

Chiropractic Treatments and Scoliosis-specific Exercise Therapy as An Alternative to Bracing for Adolescent Idiopathic Scoliosis: A Narrative Review

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ABSTRACT

This narrative review aimed to investigate the efficacy of chiropractic treatments and scoliosis-specific exercise (SSE) for adolescent idiopathic scoliosis (AIS) as an alternative treatment for bracing. We searched the PubMed, Index to Chiropractic Literature, Spine Journal, BioMed Central, Google Scholar, and Research Gate databases to identify the most current reviews (2018-2021). A total of 156 papers were identified, of which six were finally included in the analysis, after excluding 150 that were either duplicate studies or failed to meet the inclusion criteria. However, one paper was included despite failure to meet the inclusion criteria because we believed the findings were significant, and hence, it was worth reviewing. All the reviewed papers reported the benefits of exercise and chiropractic as part of AIS management. Only one study showed that SSE alone slows curve progression, whereas the other six papers (four papers investigating chiropractic intervention alone and two investigating SSE alone) showed significant curve reduction after analyzing the X-ray findings. The other outcomes included increased flexibility, greater trunk rotation angle, and improved quality of life. The quality of the evidence in these studies ranged from very low to moderate. Despite the lack of high-quality research, the evidence reviewed illustrates the benefits of chiropractic treatments and Schroth therapy for AIS patients. The findings also suggest that SSEs and chiropractic manipulations can be used either alone or in combination as an alternative to bracing.

Keywords: adolescent idiopathic scoliosis, chiropractic scoliosis treatment, scoliosis, scoliosis-specific exercise

INTRODUCTION

Scoliosis is a three-dimensional structural deformity with a Cobb angle (lateral curvature) $> 10^\circ$ in the coronal plane. Its development and progression are often related to growth and are accelerated during growth spurts. Scoliosis may be either structural or functional. Structural scoliosis includes anatomical changes in the spine that persist in all positions. In contrast, functional scoliosis is not an actual spinal deformity but an attempt to maintain an upright stance in response to disorders elsewhere in the body, such as unequal leg length. Therefore, treatment will be directed according to the primary abnormality, thus reducing the Cobb angle [1].

Among the different types of scoliosis, adolescent idiopathic scoliosis (AIS) is the most common, with an overall prevalence of 5.2% in the population [2]. AIS, characterized by lateral deviation, axial rotation, and abnormal sagittal curvature of the spine, is the most common spinal deformity [2]. Based on the Cobb angle, the current SOSORT (International Scientific Society on Scoliosis Orthopedic and Rehabilitation Treatment) guidelines recommend practitioners to watch and wait ($< 25^\circ$), bracing with or without exercises ($25-40^\circ$), and surgical intervention ($> 40^\circ$) [3]. Risser sign (skeletal maturity), trunk deviation, quality of life, and prediction of curve progression by measuring the infra-apex segment are standard measures used to determine the therapeutic outcomes in AIS patients. Recently, multiple studies have shown the inefficiency of bracing as a corrective measure. Schreiber et al. conducted a randomized controlled study and concluded that adding specific exercises was superior to bracing alone in improving Cobb angles and trunk rotation [4]. In addition, a cohort study conducted by Byun and Hann [5] demonstrated that chiropractic techniques effectively reduce the spinal curvature in AIS patients within as little as four weeks, thus reinforcing the efficiency of these techniques. Current evidence shows that the risk of progression at the beginning of puberty is 20% in 10° scoliosis, 60% in 20° scoliosis, and as much as 90% in 30° scoliosis [3]. Thus, it is vital to treat scoliosis in the early stages of puberty before skeletal maturity. AIS typically develops between 10–18 years of age, and a genetic link is suggested, although studies have yet to confirm this definitively. According to research conducted by the Journal of Pediatric Orthopaedics [6], the female-to-male ratio ranges from 1.5:1 to 3:1 and increases substantially with age. In particular, the prevalence of curves with higher Cobb angles was substantially higher in girls than in boys. The female to male ratio rises from 1.4:1 for 10° - 20° curves to 7.2:1 for $> 40^\circ$ curves. Moreover, the total number of scoliosis cases in the United States is estimated to be greater than 4 million. Each year, 442,900 GP visits, 133,300 hospital visits, and 17,500 emergency room visits are made by children with scoliosis. In addition, spinal deformities in children and adolescents account for 48% of all musculoskeletal deformity healthcare visits over 857,280 every year [6,7]. The impact of scoliosis on the overall health-related quality of life can be severe compared to other medical conditions.

At present, there are no published articles that review the literature on chiropractic and Schroth therapy as an alternative to bracing for AIS. This study reviews the available literature to explore the possibilities and potential of chiropractic manipulation and scoliosis-specific exercises (SSEs) in AIS patients.

METHODS

A systematic approach was adopted for the collection and appraisal of the data. Critical appraisal skills program, appraisal notes, and checklists [8] were used for RCTs, cohort, and

case-controlled studies, with CEBMa for case reports, SIGN for clinical trials, and HNLBI for observational case series. These tools are good for evaluating each study's bias, validity, and generalizability. The quality of the body of evidence was assigned as high, moderate, or low, based on the adaptation Cochrane recommendation and CASP analysis. Randomized controlled studies were considered high-quality evidence, whereas observational studies were low-quality studies due to the study design's limitations.

In addition, only papers published in English with free full text and evaluating chiropractic manipulation, and SSE (Schroth), as the primary treatment or combined treatment were reviewed. The participants in the included studies were adolescents (10-19 years old). Papers investigating only the effectiveness of bracing for AIS or examining other manipulation therapies and research without a clear goal or conclusion were excluded.

Papers published between 2017 and 2021, after the narrative review by Mark W. Morningstar in 2017, were included to keep the information as updated as possible and reinforce the efficiency of chiropractic scoliosis treatment.

A search on PubMed, Index to Chiropractic Literature, Spine Journal, BioMed Central, Google Scholar, and Research gate was also performed using the keywords 'Schroth therapy and adolescent idiopathic scoliosis', 'chiropractic and adolescent idiopathic scoliosis,' scoliosis-specific exercise, and adolescent idiopathic scoliosis. The literature search included systematic reviews, cohort studies, case reports, retrospective chart reviews, and randomized controlled trials (RCTs). Only English literature with full text available was used.

This review aimed to investigate the efficacy of chiropractic treatments and Schroth therapy as an alternative to bracing for AIS. Despite the relatively limited number of studies, the current review provides insight into "therapy and AIS," "chiropractic and AIS," and "SSE and AIS."

RESULTS

The literature search yielded 156 papers. After reviewing the titles and abstracts, six papers were finally included in the analysis, after excluding 149 that did not meet the inclusion criteria. One additional paper (by Liu et al.) that fell outside the inclusion criteria (the subjects were < 10 to 15 years of age) was included in the analysis because it was considered significant and worth discussing [11]. This cohort study by Liu et al. [11] showed the effectiveness of specific exercises in controlling or improving curve progression. The authors also concluded that younger patients with low-risk grades were most likely to respond.

Of the six papers, two demonstrated the effectiveness of SSE (Schroth, SEAS) in reducing curve progression and improving quality of life. The other four studies demonstrated the effectiveness of chiropractic manipulation alone and in combination with exercise. All reviewed papers [9] were critically appraised and compiled into a general evidence table (Table 1). Separate charts analyzing the possibilities of chiropractic and SSE for improving/stabilizing curve progression are included in Appendix (1-7).

DISCUSSION

Negrini et al. [5] conducted a clinical trial to investigate whether SEAS reduced the need for bracing in patients with AIS. The results are promising and show that the SEAS group had the

least curve progression by the end of the study compared to the usual physiotherapy and control groups. Propensity scores were used to reduce the potential effects of confounders related to the observational design. However, although the study had a sound methodology, it could not avoid patient compliance and dropout issues. The dropout rate in the SEAS group (16%) was high, which the authors reckon was due to the lack of endurance to undergo the whole program.

In 2020, Malaj et al. [10] and Liu et al. [11] conducted two prospective cohort studies to examine the effects of exercise therapy on idiopathic scoliosis. Interestingly, Liu et al. [11] included patients aged < 10 to 15 years and thus, did not meet the inclusion criteria. However, the study was included because it used an intensive corrective exercise and daily corrective postures called the Xinmiao treatment system (XTS) instead of the commonly used Schroth or SEAS. The study also compared the correction efficacies among different age groups and concluded that younger patients with a lower Risser grade are most likely to respond better. This study had a clear methodology to evaluate curve improvement (%), stability, and progression. The inclusion criteria for the study were new AIS diagnosis, Cobb angle 10-25°, and Risser grade 0-3. According to age, the participants were divided into three groups (< 10, 10-12, and 13-15). Realizing the difficulties in recording compliance rates, the authors applied strict standards for patient recruitment. The patients were also closely monitored through phone and regular outpatient clinic visits. The assessor also ensured that parents were carefully asked about home exercises. Measurements were performed twice by the same physicians, unaware of the study being conducted. These measures significantly increase the reliability and validity of the study. Despite all the strict standards, the study was limited by the small sample size and recruitment at a single clinic, which might have biased the findings.

Malaj et al. [10] conducted another study with a similar methodology and aimed to quantify the effects of combining Schroth and Pilates exercises on the Cobb angle, angle of trunk rotation, chest expansion, flexibility, and quality of life in AIS patients. This is comparatively an all-rounded study, focusing on various aspects of AIS and not just curve progression. Sixty-nine patients were recruited at one outpatient clinic with strict inclusion criteria (10-17 years, Cobb angle 10-45°). The results were promising, with an overall improvement in all parameters evaluated. This study demonstrated that Schroth and other exercises are beneficial to patients with mild and moderate curves, although the Schroth exercises were initially developed for patients with severe scoliosis. Current evidence indicates that the risk of progression at the beginning of puberty is 20% in cases with 10° scoliosis, 60% in those with 20° scoliosis and as much as 90% in 30° scoliosis patients [5] due to the involvement of more cartilaginous components, secondary ossification centers, and relative laxity of ligaments and joints. As a result, the patient will be more responsive to manipulation therapy [12].

Moreover, the study by Malaj et al. [10] also shows that exercise has positive effects on other variables, such as chest expansion, vital capacity, flexibility, and quality of life. Although there is insufficient evidence supporting the reliability and validity of these variables as outcome measures in patients with scoliosis, multiple studies [13, 14, 15] have shown that they generally positively impact self-image, function, and overall quality of life. Besides physical health, it is critical to care about the patient's psychological health. Although Malaj et al. [10] achieved good outcomes, the study was not controlled and lacked long follow-up periods. Moreover, the Risser

grade should have been considered to gain insight into the patient's skeletal maturity, thereby reducing the study's validity.

Overall, the evidence favors SSEs such as Schroth, SEAS, and Xinmiao. No papers with negative results were returned or deemed a failure by the authors.

Dreihuis et al. [16] conducted a systematic review of 26 studies evaluating the benefits and harms of specific spinal manual therapy (SMT) techniques in infants, children, and adolescents. Their review provided a unique overview of the effectiveness of specific SMT techniques according to treatment indication and age group. Among the papers reviewed, five case reports concluded that high-velocity, low-amplitude manipulations may cause severe harm to infants and children. However, the authors could not draw any conclusions given the low reliability and validity of the included studies due to the poor quality of evidence. The outcome measures in some studies were not commonly used and were poorly described.

In 2020, Dan et al. [17] conducted another systematic review of the effectiveness of SSEs to alleviate AIS and redress the drawbacks of the Dreihuis et al. study [16]. Based on the PEDro scale, the average score for ten articles was 6.9/10. Eight of the ten studies provided level 2 evidence, while the remaining two with a prospective cohort study methodology provided level 3 evidence.

In a case study, Chu and Huang [18] investigated the effects of chiropractic treatment on symptoms and Cobb angles in patients with AIS. After six months of treatment, at the 9-month follow-up, the authors reported a 6° reduction in the thoracic curve (26° to 20°) and a 7° reduction in the lumbar curve (23° to 16°). The patient also reported alleviated soreness, improved mobility, and a better self-image. However, despite the promising results, this study is the least reliable because of the nature of the case report. While there were no mobility measurements, such as trunk rotation and flexion, the soreness was evaluated entirely based on the patient's perception. Moreover, the authors did not consider the placebo effect. These limitations reduce the validity of the study. Quantifying shoulder balance is a good outcome measure for trunk asymmetry and should be used in future studies.

After identifying the limitations of their previous study [18], Chu et al. conducted another retrospective chart review to assess changes in radiographic parameters following chiropractic treatment in ten patients with AIS [12]. This study had a more detailed methodology, assessing not just the Cobb angle but also the low-end vertebrae tilt, trunk shift, apical vertebrae translation and rotation, and the Risser grade. The study found that chiropractic treatment resulted in an average of 21.2% correction, 64% improvement in spinal morphology, and 36% curve stabilization. Another retrospective review evaluated six teenagers with AIS who received chiropractic care between 2020 and 2021 [19]. After 6-9 months of manual therapy, an average Cobb angle correction of 59 % was achieved. In addition, they also identified the lumbosacral transitional vertebrae as a factor contributing to scoliosis [20]. Changes in pelvic incidence and scoliosis were associated with sacroiliac joint dysfunction [21], and quality of life was improved when severe scoliosis was treated [22]. Other case reports on managing different symptoms showed significant scoliosis correction [23, 24, 25]. Despite the limitations of the studies, such as small sample sizes and no placebo treatment groups, they all indicated an association between chiropractic manipulations and morphologic changes in scoliotic

curvatures. To minimize bias, studies should assess more than one outcome and compare inter-observer Cobb angle measurements, although these measures might threaten the validity of the results and lead to a non-solid conclusion. Retrospective studies should be avoided if a prospective approach is available since, in the former, researchers cannot control exposure or outcome assessment and have to rely on others for accurate recordkeeping [21].

Meneke et al. [27] re-evaluated a previous study conducted in 2001. This is the most reliable study among all the reviewed articles with the most detailed research. The data were re-assessed with more appropriate scientific tools such as Bayesian analysis and R statistical software to compute logistic regression, and natural logarithms were used to measure the likelihood ratio. These analyses were performed to measure three vectors: magnitude and direction of change, level of clinically significant change (minimum acceptable clinical change), and changes in clinical outcome. Confounding factors such as placebo effects, radiographic positioning, and normal variance in postural differences have also been considered, assuming a true residual error. The authors concluded there was a 50/50 chance of curve progression. Additionally, the odds of improving the patient's scoliosis are much higher (18:7 to 14:1) if diversified or Gonstead care is provided.

Morningstar did a narrative review where only one paper demonstrated successful outcomes of Cobb angle reduction at the end of the intervention in 2017. In a case-controlled series, Morningstar and Oslin evaluated the efficacy of chiropractic rehabilitation in combination with nighttime bracing for AIS. Eighteen participants were recruited using strict inclusion criteria: (1) history of AIS, (2) initiated and completed the program at a medical clinic, (3) prescribed and incorporated home exercises, (4) compliance with nighttime bracing, and (5) completed at least one follow-up visit at the end of the growth period. The results were compared with the findings of a previous study that included a similar group of patients who participated in the same chiropractic rehabilitation program without a brace prescription (control group). With 81% of participants achieving a curve correction of 6 °or more, the authors concluded that compared to bracing alone, children who met the SOSORT criteria of bracing in combination with chiropractic treatment achieved improved results.

This review has several limitations. First is the lack of high-quality studies, making it difficult to draw solid conclusions from the included studies. Out of the seven reviewed papers, only two had a controlled group and decent sample sizes ($n < 50$). Small sample size is likely to mask variations and build-up of systematic errors. None of the studies had baseline measurements of the outcomes, and, thus, were unable to show an improvement or change following the interventions effectively. Future studies should have baseline measurements for all exposures and potentially confounding factors, such as bone age and the Risser scale.

Despite the positive results of these studies, there is a risk of bias, as many of these studies were conducted by those with interest in favorable outcomes. The exposure and outcome measures should be double-blinded, and a controlled group should always be established.

IMPLICATION OF FUTURE STUDY

First, it is important to apply the inclusion and exclusion criteria defined by PICOTS to reduce selection bias and ambiguity. Second, a dual review can ensure that the inclusion and exclusion

criteria are applied consistently, thus avoiding systematic errors. Third, future reviews should focus on studies with high-level evidence, such as RCTs.

CONCLUSION

There is limited but evolving clinical evidence showing that chiropractic treatment and Schroth therapy are efficient alternative treatments to bracing for AIS patients. From the papers reviewed, it is clear that any two of the above methods, alone or combined, yield positive effects (curve reduction or stabilization) in these patients. Nevertheless, high-quality research is still needed to confirm and validate the effectiveness of chiropractic manipulations and SSEs in patients with AIS. Future research should also focus on other aspects of AIS, such as quality of life improvement, trunk flexibility, angle of trunk rotation, translation, and accurate outcome measurements. A cohort study with a large sample size and baseline measurements should be conducted to investigate the efficacy of chiropractic and SSE. An RCT would be ideal due to the high quality of evidence generated, but it is unlikely to be conducted.

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APPENDIX 1: NEGRINI ET AL. [9] SIGN ANALYSIS ADAPTED FROM SIGN CLINICAL TRIAL ANALYSIS CHECKLIST (SIGN, 2021)

Clinical Trial SIGN analysis question for Negrini et al. (2019)	
Focused question?	Yes. It aimed to verify the effectiveness of exercise and as an alternative to bracing for AIS in the daily clinic.
Are the cases and controls from comparable populations?	Yes. During the study term (2003-2014), the patients in the clinic databases met the inclusion criteria.
Have the same exclusion criteria been applied to all groups?	Yes. Cases with consultations only and brace prescription at baseline were excluded.
Patients in each group Number (%)	Cases: 293 SEAS Group: 145 – 49% Usual Physio: 95 – 32% Controls: 53 – 18%
Groups compared	The SEAS group was compared with the usual physiotherapy and observation groups.
Are the cases are clearly defined and differentiated from controls?	Moderately clear. There are no reports on exercise programs for the usual physiotherapy group, but clear intervention records for the control group, none or non-regular exercise.
Have the control cases been established as non-cases?	No
Have measures been taken to prevent knowledge of primary exposure influencing case ascertainment?	Yes. data were collected by the same physicians who were unaware of the study, thereby reducing bias
Is the exposure status measured in a standard, valid and reliable way?	Yes. The exposed group (SEAS group) were prescribed four physiotherapy sessions lasting 1.5 hours per year (every three months), followed by evaluation by an expert with postgraduate training in SEAS. After evaluation, patients were taught home exercises by the expert.
Were the main potential confounders identified and taken into account in the design and analysis?	Yes. Propensity scores were used to reduce the potential effects of confounders related to observational design.
Risk of bias or confounding	Acceptable. The use of propensity scores minimized the risk.
Is there clear evidence of an association between exposure and outcome?	Yes. The results show 54% success in the SEAS group, 48% in the UP group, and 40% in the control group. Success was defined as < 5° curve progression during the treatment period.
Are the results of this study directly applicable to the patient group targeted by this guideline?	Yes. The results apply to any adolescent with idiopathic scoliosis.

APPENDIX 2: MALAJ ET AL. [10] CASP ANALYSIS ADAPTED FROM CASP COHORT STUDY CHECKLIST [8]

CASP (Cohort Study) for Malaj et al. (2020)	
Focused question?	Yes. It aimed to quantify the outcomes of Schroth and Pilates exercise in AIS patients.
Was the recruitment acceptable?	Yes. Sixty-nine patients were recruited during their outpatient visits.
Was the exposure accurately measured to minimize bias?	Yes. The Cobb angle, angle of trunk rotation, chest expansion, trunk flexion, and quality of life were measured to the second decimal point before and after treatment.
Were the outcomes accurately measured to minimize bias?	Yes. The same measurement procedures were used at the beginning and end of treatment. However, it was not clear if the same assessor measured the outcomes blinded.
Have all important confounding factors been identified?	Not known. There were no reports if the same assessor measured the outcomes blinded. However, the exercise program was the same for all patients.
Have confounding factors been taken into account in the design/analysis?	Yes. A longer follow-up plan was recommended, using the Risser sign rather than the Cobb angle alone.
Was the follow-up of subjects complete or long enough?	No. There was no follow-up plan.
Study Results	Significant Improvements ($P > 0.05$) were seen in both groups of patients wearing and not wearing in all aspects of the measurement objective.
How precise are the results?	Moderately precise. The authors did not record confidence intervals but recorded $P < 0.05$.
Are the results credible?	Moderately credible. This study did not consider skeletal maturity and had no follow-up. Given the natural history of scoliosis, a longer follow-up is recommended to ensure that the correction can be sustained, allowing solid conclusions to be made.
Can results be applied to the local population?	Yes. The sample size was good, and the results can be applied to a broader population.
Are the results consistent with other available evidence?	Yes. Other studies have yielded similar results showing an overall improvement following a scoliosis-specific exercise program in AIS patients.
Implication for practice?	The findings show that combining exercise with chiropractic can improve therapeutic outcomes.

APPENDIX 3: LIU ET AL. [11] CASP ANALYSIS ADAPTED FROM CASP COHORT STUDY CHECKLIST [8]

CASP (Cohort Study) for Liu et al. (2020)	
Focused question?	Yes. It aimed to explore the interventional effects of exercise therapy on idiopathic scoliosis.
Was the recruitment acceptable?	Yes. Ninety-nine patients were recruited during their outpatient visits.
Was the exposure accurately measured to minimize bias?	Yes. The Cobb angle and Risser scale were measured to the first decimal point before and after treatment.
Were the outcomes accurately measured to minimize bias?	Yes. The same measurement procedures were used at the beginning and end of treatment. However, it was not clear if the same assessor measured the outcomes blinded.
Were all the important confounding factors identified?	Not known. There were no reports if the same assessor measured the outcomes. However, the exercise program was the same for all patients.
Have confounding factors been taken into account in the design/analysis?	Yes. A longer follow-up plan was recommended, using the Risser sign rather than the Cobb angle alone.
Was the follow-up of subjects complete or long enough?	Yes. The patients were followed up for more than one year.
Results of the study	The Risser sign showed significant improvement from the first referral to the final follow-up ($P < 0.05$). There was also a significant difference in the final Risser grade between the different groups ($P < 0.05$).
How precise are the results?	Moderately precise. There are no records of the confidence intervals. However, the results obtained in the overall group were significant ($P < 0.01$).
Are the results credible?	Yes. The authors ensured no confounding factors such as a previous bracing treatment or scoliosis surgery. <u>The</u> follow-up period was more than one year.
Can results be applied to the local population?	Yes. The sample size was good, and the results can be applied to a broader population.
Are the results consistent with other available evidence?	Yes. Other studies have yielded similar results showing an overall improvement following a scoliosis-specific exercise program in AIS patients.
Implications for practice?	The findings show that combining exercise with chiropractic can improve therapeutic outcomes.

APPENDIX 4: PU CHU AND KAI HUANG [18] CEBMA ANALYSIS FROM CEBMA CASE REPORT CHECKLIST

Case Report (CEBMA) for Chu and Huang (2017)	
Focused question	Yes. It aimed to assess the effectiveness of chiropractic adjustment in early AIS patients.
Is the research method (study design) appropriate for answering the research question?	Yes. A case report is suitable for evaluating the effectiveness of treatment in target patients.
Are both the setting and the subject representative of the population to which the findings will be referred?	Partially yes. A single case report may lack validity to represent every AIS patient.
Is the researcher's perspective clearly described and considered?	Yes. A few previous studies have been considered before this case study.
Is the methodology clearly described?	Yes. It included chiropractic treatment, with 5 minutes of massage therapy and flexion-distraction on a machine table. Six months of treatment and follow-up at nine months.
Is the data analysis valid and reliable?	Valid data with good ethical consideration (signed consent). However, less reliable due to the small sample size
Were quality control measures used?	Not known. There were no reports of any changes to improve the study's quality.
Did more than one researcher repeat the analysis to ensure reliability?	Not known. There were no reports of replicate radiograph measurements.
Are the results credible?	Yes. Experienced chiropractors at one of the largest chiropractic clinics in Hong Kong conducted the study for a decent time.
Are the conclusions drawn justified by the results?	Partially yes. The authors concluded that early chiropractic intervention should be recommended for AIS patients. This case study showed a 6° reduction in the thoracic curve and a 7° reduction in the lumbar curve. However, a single case report may not be reliable enough to justify the conclusion.
Are the findings of the study transferable to other settings?	Yes. There are clear descriptions of the techniques used and radiographic records before and after treatment.

APPENDIX 5: MORNINGSTAR ET AL. (2019) CASP ANALYSIS ADAPTED FROM CASP CASE-CONTROL STUDY CHECKLIST [8]

CASP (Case-control Study) for Morningstar et al. (2019)	
Is the question focused?	Yes. It aimed to compare the effects of combining chiropractic treatment and nighttime bracing on Cobb angle reduction with chiropractic treatment alone.
Was the method used to answer the question appropriate?	Yes. A case-controlled series is an appropriate choice to compare treatments.
Was the case recruitment acceptable?	Yes. Strict inclusion criteria (history of AIS, initiation, and completion of the initial chiropractic rehabilitation program, home exercises, nighttime bracing, at least one follow-up visit at the end of the growth period) were applied.
Was the control selection acceptable?	Yes. A previous study by the same author used a different approach, reducing potential bias.
Was the exposure accurately measured to minimize bias?	Yes. Baseline radiographic measurements were taken before and after treatment and analyzed.
Were groups equally tested?	Yes. Same inclusion criteria were applied in both studies and programs.
Were potential confounding factors considered in design or analysis?	Not known. The study was not blinded, and the compliance rate of nighttime bracing was assumed 100%. However, similar measurement methods were used in both cases/groups.
How significant was the treatment effect?	Moderately significant. The effects of chiropractic rehabilitation with nighttime bracing were compared with bracing alone. The primary outcome measures were the Cobb angle and Risser scale. Although with bracing, there was 53%, 58%, 66%, and 78% correction in the thoracic, double major, thoracolumbar, and lumbar curves, respectively, the study was not powered enough due to the small sample size (n = 18).

Was the estimation of the treatment effect precise?	Yes. Statistically, the curve correction was significant ($p < 0.05$). However, the sample size was small, with no dropouts. Confidence intervals were not reported.
Are the results credible?	Moderately credible. The chiropractic rehabilitation element was insufficient in the program. Only the Cobb angle was measured, leading to possible bias during patient selection.
Can results be applied to the local population?	Yes. They apply to a broader population.
Are the results consistent with other available evidence?	Yes. Similar results can be obtained in different studies if the same methodology is applied.

APPENDIX 6: MENKE ET AL. [27] CASP ANALYSIS ADAPTED FROM CASP COHORT STUDY CHECKLIST [8]

CASP (Cohort Study) for Menke et al. (2020)	
Is the question focused?	Yes. It aimed to re-evaluate and analyze 41 complete sets of spine radiographs from a previous study in 2001 and determine the effectiveness of chiropractic management.
Was the recruitment acceptable?	Yes. A previously published method (Lantz & Chen, 2001) was used.
Was the exposure accurately measured to minimize bias?	Yes. The Cobb and Risser-Ferguson methods were used. Cobb: Two end-vertebrae were chosen at the superior and inferior aspects of the curve. Risser-Ferguson: In addition to the end-vertebrae (as in the Cobb method), a middle segment, the most laterally displaced, was identified. Diagonal lines were drawn from the opposing vertebral body corners, such that they crossed near the middle of the vertebral body.
Were the outcomes accurately measured to minimize bias?	Yes. A new hypothesis was formulated using the Bayesian analysis (discussed later) to minimize bias, possibly inherited from a previous study.
Were all important confounding factors identified?	Yes. The potential sources of error (placebo effects, radiographic positioning) were considered, and the chronological age, bone age, and the number of visits were analyzed in addition to the Cobb angle.
Were the confounding factors considered during the study design/analysis?	No. There were no clinical trials. The study was not blinded, and no control group was included to show differences between groups with and without chiropractic management.
Was the follow-up of subjects complete or long enough?	No. There was no follow-up plan
Results of the study	Overall improvement outpaced the progression of AIS. The Cobb angles and filter sizes improved three times compared to the baseline measurements. Based on the analysis and radiographic coding, patients with more compression in the scoliotic curves and higher bone age were more likely to show improvements.
How precise are the results?	Good. The 95% confidence intervals were recorded.
Are the results credible?	Yes. The Bayesian analysis estimates the probabilities of clinical events before and after treatment, building upon earlier research and refining hypotheses, increasing predictability and clinical confidence. In addition, probabilistic models are good for reducing clinical uncertainty.

Can the results be applied to the local population?	Yes. Given the study's decent sample size, these results apply to a broader population.
Are the results consistent with other available evidence?	Yes. The results can be reproduced if the same methodology is applied.
Implications for practice?	The findings show that chiropractic management can be improved in AIS patients.

APPENDIX 7: PU CHU ET AL. [12] HNLBI ANALYSIS ADAPTED FROM HNLBI OBSERVATIONAL CASE SERIES CHECKLIST (NHLBI, 2020)

HNLBI Observational case series for Pu Chu et al. (2020)	
Is the question focused?	Yes. It aimed to investigate the role of chiropractic intervention in patients with AIS.
Was the study population specified and defined?	Yes. The study population included all school children treated for scoliosis in the author's clinic from January 2015 to December 2018.
Was the study's participation rate at least 50%?	Yes. There were no dropouts among the participants.
Were all the subjects selected or recruited from the same or similar populations?	Yes. All the subjects were recruited from the same clinical populations.
Were the inclusion and exclusion criteria specified and applied uniformly to all participants?	Not known. The participants were diagnosed with AIS during a school screening. No explicit exclusion or inclusion criteria have been described in the methodology.
Was a sample size justification, power description, or variance and effect estimates provided?	No. The sample collection was reasonable and justified. However, the sample size was relatively small, with no power description due to the nature of the study.
For the analyses in this paper, were the exposure(s) of interest measured before the outcome(s) were measured?	Partially yes. The exposures were measured before the outcomes, but no nonexposed members were compared.
Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed?	Yes. The shortest treatment time was five months, but given that an intensive program was provided, authors believe it was sufficient time.
Did the study examine different levels of exposure as related to the outcomes?	Yes. The Cobb angle was examined. The Risser scale was evaluated on skeletal maturation.
Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?	Yes. The tools and methods (Cobb's angle) used to measure exposure were reliable and validated. The same methodology was applied to all participants.
Were the exposures assessed more than once over time?	Not known since it is not reported.
Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?	Yes. There were baseline measurements for all outcomes ($p < 0.05$). The follow-up measurements (measured to the first decimal place) were also done.

Were the outcome assessors blinded to the exposure status of participants?	Not known since it is not reported.
Was the loss to follow-up after baseline 20% or less?	The overall follow-up rate was high due to the short study duration.
Were key potential confounding variables measured and adjusted statistically?	No. It is unlikely for patients to participate in a randomized controlled group and no confounding variables were measured and adjusted.