	8 weeks (Inpatient).	(SE+ brace) (Brace alone or CON)	CA ATR QoL	The CA in SE ameliorated (CA≥6°), worsened (CA≥6°) and remained unchanged by 17%, 21% and 62%, respectively, while the average of these changes in the CON was 4%, 50% and 46%, respectively.
Gür et al. (2017) (27)	20°-40° RS=2	(N=25, two groups, 13 in CE and 12 in CON)	10 weeks (Inpatient).	(CE+ traditional exercise) (Traditional exercise or CON) (Brace in both groups)	CA ATR Trunk asymmetry Cosmetic trunk deformity QoL	The CA changed significantly in the CE (32° to 26.4°), compared to the CON (P<0.05).
Yagci et al. (2019) (28)	20°-45° RS 2 -3	(N=30, two groups, 15 in each)	4 months (Inpatient and outpatient).	(CE) (SEAS) (Brace in both groups)	CA ATR Trunk asymmetry Cosmetic trunk deformity QoL	The CA changed significantly from 27.45° to 22.05° in the CE and from 26.75° to 21.9° in the SEAS (P<0.05).
Kocaman et al. (2021) (29)	10°-30° RS≤3	(N=28, two groups, 14 in each)	10 weeks (Inpatient).	(SE) (CE)	CA ATR Cosmetic trunk deformity Spinal mobility Peripheral muscle strength QoL	The SE showed greater improvement in CA (16.72° to 9.55°) than CE (16.23° to 12.95°) (P<0.05).
Mohamed and Yousef. (2021) (30)	10°-30° RS=NR	(N=34, two groups, 18 in each)	6 months (Inpatient).	(SE) (PNF)	CA ATR Plantar pressure distribution on both lower limbs Functional capacity	A significant reduction in CA was observed in both groups, especially in SE (from 20.42° to 14.11° and 20.21° to 17.46° for SE and PNF, respectively) (P<0.05).

Abbreviations: ATR= Angle of Trunk Rotation, CA= Cobb angles, SE= Schroth exercises, CE= Core-stabilization exercises, SEAS= Scientific Exercise Approach to Scoliosis, PNF= Proprioceptive Neuromuscular Facilitation. QoL= Quality of Life, NR= no reported, RS= Risser sign

Proposed questions

Can SE be effective in reducing the Cobb angles of AIS?

In total, six papers took this issue into consideration (26, 29-32, 34). Among them, one trial (non-RCT) was of low-quality (PEDro=3) (32), another (RCT) was of high-quality (PEDro=9) (31), and the rest (three RCTs and one non-RCT) were of moderate-quality (PEDro=5-7) (26, 29, 30, 34) (Table 1). All of these papers reported a significant reduction in CA, however, in two papers (moderate and high-quality RCTs), the differences were not clinically significant (less than 5°) (26, 31) (Table 1, 2).

In the study conducted by Schreiber et al., after six months of training, only a 4° decrease in the sum of curves (root mean square value) was observed (31). In the study conducted by Kuru et al., despite six months of training, only a relative improvement in relation to the SE in the clinic (-2.53°; P=0.003) compared to SE at home (CON) was found (26) (Table 2).

Furthermore, four other studies (two RCTs and two non-RCTs) found the reduction of the CA to be greater than 5°. In a study (low-quality non-RCT) conducted by Otman et al. CA decreased from 26° to 23.45°, 19.25° and 17.85° after two, six and twelve-months, respectively (P<0.01) (32). Kwan et al. (moderate-quality non-RCT) found that 17% of the subjects showed improvement with SE (SE+brace), while only 4% improved with no training (brace alone) after eight weeks (34). Mohamed and Yousef. (moderate-quality RCT) reported that after a year, both SE and Proprioceptive Neuromuscular Facilitation (PNF) techniques improved the CA (20.42° to 14.11° and 20.21° to 17.46° for SE and PNF, respectively), with a significant change in SE alone (P<0.001) (30). Kocaman et al. (moderate-quality RCT) observed that after ten weeks of follow-up, an improvement occurred in both SE and CE approaches, but clinically only SE were significant (CA>5°) (29) (Table 1, 2).

Therefore, considering the existence of two RCTs (moderate-quality) and two non-RCTs (low and moderate-quality), which reported a significant improvement in CA, there is moderate evidence to suggest the effectiveness of SE on CA in AIS (Level 2b).

Do CE effectively reduce Cobb angles in AIS?

In order to investigate this issue, four papers were included in this review, including three moderate-quality RCTs (27-29) and one low-quality non-RCT (33) (Table 1). Despite the significant improvement in CA in all of these studies, a reduction in these angles was clinically significant (greater than 5°) in only two papers (moderate-quality RCTs) (27, 28).

In the study conducted by Gür et al. (moderate-quality RCT), in the intergroup comparison after ten weeks in CE+ traditional exercise and traditional exercise (CON), a significant decrease in CA was not observed, but in the intragroup comparison for these angles, a clinically significant (from 32° to 26.4°) (P<0.05) was reported (27). Also, Yagci et al. (moderate-quality RCT), found a significant reduction in CA in both SEAS and CE groups (27.45° to 22.05° in the CE and 26.75° to 21.9° in the SEAS) after four months of follow-up (28) (Table 1, 2).

However, Ko and Kang. (low-quality non-RCT) found slight changes in the reduction of CA (15.20° to 14.77°) following twelve weeks of CE (P<0.001) (33). Kocaman et al. (moderate-quality RCT), aside from significant reports of further decreasing CA in the two SE and CE groups, found no clinically significant changes in CE (CA<5°) (P<0.05) (29) (Table 1 and 2).

Therefore, because of the presence of two moderate-quality RCTs that report consistent outcomes (27, 28), there is limited evidence to suggest the impact of CE on improving CA (Level 3a).

Do SE provide superior results compared to CE?

Only one moderate-quality RCT was found to investigate this issue. Kocaman et al (29) directly compared the two training approaches and monitored adolescents with CA between 10° to 30° for ten weeks and found that both training methods were effective in improving these patients' conditions (CA=16.72° to 9.55°, and 16.23° to 12.95° for SE and CE, respectively) (P<0.05). Nevertheless, clinically, only the SE

resulted in significant changes (Table 2). Thus, very limited evidence suggests that SE is superior to CE (Level 3b).

Discussion

The main aims of this review were to first, evaluate the effectiveness of CE and SE on reducing CA in AIS, and then, for the first time, to compare the two pre-mentioned methods with each other on these patients. The authors hypothesized that both exercise methods could be effective in improving CA (1, 7), and given that SE are specifically designed to correct scoliosis, they are superior to CE (7). The findings of this study confirm these hypotheses to an extent, but there are several novel aspects, especially for CE, in the results that add to the literature discussed below.

Regarding the first question, this study first focused on the effectiveness of SE. Contrary to some previous reviews that provided insufficient and limited evidence (5, 35-37), the findings of this study suggest the effectiveness of these exercises with moderate levels of evidence (Level 2b) on reducing CA in AIS. This result is consistent with what was reported in the study conducted by Van Rooyen et al (7).

The clinical standard for patient regression curves is >5° (38), therefore, any change of ≤5° was not considered as a genuine improvement. In all six selected papers that used SE as an intervention (26, 29-32, 34), the reduction of CA was reported, and only in two papers (low and moderate risk of bias), the improvement of curves was reported to be <5° (26, 31). However, in the other four papers (high to moderate risk of bias) the reduction in lateral deflection angles was reported to be >5° (29, 30, 32, 34).

Nonetheless, the papers that reported significant results were of low to moderate quality (PEDro=3-7), with an average score of 5.5 on the PEDro scale (29, 30, 32, 34). Although the two papers, which did not see changes of >5° (26, 31), were of high and moderate-quality, if attention is paid to the training protocol of these studies, their researchers initially focused on teaching the exercises to patients in the clinic and then continuing them at home. However, in all papers that reported significant changes (29, 30, 32, 34), exercises were performed under the supervision of specialists and in periods of less than six months (29, 30, 34). It seems that performing these exercises in the clinic in the presence of a specialist is necessary, which can be considered as one of their weaknesses (5).

Regarding the second question of this study in order to evaluate the effectiveness of CA, four papers (three RCTs and one non-RCT) were selected (27-29, 33). Among them, only two papers (moderate risk of bias) reported significant clinical improvement >5° (27, 28), and the other two papers reported only a slight decrease in the CA (high and moderate risk of bias) (29, 33). The average score on the PEDro scale for all of these papers is 6.25, while the average score for the two papers that reported a clinically significant decrease in CA is 7. Therefore, in line with two previous systematic reviews (1, 15), there is still limited evidence to suggest the positive effects of this method on the improvement of AIS (Level 3a). Researchers in these studies experienced training courses of under 4 months in mild to moderate scoliosis (27-29, 33), and surprisingly, one article, notwithstanding doing the majority of its activities at home, actually announced significant improvement (28).

Unfortunately, only one paper (moderate risk of bias) was found to answer the third question of this study to compare the aforementioned exercise methods. In this study (PEDro=7), the researchers directly compared both SE and CE approaches for ten weeks under expert supervision on AIS (10-30°), and although the reduction in CA was observed in both groups, the improvement that occurred by performing SE was more pronounced (SE with a mean decrease in thoracic and lumbar -7.93° and -6.40, respectively, while, CE with a mean decrease in thoracic and lumbar -3.71° and -2.83, respectively) (29). It was possible that if the researchers in this study performed their training

interventions at home for a longer period, the CE group would have achieved better results, which is an issue that requires further investigation in the future. However, very limited evidence was found to suggest that SE was superior to CE (Level 3b). Nevertheless, there are a few pros and cons in how these two approaches are implemented that can help in deciding which one to choose (5, 10, 39, 40).

Firstly, due to the complexity of SE and the need for special equipment and also direct feedback and feed forward activities between the specialist and the patient, it seems necessary to perform this type of exercise in the clinic (5, 10), but CE are much easier to do and are easily possible to continue at home (39). Hence, a few elements including accessible transportation, clinician accessibility, treatment office distance, and essential equipment might restrict SE selections (5, 40). Conversely, if the problems mentioned in the Schroth method are ignored, doing it in the clinic can probably lead to better results than CE in a shorter period of time (29), which due to access to online monitoring networks, these problems can be largely alleviated.

Secondly, given that AIS, especially in early adolescence and at the beginning of treatment, do not have adequate neuromuscular control to perform motor skills for SE, CE can be an easy and appropriate option to activate the musculoskeletal system (27, 41). However, for AIS with high motor skills, (such as athletes or late adolescence), SE may be a better option. Therefore, the above cases provide gaps for further studies in the future.

The current review had several main limitations. First, the lack of access to studies comparing SE and CE (except for the paper by Kocaman et al.) (29). Second, very limited access to RCTs and high-quality studies (26-30, 32-34), which complicates the process of extracting sufficient information to arrive at any firm conclusions. Third, major studies showed significant methodological heterogeneity, so it was not possible to perform a meta-analysis (28-30, 32-34). Fourth, the lack of studies separating the effect of braces and exercise in moderate scoliosis (27, 28, 31), which made it difficult to evaluate the effects of exercise. Fifth, the outcomes of this review are limited to CA. Lastly; this review was limited to English studies.

This is the first review comparing these two practice approaches in helping treat AIS, which remains unclear, especially based on the areas (thoracic, thoracolumbar, etc.) and severity (especially moderate) of deformity, different training courses (short, medium and long term) and the level of physical fitness of the patient (AIS who are athletic, active or sedentary). Accordingly, it is highly recommended to future researchers, in addition to thinking about these suggestions, to pay attention to the limitations of this review and consider them in further research.

Conclusion

Moderate (Level 2b) and limited (Level 3a) evidence with moderate-quality suggests that SE and CE can significantly decrease the CA in AIS, respectively, while very limited (Level 3b) evidence suggests that the SE method is superior to the CE method in reducing the CA in these patients. Therefore, further RCTs and high-quality studies are needed in the future in order to reach a definitive answer.

Journalism Ethical considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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Conflict of Interest

The authors declare that there is no conflict of interest.

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