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Meta-Analysis of Physical Therapy Interventions for Scoliosis and Back Pain: Exploring Spine Solutions

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Correspondence
Asma Hameed

Ms. Asma Hameed
Assistant Professor, Ziauddin University
asma.h@zu.edu.pk

Ms. Misbah Anis Tabba
Physiotherapist, Liaquat National Hospital and Medical College
misbah_tabba@hotmail.com

Mr. Syed Amjad Hussain
Physiotherapist, Liaquat National Hospital and Medical College
amjadlnh93@gmail.com

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Abstract

Introduction

Scoliosis has been considered a major socioeconomic burden. It has been reported to affect around 0.93% to 12% of patients globally. There are multiple intervention options available to treat the condition. Among them, physical therapy is one of the most widely considered approaches. The growing evidence and adaptation of physiotherapy enhances the necessity for a rigorous meta-analysis.

Methodology

A complete review of various studies was conducted to assess the risk of biasness. The risk was calculated using Cochrane tool rigorously. To explore the solutions using physical therapy, Data were searched on Google Scholar, PEDro, MEDLINE, Cochrane Library, Embase and Web of Science, including an analysis of allocation risk. Studies in which participants were randomized and Blinded were included. Valid outcome measures were considered. Reviewing of data and selective reporting was a pivotal component of the assessment criteria.

Results

Patients were selected from seven RCTs .i.e. n=395 patients were selected. Scoliosis-specific exercises (SSE) showed a significant effect on reducing the Cobbs' angle as compared to the control group. The effect size was determined to be -1.03 (95% CI, -1.62 to -0.43) through standardized Mean Difference (SMD) as estimated using a random effects model.

Conclusion

Scoliosis-specific exercises were found to be more effective in improving posture and back pain and reducing the Cobb's angle in patients.

Keywords

Exercise, Musculoskeletal disorders, Physical Therapists, Rehabilitation, Scoliosis.

Introduction

The distinctive feature of scoliosis is a lateral curvature of the spine, which usually becomes apparent during the prepubescent development spurt[1]. Worldwide, the incidence of idiopathic scoliosis among teenagers varies from 0.93% to 12%. The condition may result in decreased lung function, respiratory impairment, chronic discomfort, weakening of the muscles around the spine, limited spinal movement, and psychological distress[2-3]. Depending on the severity of the condition, there are several treatment options for scoliosis. Non-operative treatments including bracing and scoliosis-specific exercise (SSE) are frequently advised to prevent further progress in situations when the curvature is modest (10°–25°), as is the case for many individuals. These treatments are intended to relieve discomfort related to the disease and address cosmetic problems. Similar cautious strategies are taken into consideration for mild curves with a range of 25° to 45°. But when scoliotic curves are severe—50° or more—surgical intervention becomes a reserved but crucial option[4-5]. This multi-tiered method is a complete strategy for controlling scoliosis, ranging from non-operative therapies for milder instances to surgical options for severe abnormalities. For patients with growth potential, bracing is the most popular conservative therapy if the Cobb angle is more than 25°. In order to straighten the trunk and de-rotate the rib cage, it generates an external pushing force[6]. The results of brace treatment are significantly influenced by skeletal maturity, curve magnitude, flexibility, and compliance with brace utilization. Nonetheless, bracing can cause patients' backs to flatten, be unpleasant, and have a detrimental impact on their quality of life (QoL). Furthermore, the majority of braces are unpleasant to wear, which lowers the compliance rate with brace usage[7-8]. On the other hand, patients often accept Scoliosis Specific Exercises (SSE). Furthermore, in order to stop the progression of scoliosis, SSE is advised either in addition to bracing or instead of it. Patients seem to embrace Scoliosis-Specific Exercise (SSE) as a viable option. In order to stop the progression of scoliosis, SSE is advised as a stand-alone intervention as well as a supplemental strategy to bracing[9-10]. There have been several SSE strategies investigated, with a focus on three main ideas: training in activities of daily life, stabilization of corrected postures, and three-dimensional self-correction[11]. Although particular methods may differ, they all work towards improving the overall management of scoliotic curves[11]. SSE has been shown to have positive impacts on curve regression in a number of recent research, which

emphasizes the necessity for a thorough examination using meta-analyses. The effectiveness of SSE in controlling scoliotic curves may be better understood by analyzing and synthesizing the available data, which will help researchers and clinicians to better comprehend SSE's potential role in the conservative management of scoliosis.

Methodology

Electronic Database and Search Strategies

Two separate reviewers thoroughly reviewed a number of databases, including Google Scholar, PeDro, MEDLINE, Cochrane Library, EMBASE, and Web of Science. MeSH phrases including "cobb angle," "scoliosis management," "scoliosis-specific exercises," and "scoliosis exercise therapy" were used in the search. The goal of the search was to find studies on the influence of scoliosis-specific exercises on patients with scoliotic curves. This methodical search aims to incorporate relevant studies on exercise program designed specifically for people with scoliosis.

Studies and Participants Eligibility Criteria

Studies evaluating the impact of exercise treatments tailored to scoliotic characteristics such as Cobb angle changes and spinal deformity fulfilled the inclusion criteria. Analyses of suitable studies performed between 2009 and 2022 that met the inclusion criteria were taken into account. The meta-analysis follows the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) standards, as illustrated in Figure-1.

This meta-analysis excluded trials using exercise regimens that differed from scoliosis-specific exercises (SSE). Furthermore, studies not presented in English and those for which the corresponding authors could not be reached were also excluded, along with those evidences for which full-text versions were inaccessible. A well-designed data extraction form was used to methodically collect all the necessary research information, such as the names of the authors, the years of publication, the characteristics of the scoliosis target population, and the length of time that scoliosis-specific exercise therapies were used (Table-1). This strict methodology was

designed to preserve methodological rigor and scholarly standards while guaranteeing the inclusion of relevant research centered on SSE for scoliosis therapy.

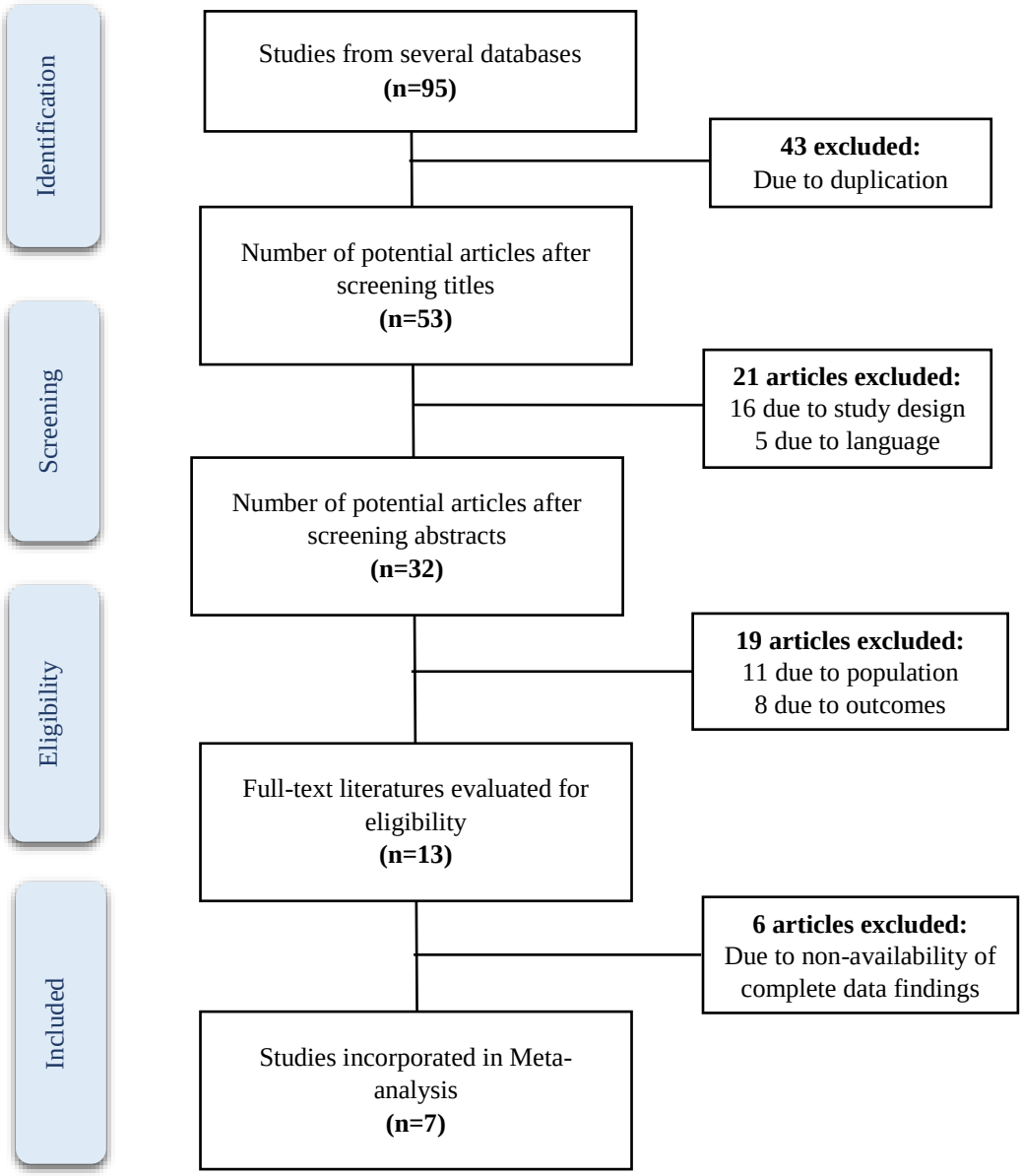

Figure-1 showing PRISMA flow of studies

Table-1 Description of studies incorporated for the purpose of meta-analysis

Author & Year of Publication	Sample Size	Target Population	Study Design	Age in Years	Intervention		Outcome
					Experimental Group	Control Group	
Yuan et al[12] 2022	52	Juvenile Idiopathic Scoliosis (JIS)	RCT	4-9 years	Scientific Exercise Approach to Scoliosis (SEES)	No exercise	Cobb Angle ATR
Kocaman et al[13] 2021	28	Adolescent Idiopathic Scoliosis (AIS)	RCT	10-18 years	Schroth Group SSE	Core Exercises	Cobb Angle Thorax Cobb Angle Lumbar Angle of Trunk Rotation (ATR)
Won et al[14] 2021	20	AIS	RCT	10-18 years	Neuromuscular Stabilization Technique	Non Scoliosis Specific Exercises	Cobb Angle
Mohamed et al[15] 2021	34	AIS	RCT	14-16 years	Schroth Group	PNF group	Cobb Angle and ATR
Negrini et al[16] 2019	198	AIS	RCT	>10 years	SSE	No exercises	Cobb Angle and ATR

Yagci et al[17] 2019	30	AIS	RCT	>12 years	SEAS	Core Exercises	Cobb Angle and ATR
Zapata et al[18] 2019	49	AIS	RCT	10-17 years	Schroth Exercises	Standard Care	Cobb Angle

EG denotes Experimental group performed Scoliosis Specific Exercises
CG denotes Control Group performed either conventional exercises or no exercises

Assessment of Risk of Bias

The methodological assessment of the included studies was thoroughly assessed by using the Cochrane tool parameters in a systematic manner to determine the risk of bias. Examining allocation risk in detail, including randomization and concealment techniques, was part of the assessment. Blinding strategies for participant involvement and outcome evaluation were used in the analyses. A careful review of the data, addressing concerns about incompleteness and selective reporting, was a crucial component of the evaluation process. Possible bias of various forms was also extensively investigated based on the authors' assessment. The extensive use of the Cochrane methodology provided a sophisticated and trustworthy academic assessment of the bias risk in the selected papers, which contributed to the meta-analysis's overall methodological strength.

Quantitative Analysis

The study conducted the analysis using MedCalc Statistical Software, version 20.112. The pooled effect was found using the Standardized Mean Difference (SMD) with a 95% confidence interval (CI). Cohen's rule of thumb, classifies effect sizes into three categories—small (SMD values between 0.2 and 0.4), moderate (SMD values between 0.5 and 0.8), and larger (SMD values more than 0.8)—was used to compute the effect size of SSE on outcome measures.

The I^2 statistic was used to determine the degree of heterogeneity. This statistic was crucial in helping to distinguish between a fixed effects model ($I^2 < 50$, implying homogeneity) and a random effects model ($I^2 > 50$, indicating high heterogeneity). This methodical statistical technique improved the quantitative analysis's accuracy and dependability, strengthening the findings' validity in the context of managing scoliosis.

Results

Flow of Study Inclusion

At the beginning, n=95 articles were found after a thorough search across six databases. After title screening, 53 articles were kept for additional assessment. Following an abstract screening process, n = 32 papers were found to be relevant for full-text evaluation. Ultimately, following a rigorous examination, n = 7 studies satisfied the preset inclusion requirements and were moved on to the analysis stage.

The combined sample size included n=395 patients from the 7 studies that were selected, with an emphasis on determining that Scoliosis Specific Exercises (SSE) affected the Cobb angle. In addition, an analysis was conducted on a subset of 5 trials with n = 342 individuals to determine the effect of SSE on the Angle of Trunk Rotation (ATR). The accuracy and academic rigor of the ensuing analyses on the effects of SSE on scoliosis-related outcomes were enhanced by this improved selection procedure and thorough breakdown of participant numbers.

Estimating the Pool Effect of SSE on Cobb Angle

A total of 395 participants from seven studies were included in the meta-analysis to examine the impact of Scoliosis-Specific Exercises (SSE) on scoliotic outcomes. Both random effects and fixed effects models were used in the analysis. The summary mean difference (SMD) for SSE under the fixed effects model was -0.649 (95% CI: -0.867 to -0.431), suggesting a modest and statistically significant effect size in favor of SSE. A more cautious estimate with an SMD of -1.030 (95% CI: -1.625 to -0.434) was produced using the random effects model, which adds additional evidence to the positive effects of SSE on scoliotic outcomes. Significant diversity among the studies was found by the test for heterogeneity (Q = 36.0172, p < 0.0001, I2 = 83.34%), indicating a high degree of inconsistency (Table-2).

Table-2 Pool effect of SSE on Cobb Angle

Study	N1	N2	Total	SMD	SE	95% CI	t	P	Weight (%)	
									Fixed	Random
Yuan et al[12] 2022	24	28	52	-1.346	0.304	-1.956 to -0.735			13.28	15.19
Kocaman et al[13] 2021	14	14	28	-2.127	0.464	-3.081 to -1.173			5.70	12.62
Won et al[14] 2021	10	10	20	-1.245	0.471	-2.235 to -0.255			5.53	12.51
Mohamed et al[15] 2021	17	17	34	-1.504	0.381	-2.281 to -0.727			8.45	13.97
Negrini et al[16] 2019	145	53	198	-0.0712	0.160	-0.387 to 0.244			48.01	17.08
Yagci et al[17] 2019	15	15	30	-0.378	0.359	-1.112 to 0.357			9.55	14.33
Zapata et al[18] 2019	19	14	33	-0.872	0.360	-1.607 to -0.138			9.48	14.31

Total (fixed effects)	244	151	395	-0.649	0.111	-0.867 to -0.431	-5.854	<0.001	100.00	100.00
Total (random effects)	244	151	395	-1.030	0.303	-1.625 to -0.434	-3.399	0.001	100.00	100.00
Test For Heterogeneity										
Q	36.0172									
DF	6									
Significance level	P < 0.0001									
I^2 (inconsistency)	83.34%									
95% CI for I^2	67.14 to 91.56									

Estimating the Pool Effect of SSE on ATR

Five studies with a total pooled sample size of 342 patients examined the effects of scoliosis-specific exercises (SSE) on the Angle of Trunk Rotation (ATR) in the meta-analysis. Both fixed effects and random effects models were used in the investigation. The summary mean difference (SMD) for the fixed effects model was -0.418 (95% CI: -0.655 to -0.180), suggesting a small to moderate effect size that was statistically significant in favor of SSE for lowering ATR. On the other hand, a more cautious estimate was produced by the random effects model, with an SMD of -1.116 (95% CI: -2.097 to -0.135), indicating a bigger but still significant impact size. Significant diversity amongst the studies was found by the test for heterogeneity (Q = 50.2097, p < 0.0001, I2 = 92.03%), suggesting significant inconsistency. Because of the high level of heterogeneity that has been seen, it is important to carefully evaluate the data and take into account any possible sources of variance between studies (Table-3).

Table-3 Pool effect of SSE on ATR

Study	N1	N2	Total	SMD	SE	95% CI	t	P	Weight (%)

									Fixed	Random
Yuan et al[12] 2022	24	28	52	-0.685	0.282	-1.252 to -0.118			18.33	21.22
Kocaman et al[13] 2021	14	14	28	-0.826	0.383	-1.614 to -0.0384			9.93	20.07
Mohamed et al[15] 2021	17	17	34	-4.841	0.676	-6.217 to -3.464			3.19	16.05
Negrini et al[16] 2019	145	53	198	-0.0898	0.160	-0.405 to 0.226			56.99	22.25
Yagci et al[17] 2019	15	15	30	-0.0378	0.355	-0.766 to 0.690			11.55	20.41
Total (fixed effects)	215	127	342	-0.418	0.121	-0.655 to -0.180	-3.459	0.001	100.00	100.00
Total (random effects)	215	127	342	-1.116	0.499	-2.097 to -0.135	-2.238	0.026	100.00	100.00
Test For Heterogeneity										
Q	50.2097									
DF	4									
Significance level	P < 0.0001									
I^2 (inconsistency)	92.03%									
95% CI for I^2	84.39 to 95.93									

Risk of Bias Assessment

The critical appraisal of the studies was performed on the guidelines of Cochrane (Table-4).

Randomization

Randomization was found in all studies suggesting a low risk of bias (12-18)

Allocation Concealment

Allocation concealment was found in all studies (12-18)

Blinding of Participants and Personnel

In study (12 and 14) participants were blinded. In remaining studies blinding or participants and personnel was unknown (13, 15, 16, 17 and 18).

Outcome Assessment Blinding

Outcome assessment was at low risk in all studies (12-18).

Incomplete Outcome Data

All studies reflects low risk of bias (12-18).

Reporting Selection Bias

All studies reflects low bias risk under this head (12-18).

Table-4 Assessing the Risk of Bias

Authors	Allocation Randomization	Allocation Concealment	Participants Blinding	Outcome Assessment Blinding	Incomplete Outcome Data	Selective Reporting
Yuan et al[12] 2022	+	+	+	+	+	+
Kocaman et al[13] 2021	+	+	?	+	+	+
Won et al[14] 2021	+	+	+	+	+	+
Mohamed et al[15] 2021	+	+	?	+	+	+
Negrini et al[16] 2019	+	+	?	+	+	+
Yagci et al[17] 2019	+	+	?	+	+	+
Zapata et al[18] 2019	+	+	?	+	+	+

−, bias at high risk
+, bias at low risk
? , unknown risk of bias

Discussion

Scoliosis-Specific Exercises (SSE) were evaluated for their effect on scoliotic outcomes by a meta-analysis that focused on Cobb angle and Angle of Trunk Rotation (ATR). There were seven included studies totaling 395 patients diagnosed with either juvenile idiopathic scoliosis (JIS) or adolescent idiopathic scoliosis (AIS), ages ranging from 4 to 18 years. The Scientific Exercise Approach to Scoliosis (SEES), Schroth exercises, Core exercises, Neuromuscular Stabilization Technique, and Standard Care were among the therapies used in the trials were evaluated and analyzed. According to Cochrane criteria, the risk of bias assessment showed a typically low risk

across trials. All trials used randomization and allocation concealment; two studies reported participant blinding. In all trials, there was not much risk associated with insufficient outcome data and reporting selection bias, and there was minimal risk related with outcome assessment blinding. A statistically significant and moderate impact size was found in favor of SSE for decreasing the Cobb angle using quantitative analysis utilizing both fixed and random effects models. The favorable impacts of SSE were nevertheless confirmed by the random effects model, which offered a more cautious estimate. The random effects model had a larger but statistically significant impact size, while the fixed effects model had a low to moderate effect size favouring SSE. However, considerable heterogeneity was seen in both analyses, emphasizing the importance of careful interpretation and considering potential reasons of variance. The observed heterogeneity was impacted by changes in participant ages, sample sizes, and interventions between studies. A study looked at the effect of physiotherapy-based scoliosis-specific exercise (PSSE) on people with intermediate idiopathic scoliosis (JIS). In addition to daily corrective posture exercises based on the Scientific Exercise Approach to Scoliosis (SEAS), the PSSE group received 30 minutes of daily over-corrective training utilizing Schroth methods. The PSSE group exhibited a substantial reduction in the angle of trunk rotation (ATR) from 3.0° to 5.0° and in the Cobb angle from 15.0° to 5.0° after a year of intervention. The observation group, on the other hand, noticed an increase in the Cobb angle but no discernible change in the ATR12. PNF and Schroth exercises were examined on n=34 females of aged between 14 to16 years, with scoliotic curves that were randomized to the PNF group or the Schroth group. For six months in a row, participants in two groups received one-hour treatments for 3days/week. The right total static plantar pressure and Cobb's angle significantly decreased in both groups, with the Schroth group seeing a greater reduction in both parameters. While there were no discernible changes in the PNF group, the Schroth group showed a considerable decrease in the Cobb angle of angle trunk rotation[15]. In routine clinical settings, the efficacy of physiotherapeutic scoliosis-specific exercises (PSSEs) for adolescents with idiopathic scoliosis (AIS) was investigated. The study comprised 327 consecutive patients who met particular inclusion criteria. Patients were divided into groups and allocated to conduct PSSE in accordance with the SEAS (Scientific Exercise Approach to Scoliosis) School, get standard physiotherapy (UP), or receive no therapy (controls). Analysis was done on the treatment results at the conclusion, such as medical release, Risser sign 3, or failure (defined as

needing bracing before growth ends or Cobb angle more than 29°). With a 1.7-fold increase in success rate compared to controls in the efficacy analysis and a 1.5-fold rise in intent-to-treat analysis, the data showed that SEAS considerably decreased the chance of failure and improve patient adherence to exercises[16]. Participants with AIS curves ranging from 12° to 20° and Risser grade 0 can select between the PSSE group, which followed the Barcelona Scoliosis Physical Therapy School program, and the control group, which received just observation. Cobb angles were measured by a blind observer at the baseline, six-month, and one-year follow-ups. At the 1-year follow-up, the exercise group exhibited smaller curves 16.3° post intervention vs. 21.6° baseline and less curve advancement to 0° post vs. 5.6° at baseline based on 49 patients data. This small prospective series reveals that PSSEs led to much less curve growth compared to controls, even if bracing rates were similar between groups (37% vs. 43%)[18].

Conclusion

The study found that, Scoliosis-Specific Exercises were found to be effective in reducing the Cobb's angle as estimated using the SMD model that revealed a substantial effect size. Future studies should focus on addressing the causes of heterogeneity and improving our knowledge of particular exercise regimens within SSE that might produce the best outcomes. However, the current meta-analysis offers encouraging data about the possible efficacy of exercises specifically designed for scoliosis care, providing a foundation for additional investigation in both clinical and research contexts.

Authors Contribution

Hameed A: Conception, design and data acquisition.

Tabba MA: Data acquisition and analysis.

Hussain A: Drafting and critical revision.

Declaration of Interest

None.

Funding Sources

None.

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