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# Medical Rehabilitation of Children With Idiopathic Scoliosis: Monotherapy or Combined Therapy. A Systematic Literature Review

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**Abstract**

*Background*. Idiopathic scoliosis is among the most common spinal disorders diagnosed in 1–3% of children and adolescents. Treatment choice is related to disease severity, with a Cobb angle of 20–40°, a corrective brace or physiotherapy can stop its progression. However, insufficient research has shown whether combined treatment is better than monotherapy.

*Aim*. To evaluate the effect of combining bracing and physiotherapy to reduce spinal deformity, improve quality of life and lung function, and compare the results with those of monotherapy. Determine the optimal duration of combined rehabilitation to reduce the angle of deformity.

*Methods*. Relevant articles published from 2014 to 2024 in the databases PubMed, Scopus, Cochrane (CENTRAL), Web of Science, and ScienceDirect were selected based on the PRISMA 2020 guidelines. Paediatric patients (up to 19 years, before skeletal maturity) diagnosed with idiopathic scoliosis (Cobb angle > 10°), undergoing combined bracing and physiotherapy, were studied.

*Results.* Of 2 729 articles, nine were included. The analysis showed a statistically significant change in the combined therapy group: mean difference –2.93 [–4.77; –1.09], $p = 0.04$, $I^2 = 57.33\%$. Long-term treatment effect size was –6.71 [–10.89; –2.53], $p < 0.82$, $I^2 = 0\%$, while short-term treatment showed no statistically significant result. Quality of life improved in the research group, with no significant change in most control group areas. Due to the high risk of bias, lung function changes were not assessed.

*Conclusions*. Combined therapy appears to reduce spinal deformity in children with idiopathic scoliosis and improve health-related quality of life, with better results than monotherapy. Longer treatment may improve Cobb angle correction but evidence is limited.

**Keywords:** scoliosis; adolescent; physical therapy; bracing; systematic literature review

## 1. INTRODUCTION

Idiopathic scoliosis is among the most common spinal disorders in children and adolescents. This pathology is diagnosed in 1–3% of individuals aged 10–19 worldwide (Menger & Sin, 2023). Idiopathic scoliosis is a complex three-dimensional disorder characterised by lateral deviation (Cobb angle > 10°), axial rotation of the vertebral bodies, and a greater-than-normal sagittal curvature of the spine

(Addai et al., 2020). Although scoliosis is a lifelong progressive disease, at low severity or with good rehabilitation, the disease progresses by 0.1° per year. However, when the Cobb angle exceeds 45°, the deformity increases by 1° per month during the growth spurt and by 1° per year after reaching skeletal maturity (~19 years) (Lenz et al., 2021). For the majority of young people, the condition does not cause severe symptoms, however if left untreated it can progress to rib hump, pain, breathing problems, and for some, it can cause frustration with their appearance and emotional distress (Menger & Sin, 2023; Weinstein, 2019).

The gold standard for diagnosing idiopathic scoliosis is anteroposterior and lateral radiographs that are used to measure the Cobb angle (Choudhry et al., 2016). Without it, it is impossible to tell the severity of the scoliosis, and it is difficult to follow the progression of the deformity as the child matures (Jin et al., 2022). An equally important indicator is the Risser score, which describes the growth potential of the spine (Choudhry et al., 2016). In the case of an immature spine, deformity may progress more rapidly, but it is easy to stop the progression with conservative treatment or even to correct the spine back to its original position. After reaching Risser grade 4 (> 75% complete ossification) or even full maturity, it is practically guaranteed that the degree of scoliosis will not change drastically, except in the case of severe scoliosis mentioned earlier (Choudhry et al., 2016; Lenz et al., 2021).

If a minor deviation from the norm is observed, conservative treatment is applied first, and the patient is expected to reach bone maturity, after which the disease will not progress or will progress only slightly (Lee et al., 2022; Lenz et al., 2021). Suppose a Cobb angle of 10–20° is measured (mild scoliosis). In that case, x-rays are repeated every six months, and patients are taught special exercises that they can do at home. For 20–40° deviation (moderate scoliosis), an orthopaedic brace is worn to stop the progression (Ridderbusch et al., 2018), or exercises are carried out to strengthen the back muscles and correct the posture. Over the last decades, various scientifically based physiotherapy methodologies have been widely used to treat scoliosis: Schroth, the Scientific Approach to Exercise for Scoliosis (SEAS), the Side-Shift Programme, and others (Seleviciene et al., 2022). A corrective brace is also indicated, which the child has to wear from 8 to 23 hours a day until the spine has fully matured (Kaelin, 2020). If scoliosis is not managed until an angle of greater than 45° is reached (severe scoliosis), surgical treatment is required (Choudhry et al., 2016).

While existing literature extensively examines the advantages and disadvantages of physiotherapy or bracing for idiopathic scoliosis in children, there remains a notable gap in evidence regarding their combined effects. Previous studies have primarily investigated these individual interventions, leaving uncertainty about whether combining both approaches could yield better clinical outcomes than either treatment alone. This systematic literature review aims to address this gap by determining the effects of the combined use of corrective bracing and physiotherapy for treating adolescents with diagnosed idiopathic scoliosis. Specifically, this study aims to compare the outcomes of the combined treatment approach to bracing or physiotherapy, providing evidence-based insight to guide clinical decision-making.

## 2. METHODS

This systematic literature review has been conducted based on the PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines (Page et al., 2021). An independent researcher performed the database search, the inclusion and exclusion of articles. The search strategy was initiated using the PICOS (P – patient, I – intervention, C – comparison group, O – outcome, S – study type) criteria (Table 1). This approach helped to extract the necessary keywords, define the relevant outcomes to be evaluated, set the objectives, and define the inclusion criteria.

Table 1. **PICOS criteria**

| | |
|---|---|
| **P** | Patients up to 19 years of age with diagnosed idiopathic scoliosis |
| **I** | The brace was combined with one of the physiotherapeutic scoliosis exercises (PSSE) techniques, such as Schroth, SEAS, Side-Shift, or DoboMed |
| **C** | Control group undergoing monotherapy using an orthopaedic brace or PSSE |
| **O** | Change in patient status measured by Cobb angle, quality of life questionnaires, or lung function readings |
| **S** | Randomised controlled trials and cohort studies from 2014 |

**Search strategy.** The eligible articles were published between 2014 and data retrieval in September 2024 in one of five scientific databases: PubMed (MEDLINE), Scopus (Elsevier), Cochrane Central Register of Controlled Trials (CENTRAL), Web of Science (Clarivate Analytics) and ScienceDirect (Elsevier). All combinations tested and the results of the searches between the databases are shown in Table 2. The databases were searched in English using the following keywords or their combinations: *scoliosis*, *AIS*, *exercise*, *physical therapy*, *bracing*, *orthosis*, *child*, *adolescent*. The combinations were created by entering the keywords in the search box with the conjunctions "AND" or "OR". The Boolean operator "OR" used between synonyms to broaden the search to include as many different sources as possible is indicated in Table 2 by a slash "/". The "AND" Boolean operator was used between keywords with different meanings to include all groups in the search, thus narrowing and refining the search results, and is indicated in Table 2 by a plus sign "+". Full search query: (AIS OR scoliosis) AND (exercise OR physical therapy), AND (bracing OR orthosis) AND (child* OR adolescent).

Table 2. **Keywords, their combinations, and database results**

| Keywords | PubMed | Scopus | Cochrane (CENTRAL) | Web of Science | ScienceDirect |
|---|---|---|---|---|---|
| scoliosis | 32 475 | 45 425 | 1 835 | 26 031 | 49 081 |
| AIS | 21 360 | 34 961 | 7 094 | 31 402 | 86 449 |
| exercise | 610 531 | 840 462 | 151 280 | 725 603 | 1 000 000+ |
| physical therapy | 118 147 | 76 541 | 14 567 | 46 540 | 101 093 |
| bracing | 15 272 | 13 317 | 2 416 | 21 806 | 27 612 |
| orthosis | 19 883 | 45 716 | 1 731 | 7 212 | 19 752 |
| adolescent | 2 424 570 | 2 692 475 | 175 726 | 665 411 | 513 120 |
| child* | 3 420 371 | 4 018 596 | 207 653 | 3 284 570 | 1 000 000+ |
| 1 + 3 + 5 + 8 | 161 | 87 | 61 | 55 | 912 |
| (1/2) + (3/4) + (5/6) + (7/8) | 395 | 252 | 118 | 208 | 1 756 |

**Inclusion criteria.** Full-text publications in English, published between 2014 and 2024. Studies conducted worldwide. Articles relevant to the topic of study include school-age children and adolescents (aged 7–19 years) diagnosed with idiopathic scoliosis, and the Cobb angle measured at the start of the study. Randomised and non-randomised clinical trials. Scoliosis rehabilitation using a corrective brace in combination with scoliosis-specific exercises. Specified a clear study type and impact evaluation indicator.

**Exclusion criteria.** Studies using other interventions, such as surgery and non-scoliosis-specific exercises. No control group in the trial (PSSE or corrective brace). Grey literature, single case reports, expert opinions, editorials, conference abstracts, guidelines, systematic reviews, ongoing studies, and clinical trial protocols.

## 3. RESULTS

**Search results.** 2 729 articles were retrieved: 395 from PubMed, 252 from Scopus, 118 from Cochrane Central Register of Controlled Trials, 208 from Web of Science, and 1 756 from ScienceDirect, of which only nine were included in the final review (da Silveira et al., 2022; Fang et al., 2022; Gao et al., 2019; Kwan et al., 2017; Rożek et al., 2016; Stein et al., 2024; Yagci et al., 2024; Yuan et al., 2024; Zapata et al., 2023). To search exhaustively, all articles were manually reviewed and selected in the screening phase, and the relevant articles were included. The overall strategy is detailed in the PRISMA flow diagram (Figure 1).

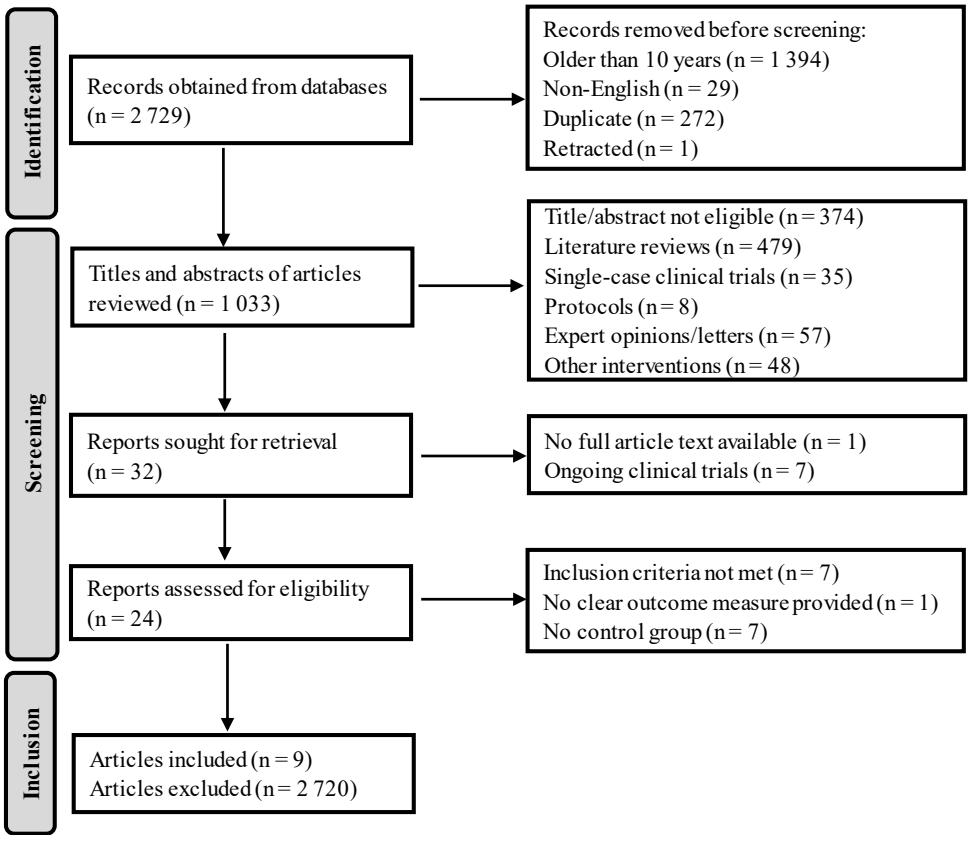


Figure 1. **PRISMA flow diagram**

**Characteristics of the included articles.** The review included each of the three randomised controlled trials, prospective cohort studies, and retrospective cohort studies (see Table 3). The total number of subjects included was 836. The number of participants across the different scientific publications ranges from 36 to 253, with a mean of 92.89 and a median of 49. The total number of patients in the research group (combined bracing and physiotherapy) is 445, with a mean of 49.44 and a median of 28 across studies. The control group (monotherapy using brace or physiotherapy) included 391 subjects, with an average of 43.44 patients per study, median 24. The Cobb angle measured at the beginning of the studies varied between 10 and 72°, from mild to severe scoliosis. Participants' bone maturity was

measured using the Risser scale. Studies reporting this index did not exceed 3 (75% calcification of the iliac bone). In the study group, all subjects received double treatment: corrective bracing and physiotherapeutic exercises for scoliosis. In seven articles, the brace was worn for 18 to 23 hours daily, with time off for exercise and personal hygiene. Individuals in the control group received monotherapy. Two studies in the control group used physiotherapy (Stein et al., 2024; Yagci et al., 2024). The remaining seven publications used a corrective brace worn by the patients at varying intensities.

Table 3. **Characteristics of the included articles**

| Author (year) | Research method | Sample (R/C) | Age | Cobb angle | Risser sign | Intervention | |
|---|---|---|---|---|---|---|---|
| | | | | | | Research group | Control group |
| Gao et al. (2019) | RCT | 45 (23/22) | 10–14 | 22–37° | 0–2 | **SEAS + brace** 40 min/week clinic + 15 min/day at home + brace 23 h/day | **Brace** 23 h/day |
| Kwan et al. (2017) | PCS | 48 (24/24) | 10–14 | 25–40° | 0–1:32 2:11 ≥ 3:5 | **Schroth + brace** 8-week intro + home exercises + bi-monthly training + brace 18 h/day | **Brace** 18 h/day |
| Rozek et al. (2016) | PCS | 49 (28/21) | 7–16 | 25–40° | 0–2 | **PSSE + SpineCor brace** 3-week intro + exercise at home + brace 20 h/day | **SpineCor brace** 20 h/day |
| Yuan et al. (2024) | RCT | 94 (47/47) | 10–17 | 20–45° | N | **PSSE + brace** Intro programme + daily home exercises + 3–20 h/day in 3 weeks | **Brace** 3–20 h/day in 3 weeks |
| Stein et al. (2024) | RCS | 253 (192/61) | 11–19 (mean 12.66) | < 72° | N | **Schroth + brace** Inpatient 6 h/day programme + brace | **Schroth** 6 h/day inpatient |
| Zapata et al. (2023) | PCS | 74 (37/37) | 10–16 | < 35° | 0 | **Schroth + Providence brace** 8 h intro + 15min 5x/week home exercises + night brace | **Providence brace** night only |
| Yagci et al. (2024) | RCS | 36 (17/19) | 10–15 | 10–50° | N | **SEAS + Boston brace** 1x/week to 1 x/2 mos training + 30 min home exercises + brace 18 h | **SEAS** 12 x training + exercise at home 30 min/day |
| da Silveira et al. (2022) | RCT | 45 (23/22) | 10–17 | 30–45° | 2 ± 1.7 | **PSSE + S4D brace** 2x/mos 40 min training + 18–20 h/day brace | **S4D Brace** 24 h/day |
| Fang et al. (2022) | RCS | 192 (54/138) | 10–16 | 20–45° | 0–2 | **Schroth + Cheneau brace** 6-week programme, 3 x/week + 30–45 min home exercises + brace > 20 h/day | **Cheneau brace** > 20 h/day |

**Notes:** RCT – randomised controlled trial; PCS – prospective cohort study; RCS – retrospective cohort study; PSSE – physiotherapeutic scoliosis-specific exercises; N – not stated; R – research group, C – control.

Table 4. **Evaluated parameters and results of included studies**

| Author (year) | Duration | Cobb angle | QoL | Lung function | Results |
|---|---|---|---|---|---|
| Gao et al. (2019) | 6 mos | + | – | FEV1, FVC, FEV1/ FVC | RG had a better Cobb angle correction than CG<br>FEV1 and FVC differed significantly at 6 mos<br>FEV1/FVC was significantly higher in RG at 1 and 6 mos follow-up |
| Kwan et al. (2017) | 18.1 ± 6.2 mos | + | SRS-22 | – | RG: Cobb ↓17%, ↑21% stabilised in 62%<br>CG: Cobb ↓4%, ↑50% stabilised in 46%<br>SRS-22 scores favoured RG (4.76 vs. 4.6) |
| Rozek et al. (2016) | 18 mos | + | – | – | RG (SRS criteria): Cobb ↓25%, ↑35.7% stabilised in 39.3%<br>While CG: ↓14.3%, ↑57.1%, 28.6% stabilised |
| Yuan et al. (2024) | 12 mos | + | SF-36 | – | Cobb angle after treatment is lower in RG<br>After 1 year, RG showed a better QoL improvement in several areas |
| Stein et al. (2024) | 28.2 ± 5.1 days | – | – | IVC, FEV1, FVC, FEV1/ FVC | After the first therapy, IVC ↑2.56%, FVC ↑3.99%, and FEV1 ↑2.36%. No significant difference was found between groups |
| Zapata et al. (2023) | 2.3 ± 0.9 years | + | – | – | After treatment, the Cobb angle was lower in RG<br>RG had > 5° better deformity improvement at 1 year |
| Yagci et al. (2024) | 12 mos | + | – | – | RG: Cobb ↓35.3%, ↑17.6%, 47.1% stabilised<br>CG: Cobb ↓15.8%, ↑31.6%, 52.6% stabilised |
| da Silveira et al. (2022) | CG 24 h<br>6 mos RG | + | – | – | A 12° decrease in Cobb angle is observed in CG and a 5.3° decrease in RG |
| Fang et al. (2022) | 6 years | + | SRS-22, EQ-5D | – | The Cobb angle (3.55°) decreased in RG<br>The SRS-22 score in most areas and EQ-5D were significantly higher in RG |

**Notes:** QoL – quality of life; N – not specified; RG – research group, CG – control group; SRS-22 – Scoliosis Research Society Questionnaire; SF-36 – The 36-Item Short Form Health Survey; EQ-5D – EuroQol 5-Dimension Questionnaire; IVC – inspiratory vital capacity; FVC – forced vital capacity; FEV1 – forced expiratory volume in 1 s; FEV1/FVC – Tiffeneau index.

**Evaluated parameters and results of included studies.** Participant follow-up varied in duration. In the shortest study, patients were admitted to the hospital between two and eight times, with an average treatment period of one month. The longest study lasted for six years and tracked children's outcomes from admission to the end of treatment. Two studies were conducted over six months, two over 12 months, and four over 18 months. The Cobb angle is the central aspect by which patients' degrees of spinal defect were measured before the studies. This evaluative outcome combines as many as eight research articles in the systematic literature review. Three studies assessed adolescents' quality of life, self-esteem, and mental health through life questionnaires (SRS-22, SF-36, and EQ-5D). Two studies

measured FEV1, FVC, FEV1/FVC and assessed patients' lung function before and after rehabilitation. The results described are presented in Table 4.

**Assessment of the risk of bias in articles.** While writing a systematic literature review, it is essential not only to understand the results of each included study, but also to assess whether researchers, subjects and other factors (inadequate data collection, imprecision of methods of assessment, errors of interpretation, environment, etc.) may have distorted the results of the study. Quality assessment reveals gaps in the research, ensures the quality and transparency of the articles, and the objectivity, validity, and reliability of the conclusions presented (De Cassai et al., 2023). Considering the various research methods included, different instruments have been chosen to assess the risk of bias. For randomised controlled trials, the Cochrane tool "A revised tool to assess risk of bias in randomized trials (RoB II)" was used, applying the latest 2019 version available (Sterne et al., 2019). Three randomised trials were included in the systematic literature review (da Silveira et al., 2022; Gao et al., 2019; Yuan et al., 2024), which were analysed in the five risk of bias domains (D1 to D5) (Figure 2). Each domain could be rated at one of three levels of risk: low risk, indicated in green with a "+"; having some concerns, marked in yellow with a "-"; and high risk, indicated in red with an "x" in the traffic light plot.

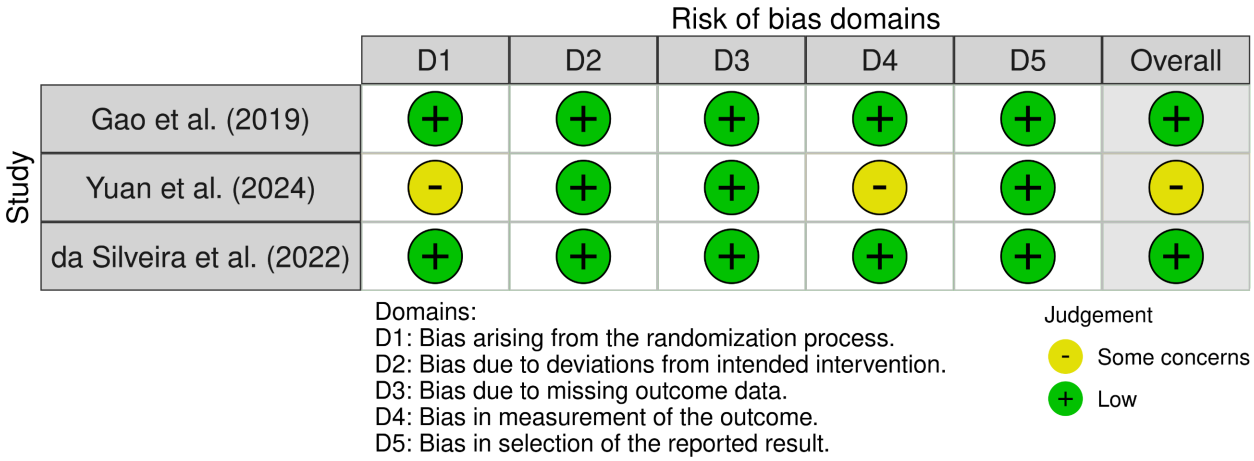


Figure 2. **Traffic light plot of RoB II risk of bias assessment**

None of the randomised controlled trials included in the systematic literature review received a high-risk rating in any area. Two of the three articles were rated at an overall low risk of bias (da Silveira et al., 2022; Gao et al., 2019). However, the remaining one had several problems in a couple of areas. The article mentions the randomisation process but does not describe whether the allocation to groups was done correctly or whether the data was properly hidden from the researchers. For these reasons, it cannot be confidently stated that the data in the publication is impartially calculated and properly reported (Yuan et al., 2024).

For the assessment of non-randomised trials, "A tool for assessing risk of bias in non-randomized studies of interventions Version 2 (ROBINS-I V2)" was adapted, using the most recent version 2, published in 2024 (Sterne & Higgins, 2024). Six non-randomised studies (Fang et al., 2022; Kwan et al., 2017; Rożek et al., 2016; Stein et al., 2024; Yagci et al., 2024; Zapata et al., 2023), were included in the systematic literature review, and were evaluated using the tool to identify the seven domains of risk of bias (D1 to D7) (see Figure 3).

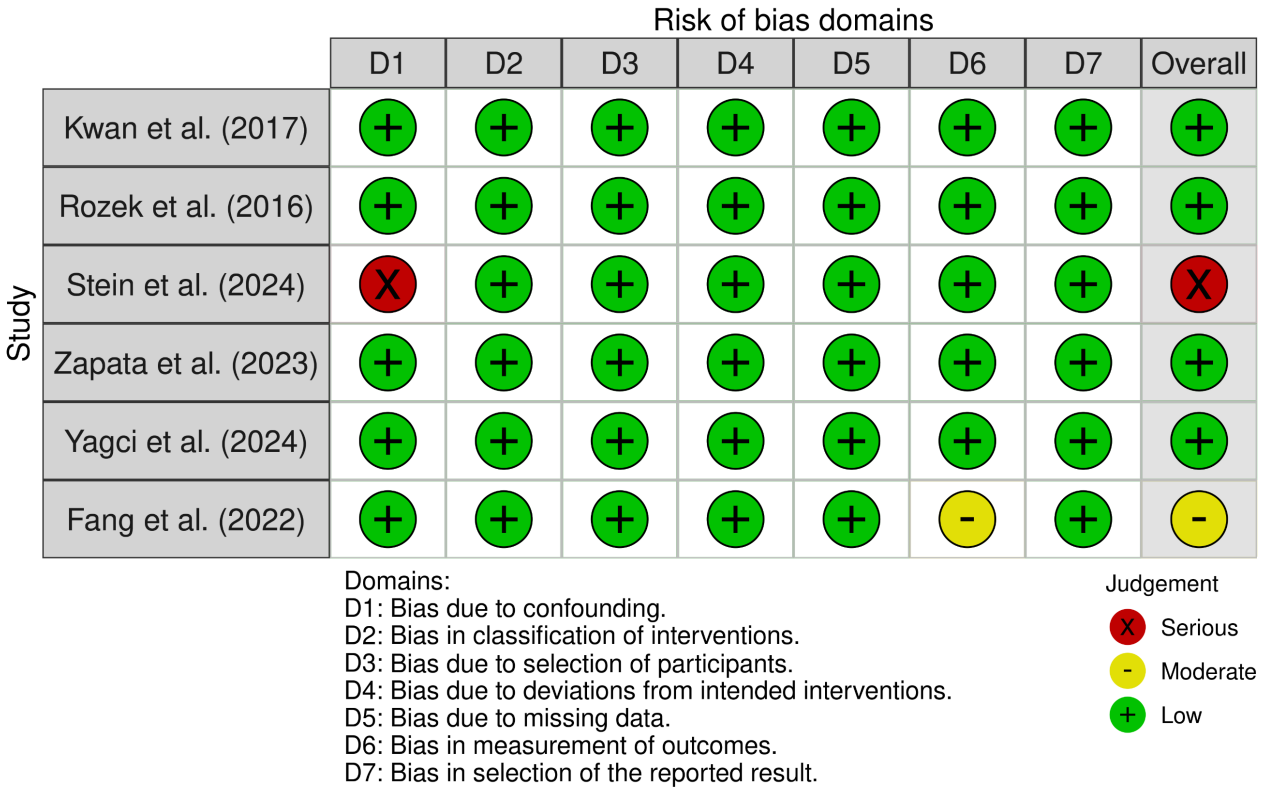


Figure 3. **Traffic light plot of ROBINS-I risk of bias assessment**

The non-randomised studies included in the review did not receive a critical risk of bias rating in any area. Four studies received the overall lowest risk score (Kwan et al., 2017; Rożek et al., 2016; Yagci et al., 2024; Zapata et al., 2023). One study had a high risk of bias in the D1 domain due to confounding, which led to an overall poor rating. As a result, it could not be included in the lung function analysis (Stein et al., 2024). Another retrospective cohort study had problems in the D6 domain. This was because the researchers were not blinded to the results, and not all the outcomes measured are objective, so there is a minimal risk that the results could have been skewed during measurement and evaluation (Fang et al., 2022).

**Summary of issues raised and results.** According to the original aims of the systematic review, the outcomes to be evaluated are: 1. management of scoliosis curvature by assessing the Cobb angle difference, 2. quality of life in children diagnosed with idiopathic scoliosis, and 3. lung function. However, due to the high risk of bias in one of the articles reporting the subjects' lung function, it is impossible to compare studies in this area and generalise the results (Stein et al., 2024). Analysing the included publications, similarities between the presentation of results were sought, and it was found that most authors reported the mean parameters measured before and after the study and their standard deviation (SD). This data made it possible to calculate the change in Cobb angle and quality of life in the experimental and control groups. These two outcomes were further analysed separately.

More in-depth calculations were conducted to assess the management of spinal curvature. The effect size of the scoliosis curvature management (mean difference) and the confidence interval were found, and a forest plot was drawn from this data (Figure 4). Only the results measured before and after the studies are included in the comparison; no intermediate measurements are compared. However, due to the variability in data presentation, two papers could not be included in the summary of spinal curvature management (Kwan et al., 2017; Yuan et al., 2024). One of the reasons is that the change in spinal

curvature is expressed only as a percentage, and the results are divided into three groups: improved, remained stable, and worsened (Kwan et al., 2017). Another article accurately reports only the mean Cobb angle measured in the research group after the study, while other measured data are presented in different graphs (Yuan et al., 2024). For this reason, attempting to calculate the indicators mentioned above would be nearly impossible, skew the results, and could not be compared with other articles using a forest plot graph. Descriptive statistics were used to assess the quality of life of children with idiopathic scoliosis. This method was chosen due to the different questionnaires used in the studies to evaluate this outcome and the abstractness and heterogeneity of the data presented. All three publications on health-related quality of life are included in the summary (Fang et al., 2022; Kwan et al., 2017; Yuan et al., 2024).

**Management of scoliosis.** Heterogeneity of the analyses was assessed using the $I^2$ statistic presented by Higgins, with a value of 50%, ≤ 75% indicating significant heterogeneity between studies (Figure 4). A p-value < 0.01 suggests that the estimated heterogeneity is statistically significant. Statistical heterogeneity indicates the percentage of differences between studies that are due to true heterogeneity and not just chance (Melsen et al., 2014).

Analysing the overall result, we see a decrease in the Cobb angle. Calculating effect sizes, only one paper (da Silveira et al., 2022) found a larger effect in the brace-wearing group compared with combined rehabilitation. This study also stands out because they measured the results immediately after 24 h in the control group and after six months of rehabilitation in the treatment group, which is likely to make the results differ from the other included studies (da Silveira et al., 2022). Other studies have found a better outcome for combined rehabilitation. The only study (highlighted in green in Figure 4) in this comparison used the SEAS approach for monotherapy rather than bracing (Yagci et al., 2024). Evaluating the results without this study, when only the brace was used in the control group, we obtain similar overall results (mean difference: –2.45, [–5.97; 1.07], p < 0.01, $I^2$ = 74.37%).

| Research | Research group | | | Control group | | | Effect size [95% CI] |
|---|---|---|---|---|---|---|---|
| | Sample | Mean | SD | Sample | Mean | SD | |
| Gao et al. (2019) | 23 | –4.87 | 4.74 | 22 | –2.05 | 5.30 | –2.82 [–5.76; 0.12] |
| Rozek et al. (2016) | 28 | 2.30 | 16.30 | 21 | 8.80 | 18.66 | –6.5 [–16.51; 3.51] |
| Zapata et al. (2023) | 37 | 1.00 | 11.71 | 37 | 9.00 | 14.56 | –8 [–14.02; –1.98] |
| Yagci et al. (2024) | 17 | –2.40 | 12.68 | 19 | 2.60 | 8.54 | –5 [–12.15; 2.15] |
| da Silveira et al. (2022) | 23 | –5.20 | 10.12 | 22 | –12.00 | 8.68 | 6.8 [1.30; 12.30] |
| Fang et al. (2022) | 54 | –3.55 | 3.72 | 138 | –0.16 | 6.12 | –3.39 [–4.81; –1.97] |

**Total ($I^2$ = 68.53%, p < 0.01)**

**Effect size [95% CI]: –2.75 [–5.88; 0.38]**

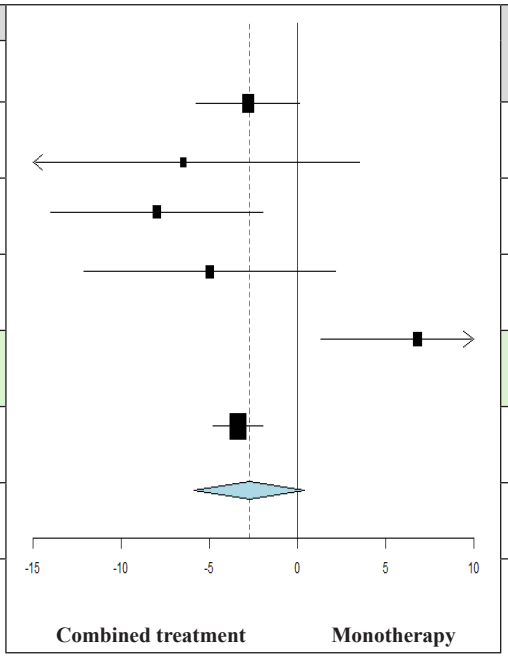


Figure 4. **Forest plot of mean Cobb angle difference between groups**

The mean differences between the treatment and control groups were calculated separately. In the combined rehabilitation group, the mean difference and confidence interval were –2.93 [–4.77; –1.09],

$p = 0.04$, $I^2 = 57.33\%$, and in the monotherapy group, the mean difference was 0.41 [–3.82; 4.64], $p < 0.01$, $I^2 = 92.23\%$. It can be noted that the experimental group showed a statistically significant decrease in the mean Cobb angle, while the control group showed a slight increase. In the research group, the confidence interval falls entirely on the negative side, which further ensures the effectiveness of the treatment. The confidence interval in the control group spans negative and positive values, and the estimated heterogeneity is very high. Such results for monotherapy are not sufficiently reliable to conclude on the effectiveness of this treatment.

In addition, a comparison was made between short-term treatment and long-term treatment. Three studies were included in each of these categories. In the short-term treatment category, patients were treated for up to six months, and the effect size between the experimental and control groups was –0.67 [–4.93; 3.59], $p < 0.01$, $I^2 = 83.81\%$ (da Silveira et al., 2022; Fang et al., 2022; Gao et al., 2019). In the long-term treatment category, patients were treated for one year or more, with a calculated cross-group effect size of –6.71 [–10.89; –2.53], $p < 0.82$, $I^2 = 0\%$ (Rożek et al., 2016; Yagci et al., 2024; Zapata et al., 2023). Both categories show an advantage of combined treatment. For treatment over a year, the confidence interval is negative, and the $I^2$ statistic indicates the homogeneity of studies. For rehabilitation of less than six months, the confidence interval ranges between the negative and the positive side of the effect scale, and the estimated heterogeneity is very high. These results show clinically significant Cobb correction and more reliable results in the long-term treatment group. Therefore, treatment beyond one year, with initial outpatient rehabilitation followed by independent continuation of the exercises and bracing, is superior.

The calculation of the secondary outcomes and separate mean difference for the control group resulted in a high heterogeneity of > 75%. Due to the small number of study groups (three each in the short- and long-term treatment categories and six in the separate control group calculation), this may have been distorted. Therefore, the Higgins $I^2$ estimate should be interpreted cautiously in this analysis, and confidence intervals should be relied on more (Von Hippel, 2015).

**Quality of life in children with idiopathic scoliosis.** In the included publications, adolescents' health-related quality of life was measured by three different questionnaires: the Scoliosis Research Society Quality of Life Questionnaire (SRS-22), the 36-item Short-Form Health Survey (SF-36), and the European Quality of Life 5-Dimensions Questionnaire (EQ-5D). The maximum number of scores varies. For example, the SRS-22 Questionnaire gives five points in each domain, the SF-36 Questionnaire gives 100 points in each domain, and the EQ-5D has an overall maximum score of one (Wong et al., 2017). To highlight the differences between groups, the cell indicating a higher difference is highlighted in green and the lower one in pink (Table 5). Cells where authors stated they did not obtain a statistically significant change ($p > 0.05$) are marked in grey. Areas not covered by a particular questionnaire are in white.

Table 5. **Quality of life scores and mean differences before and after studies**

| **Research** | | **Kwan et al. (2017)** | **Yuan et al. (2024)** | **Fang et al. (2022)** |
|---|---|---|---|---|
| **Questionnaire used** | | SRS-22 | SF-36 | SRS-22 and EQ-5D |
| **Research group** | Pain | No stat. change | ~20 ± 2 | 0.02 ± 0.08 (no stat. change) |
| | Function | 0.16 ± 0.23 | No data available | 0.17 ± 0.1 |
| | Physical role | No data available | ~23 ± 3 | No data available |
| | Self-assessment | No stat. change | No data available | 0.33 ± 0.18 |
| | Mental health | No stat. change | ~23 ± 2 | 0.27 ± 0.13 |
| | General health | No data available | ~27 ± 3 | No data available |
| | Overall result | 0.21 ± 0.2 | No data available | 0.03 ± 0.02 (EQ-5D) |

| Research | | Kwan et al. (2017) | Yuan et al. (2024) | Fang et al. (2022) |
|---|---|---|---|---|
| Questionnaire used | | SRS-22 | SF-36 | SRS-22 and EQ-5D |
| Control group | Pain | No stat. change | ~12 ± 3 | –0.09 ± 0.05 |
| | Function | No stat. change | No data available | 0.03 ± 0.07 (no stat. change) |
| | Physical role | No data available | ~11 ± 3 | No data available |
| | Self-assessment | No stat. change | No data available | 0.08 ± 0.11 |
| | Mental health | No stat. change | ~13 ± 3 | 0.04 ± 0.09 (no stat. change) |
| | General health | No data available | ~17 ± 3 | No data available |
| | Overall result | No stat. change | No data available | 0.01 ± 0.01 (EQ-5D) (no stat. change) |

The mean differences reported in all the studies and the authors' conclusions show that the questionnaires showed more significant changes in the research group than the control group. In two studies, the experimental group showed greater function, mental health, and overall outcome change. Physical role, self-assessment, and general health had one better result each. In the control group, more than 50% of the cells showed no statistically significant change. Five domains (pain, physical role, self-assessment, mental health, and general health) showed one improvement in this group. However, the results were still not superior to experimental group. In the area of pain, one of the studies reported a worsening of the children's condition, indicated by a darker pink colour (Fang et al., 2022).

## 4. DISCUSSION

The main objective of this systematic literature review was to assess the effectiveness of combined treatment to reduce spinal curvature, disease progression, quality of life, and lung function in children with idiopathic scoliosis, by collecting the most recent articles published in the last 10 years from scientific databases. The analysis results confirm the superiority of a corrective brace combined with scoliosis-specific exercises for correcting the Cobb angle, particularly in moderate cases (20–40°). When the results are analysed separately, the combined treatment showed several times better improvement and statistically more reliable results (2.93 [–4.77; –1.09], $p = 0.04$, $I^2 = 57.33\%$ vs 0.41 [–3.82; 4.64], $p < 0.01$, $I^2 = 92.23\%$). While results show a statistically significant change in the mean Cobb angle of ~3°, true clinical significance is generally considered when the Cobb angle improves by more than 5°. However, smaller changes may also have some clinical relevance in slowing progression, delaying surgical thresholds, or, in specific cases, be part of a long-term stabilisation strategy. Secondary analysis also suggested that rehabilitation should be continued for more than 12 months, with outpatient treatment and repeated rehabilitation cycles, while ensuring patients can independently continue exercises and bracing in between. Long-term treatment showed statistical and clinical change (mean difference –6.71) and was more effective in correcting the Cobb angle. When assessing the quality of life of children with idiopathic scoliosis, the questionnaires showed a greater change in the research group. In contrast, the control group showed no statistically significant change in most areas.

However, the topic is novel, and very little research has been conducted. Only nine out of 2 729 papers were included in this study. This low number of articles caused difficulties in the analysis, limited generalisability and robustness of the findings. One of the two studies assessing lung function could not be included due to a high risk of bias; therefore, not all initial outcomes were assessed (Stein et al., 2024). The remaining study on lung function reported significantly better FEV1/FVC results in the research group, while FEV1 and FVC results improved in both groups after six months (Gao et al., 2019).

However, with so little data, no conclusions can be drawn, and more research should be done to investigate this evaluative outcome. Furthermore, the reliability of the $I^2$ statistic is limited when the number of studies is low, as its precision decreases with a small sample size. Higgins' $I^2$ index is very popular in the evaluation of meta-analyses in the Cochrane Library, but in this case, its assessment becomes too challenging, so it is recommended to supplement the $I^2$ with additional measures, such as confidence intervals, or visual inspection of forest plots, to ensure a more robust evaluation of heterogeneity (Von Hippel, 2015). There was also a problem of variability in the presentation of the results, which prevented two studies (Kwan et al., 2017; Yuan et al., 2024) from being included in the analysis of scoliosis curvature management and quality of life, being assessed using a descriptive approach.

Previous systematic literature reviews have focused on rehabilitation with either monotherapy (bracing or scoliosis-specific exercises) or a combination of PSSE and other exercises. For instance, while bracing has an advantage in stopping spinal deformity progression, it fails to improve patients' quality of life, highlighting a critical therapeutic gap (Negrini et al., 2015). Similarly, analyses evaluating the impact of scoliosis-specific exercises found only low-quality evidence for Cobb angle correction, suggesting its limitations as a standalone intervention (Fan et al., 2020; Thompson et al., 2019). In contrast, emerging evidence suggests that combining non-scoliosis-specific exercises improves Cobb angle, lung function, and health-related quality of life (Ramadhani et al., 2023). However, this finding is not generally confirmed. For example, another meta-analysis assessing the effect of the Schroth methodology and core exercises calculated average Cobb angle reduction in both groups (–0.38 mean difference) compared to Schroth and core exercises (–0.42 vs. –0.35). They estimated that quality of life improved by an average of 1.01 in the Schroth group (Dimitrijević et al., 2022). To summarise these results, corrective bracing may stop the progression of deformity, but it does not improve the patients' quality of life. In contrast, PSSE, combined with other exercises or alone, could improve both. The results of previous reviews partially align with this systematic literature review and offer a more comprehensive perspective by highlighting the potential synergistic effects of combined therapy. Combined treatment results in significantly better correction of the Cobb angle and improved health-related quality of life. Hopefully, this scientific publication will show the potential of combined therapy, emphasise a gap in the literature, and lay the foundations for new randomised controlled and cohort trials.

## 5. CONCLUSIONS AND PERSPECTIVES

According to the data analysed, combined treatment of scoliosis with a brace and physiotherapy appears to reduce the angle of spinal deformity in children with moderate idiopathic scoliosis (Cobb angle 20–40°) and may positively affect the quality of life associated with the disease.

Comparison of the research data suggests that combination therapy could be more effective at managing scoliosis and improving quality of life than monotherapy (corrective bracing or scoliosis-specific physiotherapy alone).

Rehabilitation of idiopathic scoliosis for more than one year, starting as an outpatient and then continuing independently with exercises and bracing, showed clinically significantly better correction of the Cobb angle than treatment for up to six months, suggesting long-term treatment may be superior, but the evidence is limited.

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# Vaikų medicininė reabilitacija esant idiopatinei skoliozei: monoterapija ar kombinuotas gydymas. Sisteminė literatūros apžvalga

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**Santrauka**

*Tyrimo pagrindimas*. Idiopatinė skoliozė yra vienas iš dažniausių stuburo pažeidimų, nustatomas 1–3 proc. vaikų. Gydymo pasirinkimas susijęs su ligos sunkumu. Cobb'o kampui esant 20–40°, deformaciją galima stabdyti korekciniu įtvaru arba kineziterapija. Tačiau dar trūksta tyrimų, įrodančių, kad kombinuotas gydymas pranašesnis nei monoterapija.

*Tikslas*. Nustatyti gydymo įtvaru kartu su kineziterapija poveikį, siekiant sumažinti stuburo deformacijos kampą, pagerinti gyvenimo kokybę, plaučių funkciją bei palyginti gautus rezultatus su monoterapijos rezultatais. Išsiaiškinti optimalų kombinuotos reabilitacijos laikotarpį, siekiant sumažinti deformacijos kampą.

*Metodai*. Atsižvelgiant į 2020 m. PRISMA rengimo gaires, atrinktos mokslinės publikacijos, atitinkančios nagrinėjamą temą. Analizuoti „PubMed", „Scopus", „Cochrane (CENTRAL)", „Web of Science" bei „ScienceDirect" duomenų bazėse 2014–2024 metais publikuoti straipsniai. Tiriamieji – vaikai ir paaugliai (iki 19 metų, nepasiekę kaulinės brandos), kuriems diagnozuota idiopatinė skoliozė (Cobb'o kampas daugiau nei 10°), reabilitacijai naudotas įtvaras kartu su kineziterapija.

*Rezultatai.* Iš rastų 2 729-ių straipsnių, į apžvalgą įtraukti devyni. Atlikus analizę gautas statistiškai reikšmingas pokytis kombinuotos terapijos grupėje: vidutinis skirtumas –2,93 [–4,77; –1,09], $p = 0,04$, $I^2 = 57,33$ proc. Ilgalaikio gydymo kategorijoje poveikio dydis –6,71 [–10,89; –2,53], $p < 0,82$, $I^2 = 0$ proc., o trumpalaikis gydymas nedavė statistiškai reikšmingo rezultato. Vertinant gyvenimo kokybę, būklė pagerėjo tiriamojoje grupėje, o kontrolinėje grupėje daugumoje sričių nenustatyta statistiškai reikšmingo pokyčio. Dėl didelės šališkumo rizikos, nebuvo įvertintas plaučių funkcijos pokytis.

*Išvados*. Kombinuota terapija gali padėti sumažinti vaikų su idiopatine skolioze stuburo deformaciją bei daryti teigiamą poveikį su liga susijusiai gyvenimo kokybei. Gauti rezultatai buvo statistiškai reikšmingai geresni nei monoterapijos. Ilgalaikis gydymas gali pagerinti Cobb'o kampo korekciją, tačiau įrodymų nepakanka.

**Reikšminiai žodžiai:** skoliozė; vaikai; kineziterapija; įtvaras; sisteminė literatūros apžvalga

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