



Review Article

A Systematic Review of Chuna Manual Therapy for Adolescent Idiopathic Scoliosis



Ga Hyeon Jung^{1,2}, Hyun Lee^{1,2}, Hae Jin Kong^{1,2}, Hwa Yeon Ryu^{1,2}, Yong Ho Ku^{1,2}, Jae Hui Kang^{1,2,*}

¹ Department of Acupuncture & Moxibustion Medicine, College of Korean Medicine, Daejeon University, Cheonan, Korea

² Department of Acupuncture & Moxibustion Medicine, Cheonan Korean Medicine Hospital of Daejeon University, Daejeon, Korea

ABSTRACT

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This study analyzed randomized controlled trials (RCTs) and case studies investigating Chuna manual therapy and variations of this term, for adolescent idiopathic scoliosis. On June 15th, 2019, 6 online databases were used to retrieve studies. A total of 527 articles were retrieved, and 14 RCTs and 20 case studies were selected for review. Typically, the frequency of Chuna therapy was 1-2 times/week. The most common period of treatment was 12 months in RCTs and 3-6 months in case studies. Cobb's angle was the most frequent evaluation index used (11 RCTs and 20 case studies). In control groups, brace treatment was used in 8 RCTs. In 6 RCTs and 20 case studies, Cobb's angle significantly decreased after Chuna therapy, and in 4 RCTs, Chuna therapy was as effective as brace treatment, with no significant difference between groups. Adverse events were not reported except for minor reactions in only 3 case studies. This review suggested that Chuna therapy for adolescent idiopathic scoliosis was more advantageous than and as effective as brace treatment in most cases, although the risk of bias in 13 RCTs was unclear.

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Introduction

Scoliosis is a 3-dimensional deformation of the spine, which occurs mostly in adolescence [1]. Radiological examination is performed in the standing position along with coronal and sagittal imaging, and is a basic test for diagnosing and measuring causes, treatment plans and prognosis of adolescent idiopathic scoliosis (AIS). Cobb's angle is a widely used method to measure the angle of curvature of the spine, and the Nash and Moe method is used to measure the rotation of the thoracic and the lumbar vertebrae. Curvature under 10° is normal, whereas a Cobb's angle over 10° is diagnosed as scoliosis [2].

The cause of scoliosis is usually idiopathic [3] and is classified depending on the age of diagnosis, with infantile (< 3 years), juvenile (3 to 9 years), adolescent (10 to 18 years) and adult (> 18 years) idiopathic scoliosis [4].

Adolescent idiopathic scoliosis is a structurally, abnormal curvature of the spine that occurs in otherwise healthy children,

or in adolescents at puberty, and is diagnosed by excluding causes such as spinal deformity or neuropathy [5]. The pathology of AIS is still unclear, although there is a study of the role of genetics in the pathogenesis [6]. Conventional treatment for AIS includes observation, exercise, in-patient rehabilitation, braces, and operations [7]. Juvenile scoliosis patients with a Cobb's angle over 40° can be managed with a back brace or surgical procedure. However, patients whose symptoms are less severe often seek conservative treatment. Recent systematic reviews have reported that a conservative approach to the treatment of AIS provides a better outcome compared with surgery, but the evidence for effective long lasting conservative treatment, is weak in a number of cases [8].

Adolescent Koreans with idiopathic scoliosis who do not receive surgery, may eventually seek Korean traditional medicine treatment. Systematic and suitable AIS treatment methods need to be established [9]. Chuna manual therapy is an optional treatment for AIS and includes techniques such as thrust, mobilization,

*Corresponding author.

Department of Acupuncture & Moxibustion Medicine, Cheonan Korean Medicine Hospital of Daejeon University, Daejeon, Korea

E-mail: rkd12@hanmail.net

ORCID: Ga Hyeon Jung <https://orcid.org/0000-0002-7759-0972>, Jae Hui Kang <https://orcid.org/0000-0003-4812-0557>

distraction of the spine and joints, soft tissue release, visceral manipulation, craniosacral therapy, and the diaplasis technique. Korean Chuna manual therapy has developed over time by combining the advantages of Tuina from China, Shiatsu from Japan, and chiropractic from the United States [10]. Different countries have different names for Chuna therapy, but whether it is called Tuina, chiropractic, or Chuna, the treatments involve manipulation. A large number of studies using Chuna manual therapy for AIS have been published, but most are limited to reporting individual cases. There is a lack of safety and efficacy data for Chuna therapy as a treatment option for scoliosis [11]. Hence, this review of the current randomized controlled trials (RCTs) and case reports of Chuna manual therapy for AIS was performed to provide up-to-date evidence on the clinical effectiveness of Chuna manual therapy for AIS.

Materials and Methods

Search strategy and selection criteria

In order to investigate the efficacy of Chuna manual therapy for AIS, searches were performed in the following databases to analyze studies published up until June 15, 2019: PubMed/MEDLINE, Cochrane Library, and China National Knowledge Infrastructure for international publications, and the National Digital Science Library, Research Information Sharing Service and Oriental Medicine Advanced Searching Integrated System for Korean publications. The following keywords were used for the database searches with minor adjustments for each database: “scoliosis,” “idiopathic scoliosis,” “adolescent scoliosis,” “adolescent idiopathic scoliosis” and “Chuna,” “Tuina,” “chiropractic,” “manipulation.” (Appendix A).

Eligibility criteria

Inclusion criteria

All RCTs, retrospective reviews, and case reports were included that reported on Chuna manual therapy in AIS patients, and there was no language restrictions in the selection of publications.

Exclusion criteria

Studies which were not case reports, RCT or reviews of these, were excluded. Studies of degenerative or adult (> 18 years) scoliosis, and studies in which Chuna belonged to the control group, were all excluded. Studies where the full text was unavailable, were also excluded.

Outcome assessment

Two or more independent Korean medical doctors reviewed the titles and abstracts of the 527 retrieved articles according to the inclusion and exclusion criteria, and excluded duplicate studies. In cases of inconsistency, a third party participated and decided whether to include articles by consensus. There were 34 articles included in this review (14 RCTs, and 20 case reports) (Fig. 1).

Data extraction and assessment of risk of bias

The risk of bias in RCTs was assessed using the Cochrane risk of bias tool.

Results

A total of 527 studies were retrieved from 6 online databases.

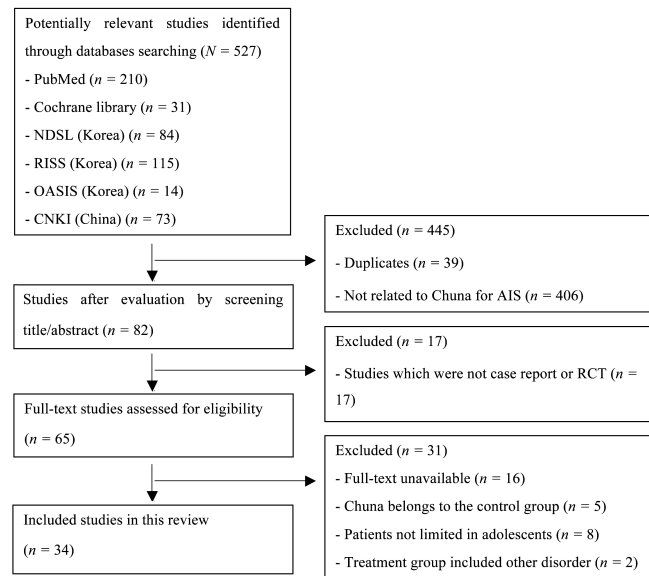


Fig. 1. Flow diagram of selection process.

AIS, adolescent idiopathic scoliosis; RCT, randomized controlled trial.

After removal of duplicates and screening articles to remove studies not related to Chuna manual therapy for AIS, 82 studies were analyzed, and 28 studies (14 RCTs and 20 case studies) were included for data analysis in this review (Tables 1 and 2).

Description of the included studies

Among the 14 RCTs, 13 studies were conducted in China, and 1 study was conducted in the United States. Among the 20 case studies, 11 were published in Korea, 6 in China, 2 in the United States, and 1 in Argentina.

Year of publication

In the 28 studies included in the analysis, the publication dates ranged from 2006 to 2018. There were 26 studies (76%) conducted in the last 10 years (Fig. 2).

Sample size of study

Among the 14 RCTs, there were 2 RCTs with less than 20 patients, 6 RCTs with 50 or more but fewer than 100 cases, and 6 RCTs with more than 100 patients. Among the 14 RCTs there were 1,134 patients in total. In 11 RCTs there were 312 males and 570 females (3 RCTs did not report the gender ratio). There were 14 of 20 case studies that consisted of less than 10 cases, 1 case study had 12 patients, and 4 case studies had 30 or more cases. Of the total 20 case reports there were 193 patients (60 males and 133 females).

Treatment frequency and period

Among 12 of the 14 RCTs [12-14,16-22,24,25], the frequency of Chuna manual therapy ranged from 1-3 times a week. Two RCTs [14,15] did not mention the frequency. In 5 RCTs [12,18,19,21,24], patients were treated 1-2 times per week, and in 3 RCTs [13,16,17], the frequency was reported as 2-3 times a week. In case studies, the frequency ranged from 1-5 times per week. In 7 studies [35,37,38,40,42-44], Chuna manual therapy was performed 1-2 times

Table 1. Key Data of RCTs.

Author (y)	Treatment group gender and mean age (y)	Intervention		Treatment frequency	Evaluation index	Result
	Control group gender and age	Treatment	Control	Treatment period		
Li (2018) [12]	M = 14, F = 26, 11.68 ± 1.69 (mean)	A: chiropractic manipulation + exercise + psychological counseling (n = 37)	B: Milwaukee brace (n = 35)	2/wk	Cobb's angle AEMG SDS SAS	Cobb's angle (°) A: 21.85 ± 2.97 → 10.83 ± 2.69 [†] B: 22.53 ± 3.19 → 9.73 ± 2.42 [†] AEMG ratio increased ^{†‡} SDS score decreased ^{†‡} SAS score decreased ^{†‡}
	M = 12, F = 28, 12.23 ± 2.07 (mean)			12 mo		
Luo (2018) [13]	M = 14, F = 23, 12.68 ± 1.53 (mean)	A: chiropractic manipulation + traction + exercise (n = 37)	B: exercise (n = 39)	3/wk	Cobb's angle	Cobb's angle (°) A: 18.43 ± 6.50 → 14.49 ± 6.56 ^{†‡} B: 20.87 ± 9.69 → 18.51 ± 9.54 [†]
	M = 14, F = 25, 12.18 ± 1.59 (mean)			3 mo		
Chen (2018) [14]	unknown (adolescent)	A: chiropractic manipulation (n = 40)	B: customized brace (n = 36)	Unknown	Cobb's angle -total effective rate VAS	Cobb's angle (°) A: 29.35 ± 5.23 → 9.15 ± 6.35 [†] B: 28.32 ± 6.02 → 18.32 ± 5.45 Cured (case) A: 11 (45.0%)/B: 8 (22.2%) Markedly effective (case) A: 18 (45.0%)/B: 8 (22.2%) Effective (case) A: 9 (22.5%)/B: 16 (44.4%) Invalid (case) A: 2 (5.0%)/B: 7 (19.4%) Total effective rate (%) A: 95.0/B: 80.5 VAS decreased A: 6.23 ± 1.21 → 1.56 ± 0.78 [†] B: 6.14 ± 1.96 → 4.12 ± 1.02
				6 mo		
Wang (2017) [15]	Unknown (adolescent)	A: spinal manipulation (n = 51)	B: traction (n = 51)	Unknown 10 times*3 courses	Cobb's angle -total effective rate	Cobb's angle (°) A: 25.30 ± 1.08 → 14.29 ± 1.38 [†] B: 25.34 ± 1.04 → 20.37 ± 1.42 Total effective rate (%) A: 96.08 [†] , B: 68.68
Li (2017) [16]	M = 13, F = 27, 10~18	A: chiropractic manipulation + traction + brace (n = 36)	B: Boston brace (n = 38)	2-3 times/wk	Cobb's angle -total effective rate VAS	Cobb's angle (°) A: 23.5 ± 7.4 → 10.5 ± 6.3 [†] B: 23.5 ± 7.9 → 14.4 ± 6.8 Cured (case) A: 12 (33.3%) [†] , B: 4 (10.5%) Markedly effective (case) A: 10 (27.8%) [†] , B: 7 (18.4%) Effective (case) A: 12 (33.3%), B: 18 (47.4%) Invalid (case) A: 2 (5.6%) [†] , B: 9 (23.7%) Total effective rate (%) A: 94.4, B: 76.3 VAS decreased A: 3.0 ± 1.2 → 0.7 ± 0.8 ^{†‡} B: 3.1 ± 1.2 → 1.4 ± 1.0 [†]
	M = 12, F = 28, 10~18			3 mo		
Du (2016) [17]	M = 22, F = 43, 9.3 ± 4 (mean)	A: spinal manipulation + exercise + acupotomology (n = 65)	B: Milwaukee brace (n = 58)	3/wk	VC, FEV1/ FVC, MVV, AEMG ratio of the sEMG	Pulmonary function A: improved [†] , B: decreased [†] VC (ml/kg) A: 89.3 ± 8.9 → 94.1 ± 9.8 ^{†‡} B: 90.5 ± 9.9 → 85.2 ± 8.4 [†] FEV1/FVC A: 87.2 ± 7.4 → 95.7 ± 7.7 ^{†‡} B: 89.0 ± 8.1 → 82.1 ± 6.6 [†] MVV (L/min) A: 68.5 ± 8.9 → 77.4 ± 10.2 ^{†‡} B: 71.7 ± 9.8 → 66.3 ± 8.2 [†] AEMG ratio of the sEMG reduced [†] , and tended to remain at 1 after stopping treatment, adverse in control group [†]
	M = 18, F = 40, 8.9 ± 0.5 (mean)			12 mo		
Wei (2015) [18]	M = 18, F = 40, 9.1 ± 0.4 (mean)	A: spinal manipulation + exercise + acupotomology (n = 58)	B: Milwaukee brace (n = 49)	2/wk	Cobb's angle, VC, FEV1/ FVC, MVV, AEMG ratio of the sEMG	Cobb's angle (°) A: 30.4 ± 3.7 → 10.2 ± 2.2 (12 mo) [†] → 12.0 ± 2.5 (24 mo) [†] B: 31.5 ± 3.2 → 9.0 ± 2.0 (12 mo) [†] → 7.9 ± 0.8 (24 mo) Percentages of original Cobb angle (%) A: 51.4 (12 mo)a → 62.5 (24 mo) [†] B: 47.8 (12 mo) → 34.7 (24 mo) Pulmonary function A: improved [†] B: decreased [†] VC (ml/kg) A: 90 ± 9 → 93 ± 10 ^{†‡} B: 90 ± 9 → 87 ± 8 [†] FEV1/FVC A: 89 ± 7 → 93 ± 7 ^{†‡} B: 90 ± 7 → 88 ± 6 MVV (L/min) A: 73 ± 10 → 76 ± 11 ^{†‡} B: 72 ± 10 → 69 ± 8 [†] AEMG ratio of the sEMG reduced [†] , and tended to remain at 1 after stopping treatment, B: adverse [†]
	M = 10, F = 39, 8.9 ± 0.6 (mean)			12 mo		

Table 1. (Continued).

Author (y)	Treatment group gender and mean age (y)		Intervention		Treatment frequency		Evaluation index	Result
	Control group gender and age		Treatment	Control	Treatment period			
Sun (2015) [19]	M = 5, F = 4 14.5 (mean)		A: chiropractic manipulation + exercise (n = 9)	B: muscle strength training (n = 9)	1-2 times/wk	12 wks	RMDQ, VAS, lumbar ROM, torso muscle strength	RMDQ A: 7.21 ± 5.46 → 2.17 ± 3.81 [†] B: 9.43 ± 3.10 → 9.65 ± 2.74 VAS A: 5.00 ± 2.21 → 1.50 ± 0.85 [†] B: 5.74 ± 1.21 → 5.11 ± 1.98 Waist mobility (ROM) increased [†] Torso muscle strength increased [†]
	M = 5, F = 4 13.9 (mean)							
Ren (2014) [20]	M = 33, F = 47 12.38 (mean)		A: chiropractic manipulation (n = 25)	B: therapeutic exercise (n = 30) C: CTLSO brace (n = 25)	1/2d 2 mo 5 courses		Cobb's angle Cobb's angle Cobb's angle	Cobb's angle (°) A: 22.21 ± 6.76 → 20.15 ± 7.75 (p = 0.0325) B: 21.54 ± 6.70 → 17.00 ± 8.00 (p = 0.031) C: 23.04 ± 5.94 → 11.86 ± 5.07 (p = 0.000) A < B [‡] , B < C [§] , A < C [§]
Wei (2014) [21]	M = 17, F = 36 9.12 ± 0.43 (mean)		A: spinal manipulation (25 min) + exercise (40 min) + acupotomy (n = 53)	B: Milwaukee brace (n = 31)	2/wk	12 mo	Cobb's angle correction rate, VC, FEV1/FVC, MVV, AEMG ratio of the sEMG	Cobb's angle (°) A: 20.43 ± 3.78 → 10.23 ± 2.19 [†] B: 21.56 ± 3.06 → 9.05 ± 1.95 [†] Correction rate A: 52% / B: 47% VC (ml/kg) A: 90.21 ± 9.87 → 93.01 ± 10.01 ^{†,§} B: 90.31 ± 9.90 → 87.17 ± 8.89 [†] FEV1/FVC A: 89.11 ± 7.25 → 93.01 ± 10.01 ^{†,§} B: 90.03 ± 7.55 → 88.22 ± 6.95 [†] MVV (L/min) A: 73.21 ± 10.58 → 76.37 ± 11.28 ^{†,§} B: 72.98 ± 10.11 → 69.88 ± 8.95 [†] AEMG ratio of sEMG A: 1.58 ± 0.25 → 1.10 ± 0.17 ^{†,§} B: 1.49 ± 0.30 → 1.62 ± 0.47 [†]
	M = 11, F = 20 8.97 ± 0.52 (mean)							
Wang (2014) [22]	Gender unknown (adolescent)		A chiropractic manipulation + soft tissue therapy (n = 50)	B: traction (n = 50)	1/d 1 wk*5 courses		Cobb's angle total effective rate, cure rate (= the rate of recovery)	Cobb's angle (°) A: 22.38 ± 7.97 → 13.69 ± 5.51 [‡] B: 22.97 ± 8.01 → 18.19 ± 6.84 Cured (case) A:17, B:12 Effective (case) A:32, B:32 Invalid (case) A:1, B:6 Total effective rate (%) A:94.2, B:88.0, A > B [‡] Cure rate (%) A: 34.0, B: 24.0, A > B [‡]
Qian (2007) [23]	M = 47, F = 43 8.73 ± 0.56 (mean)		A: spinal manipulation (40 min) + soft tissue therapy (20min) (n = 90)	B: observed (n = 30)	1/d	10 times*1course	Cobb's angle, cure rate (= the rate of recovery)	Cobb's angle (°) A: 17.86 ± 2.84 → 11.11 ± 4.97 [†] B: 16.89 ± 2.94 → 15.64 ± 4.07 Cured (case) A: 22, B: 2 Effective (case) A: 55, B: 5 Invalid (case) A: 13, B: 23 Total effective rate (%) A: 85.56, B: 23.33, A > B [‡] Cure rate (%) A: 24.44, B: 6.67, A > B [‡]
	M = 18, F = 12 8.60 ± 0.56 (mean)							
Shen (2016) [24]	M = 18, F = 40 9.10 ± 0.44 (mean)		A: spinal manipulation + exercise + acupotomy (n = 58)	B: Milwaukee brace (n = 49)	2/wk	12 mo	Cobb's angle correction rate, VC, FEV1/FVC, MVV, AEMG ratio of the sEMG	Cobb's angle (°) A: 20.32 ± 3.76 → 10.23 ± 2.19 (12 mo) [†] , a → 12.05 ± 2.48 (24 mo) B: 21.43 ± 3.58 → 9.05 ± 1.95 (12 mo) [†] → 7.92 ± 0.85 (24 mo) Correction rate A: 51.4% (12 mo) → 62.5% (24 mo) [†] B: 47.8% (12 mo) → 34.7% (24 mo) [†] Pulmonary function (VC, FEV1/FVC, MVV) A: increased [†] , B: decreased [†] AEMG A: reduced [†] , tended to remain at 1 after stopping treatment, B: adverse [†]
	M = 10, F = 39 8.92 ± 0.51 (mean)							
Rowe (2006) [25]	A: F(16), F(13) B: F(16) C: F(13), M(16), F(10) 14 (mean)		A: chiropractic manipulation + soft tissue therapy (n = 2)	B: sham manipulation (n = 1) C: observed (n = 3)	3 (1st mo) → 2 (2nd) → 3 (3-4th) → 2 (5-6th) treatments/wk 6 mo		SQLI	A: 1 patient reported a clinically important improvement in the moods and feelings B: no clinically important changes C: 1 patient expressed a clinically important deterioration

Compared with the results before treatment in the same group, [†]p < 0.05; [‡]p < 0.01; Compared to the control group, [§]p < 0.05; ^{||}p > 0.05.

AEMG, average electromyogram; FEV1/FVC, the % of forced expiratory volume in 1 second of forced vital capacity; MVV, maximum ventilator volume; RMDQ, Roland Morris Disability Questionnaire; ROM, range of movement; SAS, self-rating anxiety scale; SDS, self-rating depression scale; sEMG, surface electromyogram; SQLI, Scoliosis Quality of Life Index; VC, vital capacity.

Table 2. Key Data for Case Studies.

Author (y)	Gender and age (y)	Intervention	Treatment frequency Treatment period	Evaluation index	Result
Zhang (2017) [26]	M = 8, F = 22, 13.37 ± 4.11 (mean)	Spinal manipulation + exercise (n = 30)	Unknown 20 times	Cobb's angle -total effective rate	Cobb's angle (°) 16.73 ± 8.23 → 10.73 ± 4.41 [†] Cure 3 cases (10.00%) Effective 22 cases (73.33%) Invalid 5 cases (16.67%) Total effective rate 25 cases (83.33%) total effective rate 25 cases (83.33%)
Zhang (2016) [27]	M = 19, F = 29, 10~20, 16 (median)	Chiropractic manipulation + traction + Chinese medicine fumigation (n = 48)	1/d 2 mo	Cobb's angle VAS score ODI score	Cobb's angle (°) 30.15 ± 4.16 → 12.10 ± 3.64 [†] VAS decreased [†] 4.85 ± 0.16 → 2.15 ± 0.10 ODI decreased [†] 33.33 ± 5.17 → 17.79 ± 2.35
Chen (2013) [28]	M = 11, F = 27, 14.5 (mean)	Soft tissue therapy + traction + chiropractic manipulation (n = 38)	Unknown 8 wks	Cobb's angle	Cobb's angle (°) 11-20 (27 cases), 21-30 (11 cases) Cure 15 cases, markedly Effective 9 cases Effective 8 cases, invalid 6 cases
Wu (2008) [29]	M = 13, F = 19, 11.98 ± 1.92 (mean)	Chiropractic manipulation (Banfa) + soft tissue therapy + acupuncture (n = 32)	1/2d 3 mo	Cobb's angle -total effective rate	Cobb's angle (°) 20.00 ± 7.91 → 8.81 ± 8.14 [†] Cure 15 (46.87%), effective 12 (37.50%), invalid 5 (15.63%) Total effective rate = 84.38% (15 cases clinically cured)
Pu Chu (2017) [30]	F(12)	Chiropractic manipulation (n = 1)	3 (1-2nd mo) > 2 (3-6th) times a wk 6 mo	Cobb's angle	Cobb's angle (°) 26 → 6 (thoracic) (23%) 23 → 16 (lumbar) (30%)
Dovorany (2015) [31]	A: F = 13 B: F = 13 (n = 2, identical twin girls)	Chiropractic rehabilitation	5 d/wk for the first 2 wks > 3 times daily for the rest 24 mo	Cobb's angle	Cobb's angle (°) A: 47 → 19 (2 wks) → 22 (24 mo) (TL-L2) B: 37 → 16 (2 wks) → 26 (24 mo) (T11-L4)
Chen (2008) [32]	F(15)	Chiropractic manipulation + Milwaukee brace (n = 1)	2/wk, Frequency gradually decreased 18 mo	Cobb's angle	Cobb's angle (°) 46 → 16 (T7-L1)
Byun (2016) [33]	M = 4, F = 1 11.8 ± 1.3 (mean)	Chiropractic manipulation + soft tissue therapy (n = 5)	3/wk 8 wks	Cobb's angle	Cobb's angle (°) 11.2 ± 1.3 → 2.4 ± 3.4 (after 4 wks) → 1.0 ± 2.2 (after 8 wks)
Park (2013) [34]	A: F(13) B: M(14) C: F(8) D: M(8)	Chuna manipulation + foot orthosis (n = 4)	Unknown Each 8, 17, 16, 5 times	Cobb's angle, difference of pelvic height, difference of balance	Cobb's angle (°) A: 37 → 32 (thoracic), 25 → 25 (lumbar), B: 11 → 7 (thoracic) C: 23 → 18 (thoracic), 18 → 13 (lumbar), D: 13 → 5 (thoracic) Difference of pelvic height(mm) A: 5 → 3, B: 8 → 6, C: 8 → 4, D: 3 → 8 Difference of balance (%) A: 6.8 → 4.2, B: 4.4 → none, C: 10.6 → 3.6, D: 6.8 → 5
Jo (2013) [35]	A: F(15) B: F(16) C: F(17)	Chuna manipulation + soft tissue therapy + acupuncture, cupping, physical therapy + brace (in 2 cases) (n = 3)	1/wk 3 mo	Cobb's angle (correction ratio), VAS	Cobb's angle (°) A: 19.22 → 12.85 (33.14%), B: 24.57 → 21.03 (14.40%), C: 30.14 → 24.31 (19.34%) VAS A: 6 → 5 → 2, B: 2 → 3 → 1, C: 2 → 2 → 1
Jang (2014) [36]	A: F(17) B: F(15)	Chuna manipulation + acupuncture, bee venom, cupping, physical therapy + exercise (n = 2)	A: 10 sessions B: 12 sessions 1 mo	Cobb's angle, VNRS score	Cobb's angle (°) A: 27 → 23 (thoracic), 17 → 10 (lumbar) B: 30 → 21 (thoracic), 16 → 16 (lumbar) VNRS A: 6 → 2, B: 6 → 3
Lee (2017) [37]	A: M(12) B: F(27)	MET + acupuncture (n = 2)	1/wk A: 15 sessions B: 20 sessions 3 mo	Cobb's angle (Correctability)	Cobb's angle (°) A: 12.7 → 3.7 (69.16%) (thoracic), 11.4 → 2.3 (79.82%) (lumbar) B: 12.0 → 8.6 (33.0%) (thoracic), 17.0 → 10.3 (39.41%) (lumbar)

Table 2. (Continued).

Author (y)	Gender and Age (y)	Intervention	Treatment frequency Treatment period	Evaluation index	Result
Lee (2012) [38]	A: F(13) B: F(24) C: F(21) D: M(16)	Chuna manipulation + soft tissue therapy + acupuncture, cupping, physical therapy (n = 4)	1/wk 3 mo	Cobb's angle (correctability), VAS score	Cobb's angle (°) A: 36.37 → 34.43 (5.33%), B: 18.53 → 17.92 (3.29%) C: 41.92 → 35.59 (15.10%), D: 15.85 → 13.15 (17.03%) VAS (1st, 2nd, 3rd mo) A: 8 → 5 → 3, B: 10 → 5 → 2, C: 5 → 7 → 3, D: 5 → 4 → 4
Hong (2010) [39]	A: F(13) B: F(14)	Chuna manipulation + acupuncture (n = 2)	A: 17 sessions B: 13 sessions A: 2.5 mo B: 1 mo	Cobb's angle (correctability), VAS score	Cobb's angle (°) A: 19 → 10.6 (44.2%), B: 11.3 → 7 (38.0%) VAS A: 5 → 1-2, B: 7 → 1-2
Cho (2009) [40]	F(7)	Chuna manipulation (n = 1)	1-2/wk 19 sessions 3 mo	Cobb's angle, Ilium shadow measurement, BMI	Cobb's angle (°) 15 → 1 (lumbar), 20 → 5 (thoracic) Ferguson's angle (°) 28 → 33 Ilium shadow measurement (cm) Lt 5.0 → 5.2/Rt 5.8 → 6.3 BMI (kg/m ²) 19.3 → 17.2
Lee (2007) [41]	A: F(15) B: F(15) C: M(16)	Chuna manipulation (cervical) + FCST, SOT + acupuncture (n = 3)	A: 21 sessions B: 15 sessions C: 27 sessions A: 3 mo B: 3 mo C: 5 mo	Cobb's angle (correctability), VAS score	Cobb's angle (°) A: 49 → 35 (29%), B: 15 → 4 (73%), C: 59 → 39 (34%) VAS A: no change, B: unknown → 1, C: unknown → 0-3
Kim (2004) [42]	F(13)	Chuna manipulation + Milwaukee brace (n = 1)	1/wk 15 wks	Cobb's angle	Cobb's angle (°) 12 → 9 (cervicothoracic), 20 → 17 (thoracic), 33 → 25 (lumbar)
Kang (2006) [43]	F(12)	Chuna manipulation + acupuncture (n = 1)	1/wk 12 wks	Cobb's angle (correctability), VAS score	Cobb's angle (°) 23 → 15 (34.7%) (thoracic), 25 → 10 (60.0%) (lumbar) VAS 2 → 0
Villafañe (2012) [44]	F(9)	Deep tissue massage, spinal manipulation + exercise + physiotherapy treatment (n = 1)	1/wk 36 wks	Cobb's angle (improvement), SRS-22, BSSQ-br, BrQ	Cobb's angle (°) 18 → 7 (55%) (thoracic), 24 → 11 (54%) (thoracolumbar) after 6 mo, 11 (thoracic), 11 (thoracolumbar) SRS-22 :105, BSSQ-br: 27, BrQ: 141
Woggon (2013) [45]	12 females (adolescent)	Chiropractic manipulation (n = 12)	Unknown 2 wks	Cobb's angle	Changes over 8° Cobb's angle: 9 cases (thoracic), 10 cases (lumbar)

Compared with the results before treatment, * $p < 0.05$; † $p < 0.01$.

BSSQ-br, Bad Sobernheim Stress Questionnaire; BrQ, Brace Questionnaire; FCST, Functional Cerebrospinal Technique; MET, muscle energy technique; ODI, Oswestry Disability Index; SOT, Sacro-occipital Technique; SRS-22, Scoliosis Research Society 22; VAS, Visual Analogue Scale.

per week, in 4 studies [29,33,36,39], 2-3 times a week, and 1 study [27] patients were treated once per day. In 1 RCT [25] and 3 case studies [30-32], the frequency gradually decreased in the study. The frequency of treatment was not recorded in the remaining 2 RCTs [14,15] and 5 case studies [26,28,34,41,45] (Fig. 3).

The period of Chuna manual therapy in the 14 RCTs ranged from 5 weeks to 12 months. There were 5 RCTs with 12 months [12,17,18,21,24], which was the most common period of therapy. Two RCTs [15,23] did not mention the treatment period only the number of treatments, which was 30 and 10 times each. In the case studies, the period of treatment ranged from 2 weeks to 24 months. There were 8 studies [29,35,37,38,40-43] with treatment periods of 3-6 months, which was the most common period used. There were 6 studies [27,28,33,36,39,45] with periods of treatment of 3 months or shorter, 3 studies with 24 months, 18, or 9 months each,

respectively [31,32,44], and 2 studies [26,34] that did not mention the exact period (Fig. 4).

Evaluation index

In a single study, 1-5 evaluation indices were used. In RCTs, 1,134 patients were evaluated for 11 indicators. Eleven RCTs (79%) used Cobb's angle as the evaluation index. Three RCTs (21%) did not use Cobb's angle as an evaluation index, but reported changes in other criteria. Muscle imbalance was measured by average electromyogram ratio of the surface electromyogram in 5 RCTs (36%), and pulmonary function was measured by vital capacity, the percentage of forced expiratory volume in 1 second of forced vital capacity, and chase volume per minute in 4 RCTs (29%). The Visual Analogue Scale (VAS) was used for subjective pain

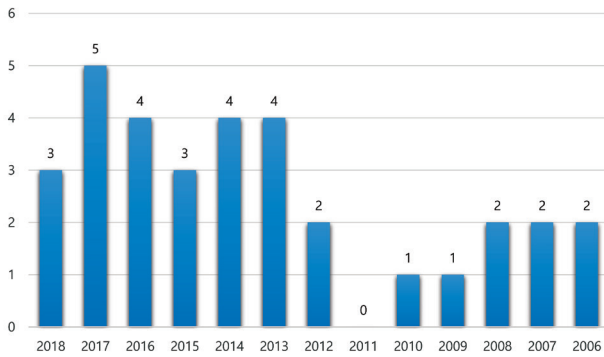


Fig. 2. Analysis of the number of publications per year.

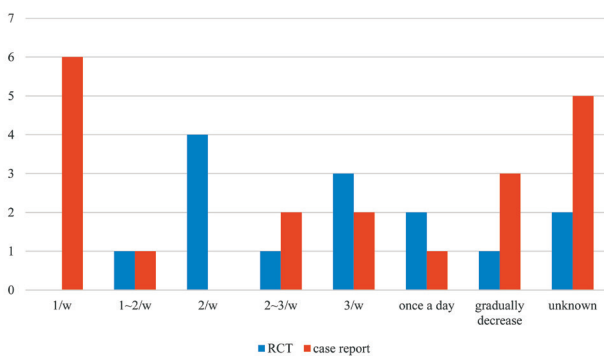


Fig. 3. Analysis of the frequency of treatments. RCT, randomized controlled trials.

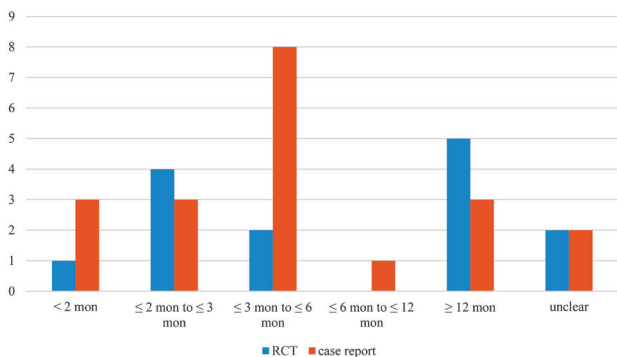


Fig. 4. Analysis of the number of studies in each treatment period. RCT, randomized controlled trials.

in 3 RCTs (21%). To show lumbar function, the Roland Morris Disability Questionnaire, range of motion, and torso muscle strength were used in 1 study. The Self-Rating Depression Scale score, and Self-Rating Anxiety Scale appeared in 1 RCT, and the Scoliosis Quality of Life Index was used in 1 RCT.

In case studies, 11 evaluation indicators were shown. All 20 case studies used Cobb's angle as the main index. The VAS score was used in 8 case studies [27,35-39,41,42], and the Oswestry Disability Index score was shown in 1 case study [27]. Two case studies [34,40]

used indices related to radiological findings, such as difference in pelvic height, Ferguson's scale and ilium shadow measurement. For psychological evaluations, Scoliosis Research Society-22, Bad Sobernheim Stress Questionnaire-brace, and Brace Questionnaire were used in 1 case study [44].

Details of the included intervention

All 34 clinical studies used Chuna manual therapy as the main intervention, but the treatment term varied (Chuna, chiropractic, spinal manipulation, or manipulative and rehabilitation techniques). Among RCTs, 8 studies used chiropractic manipulation, and 6 used spinal manipulation. Among case studies, chiropractic manipulation was used in 7 studies, Chuna manipulation in 9 studies, and manipulative and rehabilitation techniques in 1 study. There were 5 RCTs and 1 case study that used spinal manipulation, which were all Chinese studies.

Supplementary treatments varied among studies. Soft tissue therapy was used in 2 RCTs and 4 case studies, muscle energy technique was shown in 1 case study, and traction was used in 2 RCTs and 1 case study. Exercise was combined as treatment in 6 RCTs and 3 case studies. Acupuncture was used in 6 case studies, 2 of which used combined oriental medical therapy, and 1 study included bee venom in the treatment. Acupotomy was used in 3 RCTs. Psychological counseling was accompanied in 1 RCT and 1 case study. Brace treatment was accompanied in 1 RCT and in 1 case study. Foot orthosis was used in 1 case study, and Functional Cerebrospinal Technique, Sacro-occipital Technique was also used in 1 case study.

Treatment of control group

For controls, 8 RCTs [12,14,16-18,20] used brace treatment which included a Milwaukee brace in 5 RCTs [12,17,18,21,24], a Boston brace [16], a CTLSO brace [20], and customized brace [14] were used in 1 study each. Traction was used in 2 RCTs [15,22], and exercise in 3 RCTs [13,19,20]. In 1 study [23], a control group was observed, and in 1 RCT [25] sham manipulation and observation were used in 2 control groups.

Therapeutic effect

In 6 RCTs [13-16,22,23] and 20 case studies [26-45], the treatment group showed a statistically significant decrease in Cobb's angle compared to the control group, and before treatment. Four RCTs [12,17,21,24] showed Cobb's angle for both the treatment and control group decrease, but the difference between the 2 groups was not statistically significant. One RCT [20] showed that Chuna manual therapy had a reduced Cobb's angle, but it was not statistically significantly more effective than the therapeutic exercise or brace group.

Five RCTs [17-19,21,24] showed improvements in other evaluation indices. As shown in 4 RCTs [17,18,21,24], pulmonary function and muscle imbalance of the patients in the treatment group were improved markedly compared with the brace group, which showed limitations to lung development caused by the brace. One RCT [8] reported a decreased Roland Morris Disability Questionnaire score, and waist mobility, and torso muscle strength increased in the treatment group. Also, in the other 2 RCTs [14,16] and 8 case studies [27,35-39,41,43] VAS decreased. Two case studies [30,32] did not use a pain scale but they reported that subjective pain improved after Chuna manual therapy. In addition, 1 RCT [22] showed that Self-Rating Depression Scale score and Self-Rating Anxiety Scale scores meaningfully decreased

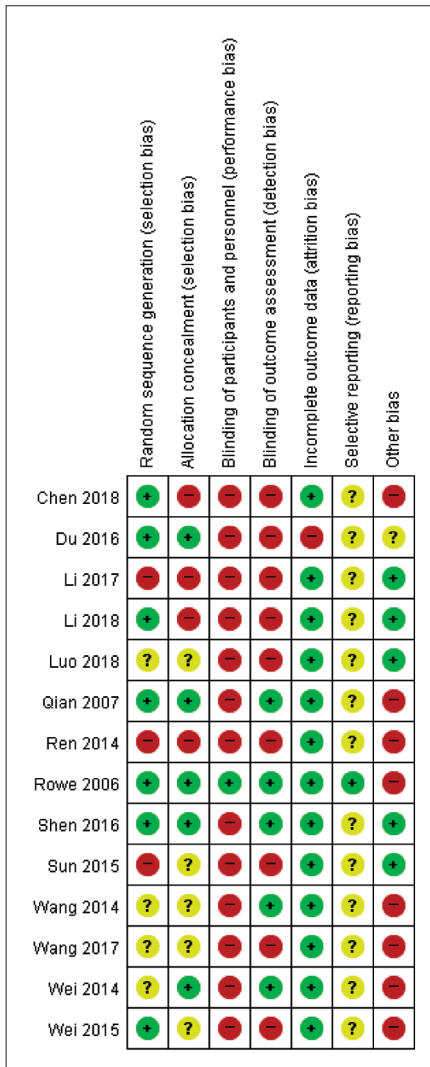


Fig. 5. Risk of bias summary for the randomized controlled trials.

after Chuna manual therapy, alleviating depression and anxiety. Scoliosis Quality of Life Index score was used in 1 RCT [25], which showed clinically important improvements in the moods and feelings of the Chuna manual therapy group.

Risk of bias in the included studies

The risk of bias was assessed for 34 studies using the Cochrane risk of bias tool (Figs. 5 and 6).

Random sequence generation

Low risk was observed in 7 studies [12,14,17,18,23-25]. Three studies [12,14,17] used a random number table, and 4 studies [17,23-25] used computers for random sequence generation. High risk was observed in 3 studies [16,19,20], 1 study [16] was randomized by visiting order (odd-even method), and 2 studies [19,20] did not mention randomization. In 4 studies [13,15,21,22], the level of risk was unclear, because there was no description of the randomization method.

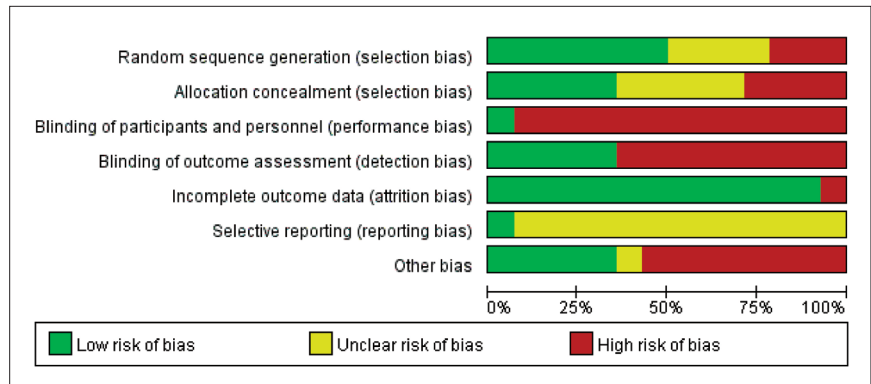


Fig. 6. Risk of bias graph for randomized controlled trials.

Allocation concealment

Low risk was observed in 5 studies [17,21,31-33]. One study [21] used a random allocation scheme handled by a designated person who informed the patient for the attending doctor, 3 studies [21,33,34] used sealed envelopes, and 1 study [25] used e-mail to inform the patient of the allocated group. Four studies [12,14,16,20] were categorized as high risk, 2 studies [12,14] used random number tables, 1 study [20] did not mention randomization, and 1 study [16] was assigned by visiting order (odd-even method). Five studies [13,15,18,19,22] were classified as having unclear risk as there was no mention of allocation concealment.

Blinding of participants and personnel

In 1 study [25], patient blinding was attempted in the treatment and sham manipulation interventions only. Thirteen studies [12-24] were considered high risk due to the characteristics of Chuna manual therapy.

Blinding of outcome assessment

Low risk was observed in 5 studies [21-25], 3 studies [22-24] were single-blinded, 1 study [21] conducted the assessment with trained and qualified participants to ensure consistency in the evaluation criteria, and 1 study [25] recruited 2 blinded observers. Nine studies [12-20] were classified as unclear risk, as there was no mention about blinding of the outcome assessment.

Incomplete outcome data

Low risk was observed in 13 studies [12-16,18-25]. Amongst those, 6 studies [12,14,16,18,21,24] had dropouts, but that did not affect the outcome significantly, and 7 studies [13,15,19,20,22,23,25] did not have any dropouts. High risk was observed in 1 study [17] which had 17 dropouts, 5 in the treatment group and 12 in the control group, with the reason given that the patients could not finish the treatment.

Selective reporting

Except for 1 study [25], which reported research protocols were successful (although 1 patient underwent a surgical intervention), 13 studies [12-24] were categorized as having unclear risks because there was no report of protocols.

Other biases

Low risk was observed in 5 studies (36%) [12,13,16,19,24]

because there was no possibility of additional bias, because there were no differences in the number of participants and in the duration of treatment, between the treatment and the control group. High risk was observed in 9 studies (64%) [14,15,17,18,20-23,25]. Three studies [14,15,22] only specified the range of ages of the patients involved. The number of participants in the treatment and control group, was significantly different in 5 studies [17,18,20,21,23], among which 1 study [18] had disparities in the number of participants who participated in the whole treatment as 58 and 49 due to dropouts. One study [25] was conducted with only 6 patients due to the characteristics of pilot study.

Dropouts

There were 66 dropouts in 14 RCTs. One RCT [17] had 17 dropouts out of 140 patients involved, and the reason given was they could not finish the treatment course. There were 6 RCTs [12,14,16,18,24] that had dropouts of less than 10% of all participants, which did not influence the results. Four RCTs [14,17,18,24] had more dropouts in the control group compared to treatment group, which showed Chuna manual therapy had better compliance than wearing a brace.

Adverse Events

Six RCTs (43%) [12,15,16,18,21,23] and 1 case study (5%) [28] reported that there were no adverse reactions regarding vital signs, fractures, dislocations, exacerbations or fainting. Four case studies (20%) [29,32,39,44] reported adverse events. Of those, 2 studies [32,39] reported benign reactions which included local pain and tenderness of local musculature after manipulation. One case study [29] used acupuncture as a supplementary treatment, and 18 patients reported discomfort such as local bruising, tingling sensation, or pain after acupuncture. One case study [44], which used physiotherapy treatment as a supplementary treatment, noted that there were no psychological sequelae observed.

Discussion

There are 3 types of scoliosis which are congenital, neuromuscular, and idiopathic. Scoliosis is rarely caused by spinal cord disorders [3]. The most common type of scoliosis is idiopathic which represents between 85% to 90% of cases in this multifactorial disease [46]. Prognostic factors of AIS include age of diagnosis, menstrual age, skeletal maturity, and degree of curvature [6]. An imbalance of the spine and pelvis due to abnormal walking and posture, can lead to serious physical and esthetic problems [47]. Radiographical imaging has been used to determine the prevalence of AIS which has been reported to affect approximately 1.56% [48] to 2.28% [49] of the population worldwide. Various treatment methods are suggested according to the severity of symptoms and skeletal maturity. Non-surgical observation, brace prescription, and surgical treatment are the main treatments. Young patients with a Cobb's angle between 20-35° are treated with braces, and surgical procedures are required in the case of severe curvature above 40° [50]. However, wearing a brace has been reported to be controversial because of insufficient evidence [6], can deteriorate the quality of life [51], and may cause embarrassment [52]. In general, for scoliosis of less than 20°, Chuna manual therapy may be applied in the absence of active treatment [53].

Chuna manual therapy includes the manipulation using the hands or other parts of body, or using devices to assist in the stimulation of the meridians for the correction of skeletomuscular malposition, and together with active and passive exercise, physical

symptoms may be improved [54]. In 2019, Chuna manual therapy was included in the national health insurance coverage [55]. Now that costs for Chuna manual therapy are more affordable, it is expected that it will be used in a wider variety of diseases.

Previous systematic reviews have summarized manipulative therapies used to treat AIS. Lotan et al [56] reported that most case studies in this area of research have limitations due to poor methodological quality, and only reported on 1 RCT. Romano et al [11] also reviewed manual therapy for AIS studies, and due to the lack of high quality studies, it was concluded that it was difficult to assume that manual therapy techniques were effective at curing AIS, highlighting the need for control groups in these studies.

To analyze the efficacy of Chuna manual therapy for AIS, 6 online databases were used, and 34 clinical studies were selected for systematic review in this study. Interestingly, 26 studies were performed in the last decade, indicating an increasing interest in this area.

Chuna therapy was performed typically "1-2 times per week" for 3-6 months (5 RCTs) or for 12 months (8 RCTs).

Twenty-seven studies (79%) used Cobb's angle to measure changes before and after Chuna manual therapy. VAS and Numerical Rating Scale scores were also commonly used to measure subjective pain. Various indices were used to show improvements in pulmonary function [17,19,21,24], muscle balance [12,17,18,21,24] and psychological change [12,25,44] following Chuna manual therapy. Heterogeneity among evaluation indices resulted in difficulties performing meta-analysis of previous RCTs. Accordingly, a standardized evaluation index to measure efficacy of AIS is needed, although using more diverse indicators would help in the assessment of various aspects of Chuna manual therapy.

All the studies in this review used Chuna manual therapy as the main intervention. In RCTs, brace treatment was the most common intervention used as the control group [12,14,16-18,20,21,24]. Brace treatment is considered a typical method of conservative treatment for AIS. Therefore, this review mainly focused on differences in efficacy between Chuna manual therapy and brace treatment.

Thirty-one studies (91%) showed that Cobb's angle decreased after Chuna manual therapy, and 4 studies (12%) indicated chiropractic manipulation was as effective as brace treatment, but no significant difference between the 2 groups was reported. However, in these 4 studies, Chuna manual therapy had several advantages over brace therapy, for instance, improved pulmonary function and muscle imbalance. Three studies (9%), which used evaluation indices other than Cobb's angle, reported that adolescents who had Chuna manual therapy, had less subjective pain and a better quality of life, which was reflected in the VAS, Scoliosis Quality of Life Index, or Oswestry Disability Index scores.

Adverse events were uncommon in the analyzed studies. Seven studies reported that there were no adverse reactions during Chuna manual therapy, and 3 other case studies reported benign reactions such as local pain or bruising. There were fewer dropouts in the Chuna manual therapy groups, which suggested that patients were more compliant compared with the brace group, where more patience to finish the course of treatment may be required.

In this review, the risk of bias was evaluated using Cochrane's risk of bias tool. Overall the assessment of bias indicated that most of the 34 studies had "unclear risk" items. Seven RCTs (50%) used a randomizing method, and 3 RCTs (21%) used a visiting order for randomizing, or did not report that the study was randomized. Only 5 RCTs (36%) used allocation concealment such as a sealed envelope. Most RCTs did not blind the participants to the study due to the characteristics of Chuna manual therapy. There was 1

study that included blinding of the participants and performed sham manipulation. More effort should be made in RCTs to blind the treatment. Outcome assessment was blinded in 5 studies (36%). Thirteen studies (93%) were categorized as “low risk” in the assessment of incomplete outcome data but the outcomes were not affected meaningfully. Only 1 study (7%) [25] had a protocol. From the evaluation of bias, it would be recommended that RCTs have a protocol thus reducing the risk of bias.

Even though there are different names to refer to manipulation therapy, such as Chuna, Tuina spinal and chiropractic treatment, after a thorough examination it is apparent that the actual manipulations used are not distinct from each other and include implementation of sudden, momentary pressure for correction techniques for the pelvis, thoracic, and lumbar vertebrae. Chuna manual therapy has been developed by incorporating various manipulative therapies from other countries. Therefore, in this review all these terms were included in the search. However, it is a limitation that there is no united nomenclature.

Conclusion

A review of 34 studies using Chuna manual therapy in the treatment of AIS showed that Chuna was more effective, or as effective, as commonly used treatments such as brace therapy. Chuna manual therapy had higher compliance, and less psychological sequela, and improved pulmonary function and muscle balance compared with other common treatments for AIS. This review has limitations due to the absence of a consensus naming of manipulation therapy, and outcome measures. A more detailed classification is needed to name various treatment methods of Chuna manual therapy more accurately. In addition, there is a need for well-designed RCTs to reduce the risk of bias.

Conflicts of Interest

The authors have no conflicts of interest to declare.

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Appendix A. Search Formulas According to Each Database.

<Results for PubMed>

Search	Query	Items found
#1	Search ((scoliosis) OR (idiopathic scoliosis) OR (adolescent scoliosis) OR (adolescent idiopathic scoliosis))	24,171
#2	Search ((Chuna) OR (Tuina) OR (chiropractic) OR (manipulation))	100,066
#3	#1 AND #2	210

<Results for Cochrane library>

Search	Query	Items found
#1	Search ((Chuna) OR (Tuina) OR (chiropractic) OR (manipulation))	7,833
#2	Search ((scoliosis) OR (idiopathic scoliosis) OR (adolescent scoliosis) OR (adolescent idiopathic scoliosis))	1,297
#3	#1 AND #2	31

<Results for NDSL Database>

Search	Query	Items found
#1	Search (ALL=SCOLIOSIS IDIOPATHIC SCOLIOSIS ADOLESCENT SCOLIOSIS ADOLESCENT IDIOPATHIC SCOLIOSIS)	22,645
#2	Search (ALL=CHUNA TUINA MANIPULATION CHIROPRACTIC)	165,300
#3	#1 AND #2	84

<Results for RISS Database>

Search	Query	Items found
#1	Search (ALL: Chuna <OR> ALL: Tuina <OR> ALL: chiropractic) (ALL: scoliosis)	88
#2	Search (ALL: manipulation <AND> ALL: scoliosis)	27
#3	#1 OR #2	115

<Results for OASIS Database>

Search	Query	Items found
#1	Search (Scoliosis <AND> Chuna)	11
#2	Search (Scoliosis <AND> manipulation)	3
#3	Search (Scoliosis <AND> Tuina)	0
#4	Search (Scoliosis <AND> chiropractic)	0
#5	#1 OR #2 OR #3 OR #4	14

<Results for CNKI>

Search	Query	Items found
#1	Search (“scoliosis” OR “idiopathic scoliosis” OR “adolescent scoliosis” OR “adolescent idiopathic scoliosis”)	4,802
#2	Search (“Chuna” OR “Tuina” OR “Chiropractic” OR “manipulation”)	52,548
#3	#1 AND #2	73