Effectiveness of Physiotherapeutic Scoliosis-Specific Exercises Versus General Exercises in Adolescent Idiopathic Scoliosis: A Systematic Review and Meta-Analysis

Luljeta Stanaj^{1*}, Muhammed H. Pekeren², Nikos Karavidas³, Yavuz Yakut⁴, Enkeleda Sinaj⁵

¹ Department of Physiotherapy, University Hospital of Trauma, Tirana, Albania
 ² Istinye University, Institute of Graduate Education, Istanbul, Turkey
 ³ Schroth Scoliosis and Spine Clinic, Athina Greece
 ⁴ Hasan Kakyoncu University, Department of Physiotherapy and Rehabilitation, Gaziantep, Turkiye
 ⁵ University of Medicine, Faculty of Technical Medical Sciences, Tirana, Albania

Abstract

Introduction: The effectiveness of physiotherapeutic scoliosis-specific exercises (PSSE) over general exercises (GE) in adolescents' idiopathic scoliosis (AIS) is a topic of much debate.

Method: PubMed, Scopus, Cochrane, Embase, and PEDro databases were systematically searched for studies comparing PSSE versus GE and reported the outcomes of Cobb angle (CA), Anterior Trung Rotation (ATR), and Quality of life (QoL). Mean differences (MD) and 95% confidence intervals (CI) were pooled using a random- effects model. Heterogeneity was examined with I2 statistics.

Results: We included 6 RCTs and 3 observational studies with 749 patients with AIS, of whom 442

(59.1%) patients received PSSE therapy and 307 (40.9%) were assigned to GE. The mean age was 13.57 years. Mean follow-up ranged from 3 to 54 months. Risser signs 0-5. PSSE significantly reduced Cobb angle (MD -3.10°; 95%CI [- 5.55,-0.66]; I2=91%; p=0.01) and ATR (MD -2.13°; 95%CI [-3.05, -1.22]; I²=89%; p<0.001) as compared with GE. There was no statistical difference between groups in QoL analyzed by the Scoliosis Research Society Questionnaire 22 total score (MD 0.06°; 95%CI [-0.21, 0.34]; I²=88%; p=0.64).

Conclusions: These findings suggest that PSSE promoted a higher reduction in Cobb angle and ATR than GE in patients with AIS without a significant impact in QoL.

Address for correspondence: Luljeta Stanaj*, Department of Physiotherapy, University Hospital of Trauma, Tirana, 1000, Albania. Address: Street Isuf Elezi, Tirana. E-mail: luljeta.stanaj@umed.edu.al

Keywords: Adolescent idiopathic scoliosis, physiotherapeutic scoliosis specific exercises, general exercises

INTRODUCTION

Idiopathic scoliosis is a three-dimensional spinal deformity with an unknown etiology characterized by a lateral deviation in the frontal plane, an axial rotation in the horizontal plane, and an abnormal curve in the sagittal plane (1). Scoliosis can develop at any age, but it appears more in periods of rapid growth, including the first 6-24 months of life, between 5 and 8 years, and with a high growth point in puberty, approximately around the age of 11-14 years (2,3,4). According to the Society on Scoliosis Orthopaedic and Rehabilitation Treatment (SOSORT), the global incidence of adolescent idiopathic scoliosis (AIS) is around 0.93%-12.0% (5). Women are more affected (6), at a rate of 10:1 as compared with men (7).

According to SOSORT, the physiotherapeutic scoliosis-specific exercises (PSSE) should be based on 3D correction. PSSEs have in their foundation the 3-dimensional correction of the posture, the stabilization of the corrected posture, the education of the patient, and the integration of these positions in daily life activity (5).

However, the PSSEs are complex, require training, and are not widely adopted, which limits their scientific validation. Prior meta-analyses have shown that PSSE is superior to general exercises in reducing Cobb angle, and angle of trunk rotation (ATR) (8,9). However, these prior meta-analyses included studies comparing PSSE therapies versus standard care or observation therapies, which limits the direct comparison of PSSE versus other active therapies. Also, the prior meta-analysis did not include the novel PSSE- Schroth therapy (10). Therefore, we performed an updated systematic review and meta- analysis to compare two active therapies -PSSE versus general exercises in patients with idiopathic scoliosis (IS).

METHODS

The systematic review and meta-analysis were performed and reported following the Cochrane Collaboration Handbook for Systematic Reviews of Interventions and the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) Statement guidelines (11,12). This systematic review with meta-analysis was registered in the International Prospective Register of Systematic Reviews (PROSPERO; CRD42024576432).

Study eligibility

We included studies that met the following eligibility criteria: (1) peer-reviewed RCTs or observational studies; (2) comparing PSSE versus GE; (3) in adolescents with AIS aged 10-18 years old; (4) reporting at least one of the clinical outcomes of interest; and (5) studies with population meeting at least one the following AIS diagnostic criteria: use of braces, Risser stage 0-5, and a Cobb angle between 10-45 degrees. We excluded studies with (1) patients already receiving other active therapies at the same time with PSSE; (2) no outcomes of interest; and (3) an overlapping patient population with a larger study. There were no restrictions concerning the date or language of publication.

Search strategy and data extraction

MEDLINE, Cochrane, Scopus, Embase, and PEDro databases were searched from inception to August 4, 2024. The keywords used included: ("Adolescent Idiopathic Scoliosis" OR AIS OR ((Scoliosis[mh] OR "Idiopathic Scoliosis") AND AND (PSSE adolescent*)) OR "Physiotherapeutic scoliosis-specific exercises" OR Schroth OR PSSE-Schroth OR "Barcelona Scoliosis Physical Therapy School" OR BSPTS OR "side shift" OR lyon OR "Functional Individual Therapy of Scoliosis" OR FITS OR "Scientific Exercise Approach to Scoliosis" OR SEAS OR fed OR dobomed) AND ("general exercise*" OR "core exercise*" OR ((stabilization OR stabilization) AND (core OR trunk OR neurodynamic)) OR "conventional therapy" OR "muscle strengthening" OR "stretching" OR "usual therapy" OR pilates).

We extracted data for (1) Cobb angle; (2) trunk rotation; and (3) Quality of life (QoL) assessed by the SRS-22 questionnaire. All articles were systematically assessed using the pre-specified inclusion and exclusion criteria. Three reviewers (between L.S., M.P., and Y.Y) undertook the article selection and data extraction independently. Disagreements were resolved by consensus.

Quality assessment

The Cochrane tool for assessing risk of bias in randomized trials (RoB 2) was utilized for the quality assessment of randomized studies (13). The ROBINS-I was used for assessing the risk of bias in observation studies (14). Three authors (L.S., Y.Y, and M.P.) independently evaluated the risk of bias. Disagreements were resolved by consensus between authors. We explored the potential for publication bias by visually examining the funnel plots for the primary efficacy and safety endpoints.

Data analyses

Treatment effects for continuous outcomes were analyzed using mean difference (MD) with 95% confidence intervals. Heterogeneity was examined with Cochran's Q test, I² statistics, and Tau-square using the DerSimonian and Laird estimator. Heterogeneity was reported as low (I²=0–25%), moderate (I²=26–50%), or high (I²>50%). The random- effects model was used in all studies. All statistical analyses were performed using Review Manager statistical software.

RESULTS

Study selection and baseline characteristics

Our systematic search yielded 377 potential articles. (Figure 1) follows the PRISMA for study selection (11). After removing duplicates and excluding articles based on title or abstract, 36 studies were retrieved and reviewed in full for possible inclusion. Finally, 6 RCTs and 3 observational studies met all inclusion criteria and were included in our meta- analysis (10, 15-22). We included 749 patients, with 442 (59.1%) patients assigned to PPSE therapy and 307 (40.9%) assigned to GE. The mean age was 13.5 years and 615 (82.1%) patients were women.

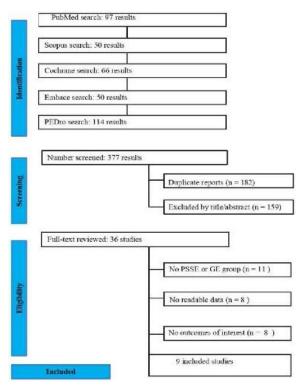


Figure 1. PRISMA flow diagram of study screening and selection

Table 1 summarizes the baseline characteristics of the included studies. Table 2 summarizes the study design, endpoint definition, and key findings of each included study.

Study	Design	Number	Female	Age	Cobb angle	Follow
		of patients			initial	Up
		I/C	I/C	I/C	I/C	
Mohamed	RCT	17/17	100%/100%	14.50 ± 1.20	20.42 ± 2.57	6 Months
2021				14.9 ± 1.40	20.21±2.80	
Kocaman	RCT	14/14	71.4%/78.5%	14.7±2.37	17.64±4.01	10 Weeks
2021				14.21±2.19	17.29±3.45	
Kim 2016	RCT	12/12	100%/100%	15.60±1.1	23.6±1.5	12 Weeks
				15.3±0.8	24.0±2.6	
Monticone	RCT	55/55	70.9%/74.5%	12.5(1.1)	19.3(3.9)	54 months
2014				12.4(1.1)	19.2(2.5)	
Noh Koog	Observational	16/16	75%/87.5%	13.8(2,8)	21.6±10.1	30 session
Dong 2014				14.9(2.3)	19.0±7.0	
Karavidas	Prospective	153/58	96.7%/93.1%	12.6	20.8(15-25)	Mean
2024	Control Study			13.1	19.4(15-25)	29.4 months
Negrini	Observational	145/95	71%/80%	12.07(1.05)	$15,36 \pm 2.67$	28 months
2019	Study			12.07(1.07)	15.38 ± 2.62	
Moubarak	RCT	15/15	60%/66.6%	12.03(1.94)	19.06±2.62	12 weeks
2022				11.5(1.58)	18.76±3.57	
Yagci	RCT	15/15	100%/93.3%	14.2(1.5)	27.6±8.0	4 months
2019				14.0(1.3)	30.0±9.3	

Values are presented as mean ± standard deviation, number (%), or range; C: control group; I: intervention group; RCT: randomized controlled trial.

Authors and	Baseline	Intervention	Variables measured	Key findings
	Characteristics	details		
Authors and publication Year N. Karavidas et al., 2024	Characteristics Age >10 years old Risser sign of 0-2 -Cobb angle of		-Cobb angle (CA) to measure the curve magnitude of the spine. -The angle of trunk rotation (ATR) was measured using the scoliometer- Scoliosis Research Society-22 (SRS-	-In the PSSE-Schroth group 63.2% remained stable, 23.9% improved, 12.9% worsened. The mean difference reached statistical significance for Cobb L/TL (p=0.02) but not for Cobb angle Th p=0.08). Only 16 subjects prescribed a brace. The success rate was 87.1%(p=0.002) -A significant decrease on ATR Th with mean 5.9°, p=0.04 and
	10-25 degrees ATR >5 with a high risk of	2. General or no exercises	22) questionnaire to assess health-related quality of life -Trunk Appearance Clinical Evaluation (TRACE), for body symmetry assessment - TAPS questionnaire	-
	progression		Compliance%	Improvement without statistical significance on pain 23.6, p=0.06; Satisfaction was excellent. -TAPS with p=0.03. On the control group 25.9% were stable, 74.1% warsened and 39 subject required brace (p=0.003). -A fully compliance analysis showed a sucses rate 94.8% as 53.8% remained stable, 41% improved 7,7% worsened. p=0.02 Moderate compliance showed 75.9% remain stable, 13% improved, 11.1% progresed p=0.05. Poor compliance 64.4% remaned stable, 0% improved and 35.5% progresed.
H. Kocaman et	- Adolescents	-Schroth group	1. Primary outcome:	Cobb Angle Thorasic and
al., 2021	idiopathic	(SG): Performed	Cobb angle	lumbar Improvement: The Schroth
	scoliosis	Schroth + traditional	2. Secondary	group showed greater
	Aged 10-18	uaunonai	outcomes:	improvement than the core

Table 2. Characteristics of the studies included in the meta analysis

	years • Risser stage < 3 • Cobb angle between 10-30 degrees • No history of other medical conditions • No prior treatment for scoliosis - 21 females, 7 males	exercises 90 min, 3 times/week -Core group Performed core stabilization (CS) exercises and traditional exercises, 90 min, 3 times/week	 Trunk rotation angle (ATR) Cosmetic trunk deformity (WRVAS) Spinal mobility (Spinal Mouse) Health-related quality of life (SRS- 22 questionnaire)- Peripheral muscle strength (Biodex dynamometer) 	group with a statistically significant p-value of <0.001. Thoracic Trunk Rotation Angle: Similar to the Cobb angle, the Schroth group had a significant improvement over the core group (p<0.001), but no significant group by time on ATR Lumbar p=0.302 Cosmetic Trunk Deformity: The Schroth group demonstrated significant enhancement in cosmetic trunk deformity (p<0.001). Quality of Life (SRS-22): The Schroth group reported significant improvements in quality of life (p<0.001). Peripheral Muscle Strength: The core group showed greater improvement in peripheral muscle strength with a significant p-value of <0.001 compared to the Schroth group.
R.A. Mohamed et al., 2021	 Adolescents aged 14-16 years old. Cobb angle <25 degrees. Risser sign of 2-5. No other treatments that could affect scoliosis. 	-Schroth exercise group - Patients received the Schroth 3D exercise for 1 hour, 3 times/week. -The proprioceptive neuromuscular facilitation (PNF) group received PNF for 1 hour, 3 times/week.	 Cobb angle (measured by x-ray) Angle of trunk rotation (measured by scoliometer). Static plantar pressure distribution. Functional capacity. Adherence rate. 	 -Post-treatment comparison between SG and PNF group revealed significant differences with superior affect to the Schroth group (p<0,001) on Cobb angle, ATR, Static plantar pressure and 6 minute walk test (6MWT). -Adherence rate 98%
E.E.S.Moubarak et al., 2022	 Adolescents with mi ld idiopathic scoliosis. Age10-14 years. Cobb angle 	-The Core stabilization group, 60 min, 3 times/week and 20min at home.	-The Cobb angle -Back cle endurance -ATR	-The post-treatment results revealed a significant difference in Cobb angle (p <0.001), ATR (p <0.001), and Total score of SRS-22(p <0.05) in favor of the CS group

	10-20 degres -Risser <2	-The Active self- correction (ASC) exercises, 60	-Quality of life using SRS-22	- No significant difference in self-image and mental health between groups (p>0.05).
		min, 3 times/week and 20 min at home	Video compliance	
M.Montione et	- Primary	The intervention	- Cobb angle	- In the experimental
al.,	diagnosis	group	-ATR	Cobb angle, improved in 69%,
2014	AIS.	ASC for 60 min , 1	- Scoliosis Research Society (SRS-	(decreased $<3^{\circ}$), worsened 8% (increase $>3^{\circ}$) and
	-Cobb	time/week	Questionnaire	remained stable. The
	10-25 degrees.	30 min, times/week	quality of life	change after training was -5.3 (p<0.001)
	-Risser sign	home.	- Compliance	-In the control group,
	< 2	- The control	-	improved, 39% worsened and 55% remained stable. The mean
	-Age > 10	group received		change after training was
	years	general		(p<0.001)
	•	exercises for 60		-The mean change in ATR
		min , 1		the ASC group after training was
		time/week and		-3.5. (p<0.001)
		30 min, 2		In the control group the ATR
		times/week at		remained stable. (p<0.001)
		home		-Significant improvements
				the experimental group on SRS-
				22 with post-training
				>0.75 for all the (p<0.001)
				-No significant changes were
				observed on the control group
				The subgroup <13 years on ASC
				group exhibited a mean change -
				4.9. $(p<0.001)$, whereas a mean
				change of -5.8 for subjects >13
				years (p<0.001)
				In the ASC group 71% improved, 9.7% worsened and
				19.3% remained stable. In the control group 9.4% improved,
				31.2% worsened and 59.4% remained stable at age <13
				years.
				In the ASC group 66.7%
				improved, 4.8 % worsened and 28.5% remained stable. In the
				control group 0% improved,

				52.6% worsened and 47.4% remained stable at age <13 years
G. Yagci et al., 2019	 Adolescents idiopathic scoliosis Cobb angle 20-45° Prescription brace or conservative treatment. Risser sign 2-3 -Aged >12 years 	Core stabilization (CS) for 40 min 1 time/week and 20 min daily at home. -SEAS group for 40 min 1 time/week and 20 min daily at home Both weared brace 23h/day	-Cobb angle, - Angle of trunk rotation (ATR), -Posterior Trunk Asymetri Index (POTSI) -Walter Reed Visual Assessment Scale (WRVAS) -Quality of life (QoL) with SRS-22 Compliance	The mean decrease on cobb angle was -5.6 for CS and -5.2 gor SEAS Compliance with the brace was 88% in CS, with 79.6% in SEAS group. Compliance with home exercises was 61.6% in CS with 63.7% in SEAS group (p= 0.78)
D.K.Noh et al., 2014	Adolescents idiopathic scoliosis -Aged 10-19 years	3 Dimentional corrective spinal technique (CST) for 60 min /day , 2-3 times /week) Concentional exercises program (CE) for 60 min /day , 2-3 times /week)	Cobb Angle Thorasic kyfosis Lumbar lordosis Sacral scope Pelvic tilt Pelvic incidence Vertebral rotation (VR) Quality of life	CST group Showed greater improvement in Cobb Angle (p=0.03) SRS-22 Score total (p=0.041) There were no significant changes in other measurement between groups.
G.Kim et al., 2016	Idiopatic Scoliosis Patients Cobb >20°	Schoth (SG), 60 min, 3 times/week Pilates (PG), 60 min 3 times/week	Cobb angle Body distribution	The intragroup comparison showed significant efect on cobb angle for both groups (p<0.05). There was a significant difference in the total weight for SG(p<0.05), but no significant in PG(p>0.05)
S.Negrini et al., 2019	Adolescents idiopathic scoliosis - Aged >10 years Riser 0-2 Cobb angle 11°-20°	SEAS Group, Usual Physiotherapy Group (UG), No therapy,	Cobb angle ATR TRACE Rib hump height	Significance difference was found for cobb angles in all groups, but within the error range 5° Trace improved significantly better tha the (UG) group Significance difference was in the SEAS group for hump height.

Pooled analysis

In patients with AIS, PSSE therapy reduced Cobb angle (MD -3.10°; 95%CI [- 5.55,-0.66]; I 2 =91%; p=0.01; Figure 2). PSSE also reduced ATR (MD -2.13°; 95%CI [-3.05, -1.22]; I 2 =89%; p<0.001; Figure 3).

There was no statistical significance in total SRS-22 score (MD 0.06; 95% CI [-0.21, 0.34]; I 2 =88%; p=0.64; Figure 4a), and in the individual components of function (MD 0.25; 95%CI [-0.40, 0.90]; I 2 =89%; p=0.45; Figure 4b), pain (MD 0.08; 95%CI [-0.51, 0.36]; I 2 =90%; p=0.72; Figure 4c), self-perceived image (MD 0.20; 95%CI [-0.39,0.79]; I 2 =96%; p=0.51; Figure 4d), mental health (MD 0.38; 95%CI [-0.03, 0.80]; I 2=88%; p=0.07; Figure 4e), and satisfaction with menage (MD 0.31; 95% CI [-0.374,]; I 2 =96%; p=0.37; Figure 4f).

Study or Subgroup	Exp Mean	erimenta SD	il Total	Mean	Control SD	Total	Weight	Mean difference IV, Random, 95% CI	Mean difference IV, Random, 95% Cl
Karavidas	20.15	4.68	163	26.73	5.65	58	14.3%	-6.58 (-8.20 , -4.96)	
Kim Kocaman	12 9.71	16.28 3.47	12	16 13.57	23.89 5.03	12 14	2.0%	-4.00 [-20.36 , 12.36] -3.86 [-7.06 , -0.66]	· ·
Mohamed Monticone	14.11 14	1.96	17 55	17.46 20.9	2.37	17	14.5% 15.0%	-3.35 [-4.81 , -1.89]	-
Moubarak	16.11	3.01	15	13.51	3.96	15	13 2%	2.60 [0.08 , 5.12]	-
Negrini Noh	17.07 13.5	7 29	145 16	17.7	7.33	95 16	14.0%	-0.63 [-2.52 , 1.26] -1.20 [-8.06 , 5.66]	
Yagci	21.4	7.1	15	24.7	9.7	15	7.9%	-3.30 [-9.38 . 2.78]	
Total			452			297	100.0%	-3.10 [-5.55 , -0.65]	•
Test for overall effect: Test for subgroup diffe Heterogeneity: Tau ³ = Rain 3. Scottaki Arginal Tr	rences: Nol 10.19; Chi ^a	t applicat	ie df=8 (P	< 0.0000	1): i ² = 919	6			-10 -5 0 5 10 Favor PS3E Favor GE
Study or Subgroup	Exp Mean	sD	Total	Mean	Control SD	Total	Weight	Mean difference IV, Random, 95% Cl	Mean difference IV, Random, 95% Cl
Karavidas	6.06	1.87	163	8.32	2.39	58	20.2%	-2.26 [-2.94 , -1.58]	-
Kocaman Mohamed	3.64 5.23	1.91	14 17	5.79 8.17	3.02 0.72	14 17	11.7%	-2.15[-4.02,-0.28] -2.94[-3.34,-2.54]	
Monticone Negrini	3.6 5.94	1.1	55 145	6.6 5	1.2	55 95	21.6%	-3.00 [-3.43 , -2.57] -0.06 [-0.86 , 0.74]	•
Yagci	6.4	3.7	15	8.7	5.6	15	5.5%	-2.30 [-5.70 . 1.10]	
Total			409			254	100.0%	-2.13 [-3.05 , -1.22]	•
Test for overall effect. Test for subgroup diffe Heterogeneity: Tau ² =	rences; Nol	t applicab	de .	0.00001	; 1° = 89%				-10 -5 0 5 10 Fevor PSSE Fevor GE
Riperto di J., 1998 Tostel		orimenta	4		Control			Mean difference	Mean difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% Cl	IV, Random, 95% CI
Kosaman 2021	4.56	0.13	14	4.3	0.17	14	34.8%	0.26 [0.15 . 0.37]	
Moubarak 2022 Noh 2014	3.45 4.5	0.13	15 8	3.56	0.12	15 4	35.6% 3.4%	-0.11 [-0.20 , -0.02] 0.40 [-1.00 , 1.80]	
Yagci 2019	4.1	0.4	15	4.1	0.4	15	26.2%	0.00 [-0.29 , 0.29]	-
Total			52			48	100.0%	0.06 [-0.21 , 0.34]	+
Test for overall effect: Test for subgroup diffe Heterogeneity: Tau ² = Figure (), SRS Function	rences: Nol	t applicab		0.0001);	l" = 88%				-1 -0.5 0 0.5 Favors GE Favors PSSE
Sludy or Subgroup	Exp Mean	erimenta SD	il Total	Mean	Control SD	Total	Weight	Mean difference IV, Random, 95% Cl	Mean difference IV, Random, 95% CI
Monticone 2014	4.7	0.2	55	4	0.4	55	39.6%	0.70 [0.58 . 0.82]	+
Moubarak 2022 Noh 2014	3.23	0.25	15	3.33	47	15	6.3% 16.9%	-0.10 [-2.48 , 2.28] 0.10 [-1.10 , 1.30]	
Yagci 2019	4.6	0.4	15	4.6	0.4	15	37.2%	-0.10 [-0.39 . 0.19]	
Total			93			89	100.0%	0.25 [-0.40 , 0.90]	
Test for overall effect: Test for subgroup diffe Heterogeneity; Tau ² =	rences: Not	t applicab		0.00001	; 1ª = 89%				-1 -0.5 0 0.5 Favors GE Favors PSSE
Study or Subgroup	Exp Mean	erimenta SD	Total	Mean	Control SD	Total	Weight	Mean difference IV, Random, 95% Cl	Mean difference IV, Random, 95% Cl
Monticone 2014									
Moubarak 2022	4.6	0.3	55	4.3	0.3	55	35.0%	0.30 [0.19 . 0.41]	-
Noh 2014	4.6 3.39 4.9	0.3 0.23 1	55 15 8	4.3 3.62 4.6	0.3 0.29 2.4			-0.23 [-0.42 , -0.04]	· · ·
Noh 2014 Yagci 2019	3.39	0 23	15	3,62	0.29	55 15	35.0% 33.6%		·
	3.39 4.9	0.23	15 8	3.62 4.6	0.29	55 15 4	35.0% 33.6% 2.9%	-0.23 [-0.42 , -0.04] 0.30 [-2.15 , 2.75]	
Yagci 2019	3.39 4.9 4.3	0.23 1 0.5	15 8 15	3.62 4.6	0.29	55 15 4 15	35.0% 33.6% 2.9% 28.6%	-0.23 [-0.42 , -0.04] 0.30 [-2.15 , 2.75] -0.40 [-0.76 , -0.04]	
Yagci 2019 Total	3.39 4.9 4.3 Z = 0.35 (P	0.23 1 0.6 = 0.72) t applicab	15 8 15 93	3.62 4.6 4.7	0.29 2.4 0.4	55 15 4 15	35.0% 33.6% 2.9% 28.6%	-0.23 [-0.42 , -0.04] 0.30 [-2.15 , 2.75] -0.40 [-0.76 , -0.04]	
Yagci 2019 Total Test for overall effect. Test for subgroup diffe Heterogeneity: Tau" =	3.39 4.9 4.3 Z = 0.35 (P rences: Noi 0.14, Chi ^p =	0.23 1 0.6 = 0.72) t applicab	15 8 15 93 Ie f = 3 (P <	3.62 4.6 4.7	0.29 2.4 0.4	55 15 4 15	35.0% 33.6% 2.9% 28.6% 100.0%	-0.23 [-0.42 , -0.04] 0.30 [-2.15 , 2.75] -0.40 [-0.76 , -0.04]	
Yagol 2019 Total Test for overall effect: Test for subgroup diffe Heterogeneity; Tau" = Fjur 4: 888 wak kots Study or Subgroup Monticone 2014	3.39 4.9 4.3 Z = 0.35 (P rences: Noi 0.14; ChP = Exp Mean 4.5	0.23 1 0.6 = 0.72) t applicate = 31.13, d commenta SD 0.3	15 8 15 93 If = 3 (P < If = 3 (P < If = 3 (P <	3.62 4.6 4.7 0.00001; Mean 3.9	0.29 2.4 0.4 () (? = 90% Control SD 0.5	55 15 4 15 89 Total	35.0% 33.6% 2.9% 28.6% 100.0% Weight 36.0%	-0 23 [-0,42, -0.04] 0.30 [-2.15, 2,75] -0.40 [-0.76, -0.04] -0.08 [-0.51, 0.36] Mean difference IV, Random, 95% CI 0.60 [0.45, 0.75]	Favors GE Favors PSSE
Yagol 2019 Total Test for overall effect. Test for subgroup diffe Heterogeneity: Tau ⁴ = Plane 4: 888 Web/Roth Study or Subgroup	3.39 4.9 4.3 Z = 0.35 (P rences: Noi 0.14; Chi ^p = Exp Mean	0.23 1 0.6 = 0.72) t applicati = 31.13, d eorimenta SD	15 8 15 93 If = 3 (P < It Total	3.62 4.6 4.7 0.00001) Mean	0.29 2.4 0.4 0.4	55 16 4 15 89 Total	35.0% 33.6% 2.9% 28.6% 100.0%	-0.23 [-0.42, -0.04] 0.30 [-2.15, 2.75] -0.40 [-0.76, -0.04] -0.08 [-0.51, 0.36] Mean difference IV, Random, 95% CI	Favors GE Favors PSSE
Yagel 2019 Total Test for overall effect: Test for subgroup diffe Heterogeneity: Tau" = Pare 4: 343 Web/Hoth Study or Subgroup Monticone 2014 Monticone 2022	3.39 4.9 4.3 Z = 0.35 (P rences: Not 0.14, Chi ^p = <u>Exp</u> Mean 4.5 3.27	0.23 1 0.6 = 0.72) t applicate = 31.13, d sorimenta SD 0.3 0.21	15 8 15 93 If = 3 (P < If = 3 (P < If = 3 (P < 15 15	3.62 4.6 4.7 0.00001) Mean 3.9 3.21	0.29 2.4 0.4 (); l ² = 90% SD 0.5 0.21	55 16 4 15 89 Total 55 15	35.0% 33.6% 2.9% 28.6% 100.0% Weight 36.0% 5.0% 6.1%	-0.23 [-0.42, -0.04] 0.30 [-2.15, 2.75] -0.40 [-0.76, -0.04] -0.08 [-0.51, 0.36] Mean difference IV, Random, 95% CI C.60 [0.45, 0.75] 0.06 [-0.69, 0.21]	Favors GE Favors PSSE
Yagol 2019 Total Test for overall effect: Test for subgroup diffe Heterogeneity: Tau" = "Jun 4: sha wak kots Study or Subgroup Monticone 2014 Moubarak 2022 Noh 2014	3.39 4.9 4.3 Z = 0.35 (P rences: Noi 0.14; Chi ² = <u>Exp</u> Mean 4.5 3.27 4.6	0.23 1 0.6 = 0.72) t applicable = 31.13, d sorimenta SD 0.3 0.21 1.4	15 8 15 93 If = 3 (P < M Total 55 15 8	3.62 4.8 4.7 0.00001; Mean 3.9 3.21 4	0.29 2.4 0.4 0.4 0.5 SD 0.5 0.21 1.2	55 16 4 15 89 Total 55 15 4	35.0% 33.6% 2.9% 28.6% 100.0% Weight 36.0% 5.0% 6.1%	-0.23 [-0.42, -0.04] -0.30 [-216 - 2.75] -0.40 [-0.76, -0.04] -0.08 [-0.51, 0.36] Mean difference IV, Random, 95% Cl 0.60 [0.45, 0.75] 0.06 [-0.09, 0.21]	Favors GE Favors PSSE
Yagel 2019 Total Test for outgroup different Fest for outgroup different Fest for outgroup different Rest outgroup different Study on Subgroup MonScone 2014 MonScone 2014 MonScone 2014 Yagel 2019 Total Test for oversill effect Test for oversill effect Test for oversill effect Test for oversill effect	3.39 4.9 4.3 Z = 0.35 (P rences: Nol 0.14; Chi ² = Mean 4.5 3.27 4.6 4.1 Z = 1.82 (P rences: Nol	0 23 1 0.6 = 0.72) t applicab = 31.13, d sorimenta SD 0.3 0.21 1.4 0.6 = 0.07) t applicab	15 8 93 93 f = 3 (P < d Total 55 15 8 15 93	3.62 4.6 4.7 0.00001) Mean 3.9 3.21 4 3.6	0.29 2.4 0.4 0.4 (control SD 0.5 0.21 1.2 0.6	55 16 4 15 89 Total 55 15 4 15	35.0% 33.6% 2.9% 28.6% 100.0% Weight 36.0% 36.0% 6.1% 21.9%	-0.23(-0.42, 0.04) 0.30(-215, 2.78) -0.40(-0.76, -0.04) -0.08(-0.51, 0.36) Moan difference IV, Random, 95%, CI C.60(0.45, 0.75) 0.06(-0.02, 2.12) 0.50(-0.07, 1.07)	Favors GE Favors PSSE
Yagel 2019 Total Test for subgroup stille Idensignen by the Idensignen Hum cr. 488 Web Woh Study or Subgroup Monscore 2014 Moubarak 2022 Iden 2019 Total Test for subgroup diffe	3.39 4.9 4.3 Z = 0.35 (P rences: Notories: Notories 4.5 3.27 4.6 4.1 Z = 1.82 (P rences: Notories: Notorie	0 23 1 0.6 = 0.72) t applicab = 31.13, d sorimenta SD 0.3 0.21 1.4 0.6 = 0.07) t applicab	15 8 93 15 93 15 15 15 15 15 15 93 15 15 15 15 15 15 15 15 15 15 15 15 15	3.62 4.6 4.7 0.00001) Mean 3.9 3.21 4 3.6	0.29 2.4 0.4 0.4 (control SD 0.5 0.21 1.2 0.6	555 16 4 15 89 Total 55 15 4 15 89	35.0% 33.6% 2.9% 28.6% 100.0% Weight 36.0% 6.1% 21.9%	-0.23(-0.42, 0.04) 0.30(-215, 2.78) -0.40(-0.76, -0.04) -0.08(-0.51, 0.36) Moan difference IV, Random, 95%, CI C.60(0.45, 0.75) 0.06(-0.02, 2.12) 0.50(-0.07, 1.07)	Pavors GE Favors PSSE Mean difference IV, Random, 99% CI
Yagel 2019 Total Test for subgroup differences the subgroup differences test for subgroup differences and the subgroup differences Study or Subgroup MonScone 2014 MonScone 2014 MonScone 2014 MonScone 2014 Total Test for overall effect. Test for subgroup differences Test for subgroup differences Test for subgroup differences Test for subgroup differences Test for subgroup differences	3.39 4.0 4.3 Z = 0.35 (P rences: Nol 0.14; Chi ² = Exp Mean 4.5 3.27 4.6 4.1 Z = 1.82 (P rences: Nol 0.12; Chi ² =	0 23 1 0.6 = 0.72) t applicate = 31.13, d continuenta SD 0.3 0.21 1.4 0.8 = 0.07) t applicate = 0.72) t applicate = 31.00 0.3 0.21 1.4 0.8 = 0.72) t applicate = 31.00 0.3 0.21 1.4 0.8 = 0.72) t applicate = 31.00 0.3 0.21 1.4 0.8 = 0.72) t applicate = 31.00 0.3 0.21 1.4 0.8 = 30.00 0.3 0.21 1.4 0.8 = 30.00 0.3 0.21 0.8 = 30.00 0.3 0.21 0.8 = 30.00 0.3 0.21 0.8 = 30.00 0.3 0.21 0.8 = 30.00 0.3 0.21 0.8 = 30.00 0.8 0.8 0.8 0.8 0.9 0.8 0.8 0.8 0.8 0.8 0.8 0.8 0.8	15 8 93 93 93 93 93 93 15 93 15 93 93 16 f = 3 (P <	3.62 4.6 4.7 0.00001) Mean 3.9 3.21 4 3.6 0.0001);	0.29 2.4 0.4 Control SD 0.5 0.21 1.2 0.6	555 16 4 15 89 Total 55 15 4 15 89	35.0% 33.6% 2.9% 28.6% 100.0% Weight 36.0% 6.1% 21.9%	-0.231-0.42, 0.04 0.30 [2-15, 2.75] -0.40 [-0.76, -0.64] -0.66 [-0.51, 0.36] Wean difference IV, Random, 95% CI 0.60 [0.45, 0.75] 0.96 [-0.09, 2.112] 0.50 [-0.07, 1.67] 0.36 [-0.03, 0.86] Wean difference IV, Random, 95% CI	Pavors GE Favors PSSE Mean difference IV, Random, 95% CI
Yagel 2019 Total Test for outgroup different fest for outgroup different fest for outgroup different fest for subgroup different fest for Subgroup Total Test for overall effect Test for outgroup different Test for outgroup different Fest for subgroup different Fest for subgroup different Fest for subgroup different Study or Subgroup Montione 2014 Montone 2014	3.39 4.0 4.3 Z = 0.35 (P rences: Not 0.14: Chi ² = Exp Mean 4.5 3.27 4.6 4.1 Z = 1.82 (P rences: Not 0.12: Chi ² = Exp Mean	0 23 1 0.6 1 1 0.6 1 1 0.6 1 0.72 1 tapplicati 2 0.72 1 tapplicati 2 0.72 1 tapplicati 2 0.72 1 tapplicati 2 0.72 1 tapplicati 2 0.72 1 tapplicati 2 0.72 0.3 0.21 1 4.08 1 4.0	15 8 93 93 93 93 93 93 15 15 15 15 93 15 93 93 93 15 93 93 93 93 93 93 93 93 93 93 93 93 93	3.82 4.5 4.7 0.00001) Mean 3.9 3.21 4 3.6 0.0001); Mean 4 4.48	0.29 2.4 0.4 () 50 0.5 0.21 1.2 0.8 () 7 = 88% Control 50 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5	555 16 4 15 89 Total Total 55 15 4 15 89 Total 555 15 15	35.0% 33.8% 2.9% 28.0% 400.0% Weight 36.0% 36.0% 31.0% 21.9% 100.0%	-0.23(-0.42, 0.04) 0.30(2-15, 2.75) -0.40(-0.76, -0.04) -0.06(-0.51, 0.36) N. Random, 95% CI (V, Random, 95% CI 0.00(0.45, 0.75) 0.05(0.06, 0.21) 0.05(0.07, 0.16) 0.38(-0.03, 0.86) Mean difference (V, Random, 95%; CI 0.28(0.26, 0.55); CB	Pavors GE Favors PSSE Mean difference IV, Random, 95% CI
Vagel 2019 Total Test for overall effect: Test for subgroup diffe Heterogeneity: Test' = "gue cr all weak work Monticene 2014 Moubarak 2022 Notification overall effect: Test for subgroup diffe Heterogeneity: Test' = "Fand 128 Subgroup Monticene 2014	3.39 4.3 2 = 0.35 (P rences: Not 0.14; Chi ² = Exp Mean 4.5 3.27 4.6 4.1 Z = 1.82 (P rences: Not 0.12; Chi ² = Exp Mean 4.3 4.3 4.3	0 23 1 0.6 = 0.72) t applicable solutions solutions 1.13, d 0.3 0.21 1.4 0.6 = 0.07) t applicable = 0.07) t applicable solutions = 0.07) 0.3 0.21 1.5, d 0.6 = 0.72) 0.6 = 0.72) 0.6 = 0.72) 0.6 = 0.72) 0.6 = 0.72) 0.6 = 0.72) 0.6 = 0.72) 0.6 = 0.72) 0.6 = 0.72) 0.75 = 0.75 = 0.	15 8 8 15 93 93 93 93 93 93 70 15 93 93 93 93 93 93 93 93 93 93 95 93 95 95 95 95 95 95 95 95 95 95 95 95 95	3.82 4.8 4.7 0.00001) Mean 3.9 3.21 4 3.6 0.0001); Mean 4	0.29 2.4 0.4 0.5 0.5 0.21 1.2 0.6 1 ² = 88% Control 5D 0.5	555 16 4 15 89 Total 55 15 15 15 89 Total 55 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5	35.0% 33.6% 2.9% 28.0% 100.0% 400.0% 56.0% 56.0% 56.0% 51.5% 100.0% Weight 29.8%	-0.231-0.42, 0.04 0.30 [2-15, 2.75] -0.40 [-0.76, -0.64] -0.66 [-0.51, 0.36] Mean difference IV, Random, 95% (21 0.60 [-0.62, 2.12] 0.60 [-0.62, 2.12] 0.50 [-0.07, 1.07] 0.36 [-0.03, 0.86] Mean difference IV, Random, 95% (21 0.60 [-0.53], 0.65] 0.60 [-0.53]	Pavors GE Favors PSSE Mean difference IV, Random, 95% CI
Vagel 2019 Total Test for overall effect: Test for outgroup diffe Heterogeneity: Test's Apure 4: ABA weak with Bitudy or Studgroup Monticene 2014 Vagel 2019 Total Test for subgroup diffe Heterogeneity: Test's Test for subgroup diffe Heterogeneity: Test's Bitudy or Subgroup Monticene 2014 Moubarak 2022 Noh 2014	3.39 4.3 2 = 0.35 (P rences: Noi 0.14; ChiP = Mean 4.5 3.27 4.6 4.1 2 = 1.82 (P rences: Noi 0.12; ChiP = Exp Mean 4.8 4.27 4.6 4.1	0 23 1 0.6 = 0.72) t applicate = 31.13, d so arrimenta SD 0.3 0.21 1.4 0.6 = 0.07) t applicate = 30.22 0.3 0.21 1.4 0.6 = 0.07) 0.3 0.21 1.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0	15 8 15 93 93 15 15 15 15 93 15 93 15 93 15 93 15 15 15 15 15 15 15 15 15 15	3.82 4.5 4.7 0.00001) Mean 3.9 3.21 3.6 0.0001); Mean 4 4.448 4.1	029 24 04 04 05 05 021 12 28% Control SD 05 022 05 022 14	555 16 4 15 89 Total Total 55 15 89 Total 55 15 4 4	35.0% 33.8% 2.9% 28.0% Weight 36.0% 5.1% 2.1% 100.0%	-0.231-0.42, 0.04 0.30 [2-15, 2.75] -0.40 [-0.76, -0.64] -0.66 [-0.51, 0.36] Mean difference IV, Random, 95% CI 0.60 [0.45, 0.75] 0.06 [-0.02, 2.12] 0.50 [-0.07, 1.07] 0.36 [-0.03, 0.80] Mean difference IV, Random, 95% CI	Pavors GE Favors PSSE Mean difference IV, Random, 95% CI
Yagel 2019 Total Test for out-group different test for subgroup different test for subgroup different test for subgroup Montsone 2014 Moubarak 2022 Notal Test for subgroup different test for subgrou	3.39 4.9 4.9 4.3 2 = 0.35 (P / 0 4.3 2 = 0.35 (P / 0 4.3 4.3 4.3 4.1 4.1 4.1 4.1 4.1 4.1 4.1 4.1 4.1 4.1	0 23 1 0 6 = 0.72) t applicate = 31.13, d orimenta SD 0 3 0 21 1, 4 0 8 = 0.07) t applicate = 0.07) t appl	15 8 93 15 93 15 93 Total 55 15 93 15 93 15 93 8 15 55 15 55 15 15 93 93	3,62 4,5 4,7 0,00001) Mean 3,9 3,21 4 3,6 0,0001); Mean 4,8 4,1 4,4 4,4	0 299 24 0 4 0 4 0 4 0 5 0 5 0 21 12 0 5 0 21 20 50 0 5 0 21 4 0 6	555 16 4 15 89 Total 55 15 15 15 15 15 15 15 15 55 15 15 15	35.0% 33.8% 2.9% 2.9% 2.9% 2.9% 36.0% 6.1% 21.9% 6.1% 21.9% 100.0%	-0.23(-0.42, 0.04) 0.30(-215, 2.75) -0.40(-0.76, -0.64) -0.66(-0.51, 0.36) Wean difference IV, Random, 95% CI 0.60(-0.45, -0.75) 0.60(-0.62, 2.12) 0.50(-0.07, -1.67) 0.36(-0.03, 0.86) Wean difference IV, Random, 95% CI 0.60(-0.53, 0.68) 0.40(-0.00, 1.80) 0.40(-0.00, 1.80) 0.40(-0.00, 1.80)	Pavors GE Favors PSSE Mean difference IV, Random, 95% CI
Yagel 2019 Total Test for subgroup difference test for subgroup difference test for subgroup difference test for subgroup Study or Subgroup Montsone 2014 Moubarak 2022 Noh 2014 Total Test for subgroup difference test fo	3.39 4.9 4.9 4.9 4.3 2 = 0.35 (P / 4.3 2 = 0.35 (P / 4.3) 4.3 4.3 4.1 4.5 4.1 2 = 1.82 (P / 4.1 4.1 2 = 1.82 (P / 4.1 4.1 2 = 0.12 (C / 4.1 4.1 4.2 4.2 4.7 4.5 4.7 4.5 4.7 4.7 4.5 4.7 4.7 4.5 4.7 4.7 4.7 4.7 4.7 4.7 4.7 4.7 4.7 4.7	023 023 1 05 05 05 05 05 05 05 021 14 05 03 021 14 06 03 021 14 06 03 021 14 06 03 021 15 06 03 021 15 06 05 05 05 05 05 05 05 05 05 05		3,62 4,5 4,7 0,00001) Mean 3,9 3,21 4 3,6 0,0001); Mean 4,8 4,1 4,4 4,4	0 299 24 0 4 0 4 0 4 0 5 0 5 0 21 12 0 5 0 21 20 50 0 5 0 21 4 0 6	555 16 4 15 89 Total 55 15 15 15 15 15 15 15 15 15 15 15 15	35.0% 33.8% 2.9% 2.9% 2.9% 2.9% 36.0% 6.1% 21.9% 6.1% 21.9% 100.0%	-0.23(-0.42, 0.04) 0.30 (2-15, 2.75) -0.40 (-0.76, -0.64) -0.66 (-0.51, 0.36) Wean difference (N, Random, 95% CI 0.60 (0.45, 0.75) 0.60 (-0.02, 2.12) 0.50 (-0.07, 1.67) 0.38 (-0.03, 0.86) Mean difference (N, Random, 95% CI 0.00 (0.65, 0.96) -0.21 (-0.37, 0.06) 0.30 (-0.13, 0.73) 0.31 (-0.37, 1.06)	Pavois GE Pavois PSSE Mean difference IV, Random, 95% CI Favoirs GE Pavois PSSE Mean difference IV, Random, 95% CI Mean difference IV, Random, 95% CI
Yagel 2019 Total Test for subgroup difference test for subgroup difference test for subgroup difference Study or Subgroup Monitorie 2014 Monitorie 2014 Monitorie 2014 Vagel 2019 Total Test for subgroup difference test for subgroup difference test for subgroup difference test for subgroup difference Study or Subgroup Monitorie 2014 Monitorie 2014	3.39 4.9 4.9 4.9 4.3 2 = 0.35 (P / 4.3 2 = 0.35 (P / 4.3) 4.3 4.3 4.1 4.5 4.1 2 = 1.82 (P / 4.1 4.1 2 = 1.82 (P / 4.1 4.1 2 = 0.12 (C / 4.1 4.1 4.2 4.2 4.7 4.5 4.7 4.5 4.7 4.7 4.5 4.7 4.7 4.5 4.7 4.7 4.7 4.7 4.7 4.7 4.7 4.7 4.7 4.7	0 23 1 0 6 = 0.72) t applicate = 31.13, d orimenta SD 0 3 0 21 1, 4 0 8 = 0.07) t applicate = 0.07) t applicat		3,62 4,5 4,7 0,00001) Mean 3,9 3,21 4 3,6 0,0001); Mean 4,8 4,1 4,4 4,4	0.29 2.4 0.4 0.4 0.5 SD 0.5 0.21 1.2 0.5 0.21 0.5 0.22 0.22 0.22 0.4 0.6 8 0.5 0.22 0.22 0.22 0.4 0.4	555 16 4 15 89 Total 55 15 15 15 15 15 15 15 15 15 15 15 15	35.0% 33.6% 28.6% 28.6% 100.0% Weight 36.0% 6.1% 21.9% 100.0% Weight 29.8% 27.1% 100.0%	-0.23(-0.42, 0.04) 0.30(-215, 2.75) -0.40(-0.76, -0.64) -0.66(-0.51, 0.36) Wean difference IV, Random, 95% CI 0.60(-0.45, -0.75) 0.60(-0.62, 2.12) 0.50(-0.07, -1.67) 0.36(-0.03, 0.86) Wean difference IV, Random, 95% CI 0.60(-0.53, 0.68) 0.40(-0.00, 1.80) 0.40(-0.00, 1.80) 0.40(-0.00, 1.80)	Pavois GE Pavois PSSE Mean difference IV, Random, 99% CI Tavois GE Pavois PSSE Mean difference IV, Random, 99% CI
Vagel 2019 Total Test for subgroup diffe Test for subgroup diffe Test for subgroup diffe Test for subgroup Mentioner 2014 Moubarak 2022 Not Test for subgroup diffe Test for subgroup f Test for subgroup f Test for subgroup	3.39 4.9 4.9 4.3 4.3 2 = 0.35 (P rences: Nol 0.14: Chi ⁺ + Exp 4.6 4.1 2 = 1.82 (P rences: Nol 0.12: Chi ⁺ + Exp 4.6 4.1 4.1 2 = 1.82 (P rences: Nol 0.12: Chi ⁺ + Exp 4.6 4.1 4.7 4.7 4.7 4.7 4.7 4.7 4.7 4.7 4.7 4.7	0.23 1 0.6 = 0.72) application splication splication = 0.07) t application = 0.07) t application = 0.07) t application = 0.07) t application = 0.07) t application = 0.07) = 0.07 =	115 8 93 93 93 93 93 93 15 93 93 93 93 93 93 93 93 93 93	3.62 4.8 4.8 4.7 0.00001 3.9 3.21 3.21 3.5 0.00011; Mean 4.48 4.1 4.48 4.1 4.48 4.1 4.48 4.1 4.48 4.1 4.48 4.1 4.48 4.3 5 5 7 7 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	0 29 0 24 0 4 0 4 0 5 0 5 0 5 0 5 0 5 0 5 0 5 0 5	555 15 4 15 89 Total Total Total Total 55 55 55 55 69 Total 55 55 55 55 55 55 55 55 55 55 55 55 55	35.0% 33.6% 28.6% 28.6% 100.0% Weight 36.0% 6.1% 36.0% 6.1% 27.1% 100.0% Weight 29.7%	-0.231-0.42, 0.04 0.30 [2-15, 2.75] -0.40 [-0.76, -0.64] -0.66 [-0.51, 0.36] Mean difference IV, Random, 95% CI 0.60 [0.45, 0.75] 0.06 [-0.02, 2.12] 0.50 [-0.02, 2.12] 0.50 [-0.02, 2.12] 0.50 [-0.02, 2.12] 0.50 [-0.02, 1.07] 0.36 [-0.03, 0.86] Mean difference IV, Random, 95% CI 0.30 [-0.37, 1.00] 0.31 [-0.37, 1.00]	Pavors QE Pavors PSSE Mean difference IV, Random, 95% CI Favors PSSE Mean difference IV, Random, 95% CI Mean difference IV, Random, 95% CI Favors PSSE Mean difference Mean difference Mean difference Mean difference
Yagel 2019 Total Test for subgroup diffe Heterogeneity: Tau' = "gene is for subgroup diffe Heterogeneity: Tau' = "gene is for subgroup Monitone 2014 Monitone 2014 Moniton	3.39 4.9 4.3 4.3 4.3 4.3 4.3 4.3 4.3 4.5 4.1 7 4.6 4.1 7 4.6 4.1 7 4.6 4.1 7 4.6 4.1 7 4.6 4.1 7 4.6 4.1 7 4.6 4.1 7 4.6 4.1 8 2 7 4.6 4.1 7 4.0 1 8 2 7 4 5 4.1 2 7 7 4 5 8 2 7 7 4 5 8 2 7 7 4 5 8 2 7 7 4 5 8 2 7 7 4 5 8 2 7 7 8 2 7 7 8 2 7 8 2 7 7 8 8 2 7 7 8 8 2 7 7 8 8 2 7 7 8 8 8 9 7 8 8 9 8 9 8 9 8 9 8 9 8 9	0 233 1 0.6 = 0.72) 1 applicable splitter splitter splitter 1 1.4 0.8 = 0.07) 1.4 0.8 = 0.07) 1.4 0.8 = 0.07) 1.4 0.8 = 0.07) 24.65, d 0.3 0.24 0.5 0.3 0.24 0.5 0.3 0.24 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5	155 8 93 93 94 15 93 93 93 93 15 93 93 93 93 93 93 93 93 93 93 94 15 93 93 95 15 93 93 93 94 15 93 93 94 15 93 94 15 94 94 95 95 94 95 95 95 95 95 95 95 95 95 95 95 95 95	3.62 4.6 4.6 4.7 0.000011 Mean 3.9 3.21 3.6 0.00011; Mean 4.4 4.4 4.4 4.4 0.000011; Mean	0 29 24 0 4 0 4 0 4 0 5 0 5 0 21 12 0 5 0 2 14 0 4	55 15 4 15 89 Total 55 15 89 Total 55 15 16 15 89 Total	35.0% 33.6% 28.6% 28.6% 28.6% 28.6% 20.6% 20.6% 36.0% 36.0% 36.0% 36.0% 36.0% 31.0% 100.0% 29.7% 100.0% 100.0%	-0.23(-0.42, 0.04) -0.30(-215, 2.75) -0.40(-0.76, -0.64) -0.68(-0.51, 0.36) Moan difference IV, Random, 95% CI C.60(0.45, 0.75) 0.06(-0.65, 0.75) 0.06(-0.65, 0.75) 0.06(-0.65, 0.75) 0.05(-0.05, 0.08) C.60(0.45, 0.75) 0.05(-0.05, 0.08) C.80(0.65, 0.95) 0.03(-10, 3, 7, 0.08) 0.03(-10, 3, 7, 1.08) Mean difference IV, Random, 95% CI 0.31(-0.37, 1.08) Mean difference IV, Random, 95% CI 0.31(-0.37, 1.08) Mean difference IV, Random, 95% CI 0.32(-0.25, 0.08) 0.31(-0.27, 0.08)	Pavors QE Pavors PSSE Mean difference IV, Random, 95% CI Favors PSSE Mean difference IV, Random, 95% CI Mean difference IV, Random, 95% CI Favors PSSE Mean difference Mean difference Mean difference Mean difference
Yagel 2019 Total Test for outgroup different for study outgroup different for study outgroup different feet for subgroup different for study or Subgroup Monitories 2018 Total Total Test for subgroup different feet for Subgroup Monitories 2014 Monitories 2014 Total Test for outgroup different feet feet feet feet feet feet feet fee	3.39 4.9 4.9 4.9 4.3 4.3 4.3 4.3 4.3 4.5 4.1 2 = 1.82 (P Mean 4.6 4.1 2 = 1.82 (P Mean 4.6 4.1 4.5 4.1 4.5 4.5 4.5 4.5 4.5 4.5 4.5 4.5 4.5 4.5	0.23 1 0.6 = 0.72) = 0.72) = 0.72) = 0.72) = 0.72) = 0.77) = 0.77) = 0.77) = 0.07) = 24.65, = 0.07) = 24.65, = 0.07) = 24.65, = 0.25, = 0.	155 8 93 93 94 15 93 93 93 94 15 93 95 15 93 95 15 93 93 95 15 93 95 15 93 93 94 170101 55 15 93 95 15 93 93 93 94 94 94 94 95 95 94 95 95 95 95 95 95 95 95 95 95 95 95 95	3.62 4.8 4.8 4.7 0.00001) Mean 4 3.9 3.21 3.6 0.0001); Mean 4.4 4.4 4.4 4.4 4.4 4.4 4.4 5.0 0.00001] Mean 3.7 1.2 1.6 1.6 1.6 1.6 1.6 1.6 1.6 1.6 1.6 1.6	0 29 24 0 4 0 4 0 4 0 5 0 0 5 0 21 1 2 0 5 0 21 1 2 0 5 0 21 1 2 0 5 0 21 1 2 0 5 0 22 1 4 0 6 0 5 0 22 1 4 0 6 0 5 0 2 0 2 4 0 5 0 5 0 5 0 2 4 0 5 0 5 0 5 0 5 0 5 0 5 0 5 0 5 0 5 0 5	55 15 4 15 89 Total 55 15 15 15 15 15 15 15 15 15 15 15 15	35.0% 33.6% 28.6% 28.6% 100.0% Weight 36.0% 6.1% 36.0% 6.1% 27.1% 100.0% Weight 29.7% 20.7% 29.7%	-0.231-0.42, 0.04 0.30 [2-15, 2.75] -0.40 [-0.76, -0.64] -0.66 [-0.51, 0.36] Mean difference IV, Random, 95% CI 0.60 [0.45, 0.75] 0.06 [-0.02, 2.12] 0.50 [-0.02, 2.12] 0.50 [-0.02, 2.12] 0.50 [-0.02, 2.12] 0.50 [-0.02, 1.07] 0.36 [-0.03, 0.86] Mean difference IV, Random, 95% CI 0.30 [-0.37, 1.00] 0.31 [-0.37, 1.00]	Pavors QE Pavors PSSE Mean difference IV, Random, 95% CI Favors PSSE Mean difference IV, Random, 95% CI Mean difference IV, Random, 95% CI Favors PSSE Mean difference Mean difference Mean difference Mean difference
Vagel 2019 Total Test for subgroup diffe Heterogeneity: Test 's for subgroup diffe Heterogeneity: Test's for subgroup Mentices 2019 Total Test for subgroup diffe Heterogeneity: Test's Fasue 1: Sis Lesters Study or Subgroup Mentices 2019 Total Test for subgroup diffe Heterogeneity: Test's Study or Subgroup Mentices 2019 Total Test for subgroup diffe Heterogeneity: Test's Study or Subgroup Mentices 2014 Moubarak 2022 Noh 2014	3.39 4.9 4.9 4.3 4.3 4.3 4.3 4.3 4.5 5.27 4.6 4.1 4.1 2 × 1.82 (P rences: Noi 0.12; Ch ² + 4.6 4.1 4.1 2 × 1.82 (P rences: Noi 0.12; Ch ² + 4.6 4.1 4.1 2 × 1.82 (P rences: Noi 0.12; Ch ² + 4.6 4.1 4.1 4.7 4.5 4.7 4.7 4.7 4.7 4.7 4.7 4.7 4.7 4.7 4.7	0.23 1 0.6 = 0.72) = 0.72)	155 8 8 93 93 93 93 93 93 93 93 93 93 93 93 93	3.62 4.8 4.8 4.7 0.000011 Mean 3.9 3.21 4 3.5 0.000011 4 4.48 4.1 4.48 4.1 4.48 4.1 4.48 4.1 4.48 4.1 4.48 4.1 4.48 4.1 4.48 4.1 4.48 4.5 4.5 5 5 4.5 5 4.5 5 4.5 5 5 5	0 29 24 04 04 04 05 00 05 021 1/2 08 00 05 022 14 0.6 02 0.5 0.25 14 0.6 0.5 0.25 14 0.6 0.5 0.25 14 0.6 0.5 0.25 11 0.5 0.25 11 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5	Total Total Total Total Total Total Total Total Total	35.0% 33.6% 28.6% 28.6% 100.0% Weight 36.0% 6.1% 36.0% 6.1% 27.1% 100.0% Weight 29.7% 20.7% 29.7%	-0.231-0.42, 0.04 0.30 [-215, 2.75] -0.40 [-0.76, -0.64] -0.66 [-0.51, 0.36] Wean difference IV, Random, 95% (-1 0.60 [-0.62, 2.12] 0.60 [-0.71, 107] 0.36 [-0.71, 0.60] 0.30 [-0.13, 0.73] 0.31 [-0.37, 1.00] Wean difference IV, Random, 95% (-1 0.70 [0.55, 0.85] -0.21 [-0.27, 0.56] 0.70 [0.55, 0.85] -0.21 [-0.27, 0.08]	Pavors QE Pavors PSSE Mean difference IV, Random, 95% CI Favors PSSE Mean difference IV, Random, 95% CI Mean difference IV, Random, 95% CI Favors PSSE Mean difference Mean difference Mean difference Mean difference
Yagel 2019 Total Test for subgroup diffe Heterogeneity: Tau' = "sur-cl-ABA Meak wath Meubarak 2022 Notal Test for subgroup diffe Heterogeneity: Tau' = "fast of subgroup Total Test for subgroup diffe Heterogeneity: Tau' = "fast of subgroup Mentione 2014 Moubarak 2022 Notal Study of Subgroup Mentione 2014 Study of Subgroup Mentione 2014 Study of Subgroup Mentione 2014 Moubarak 2022 Notal Test for overall effect: Test for subgroup diffe Heterogeneity: Tau' = "gave 41 Bit belf means in Study of Subgroup Mentione 2014 Moubarak 2022 Notal Test for subgroup diffe Heterogeneity: Tau' = "gave 41 Bit belf means in Study of Subgroup Mentione 2014 Moubarak 2022 Notal	3.39 4.9 4.9 4.9 4.3 4.3 4.3 4.3 4.3 4.5 5.27 4.6 4.1 4.1 4.1 4.1 4.1 4.1 4.2 4.1 4.2 4.7 4.5 4.7 4.7 4.7 4.7 4.7 4.7 4.7 4.7 4.7 4.7	0.23 1 0.6 1 0.6 1 0.7 1 1.7 0.6 1.7 1.7 0.7 1.7 0.7 0.7 0.7 0.7 0.7 0.7 0.7 0	155 8 8 15 93 93 15 93 15 93 15 93 15 93 15 93 15 93 15 93 15 93 15 93 15 93 15 93 15 15 15 15 15 15 15 15 15 15	3.62 4.8 4.8 4.7 0.000011 Mean 3.9 3.21 4 3.5 0.000011 4 4.48 4.1 4.48 4.1 4.48 4.1 4.48 4.1 4.48 4.1 4.48 4.1 4.48 4.1 4.48 4.1 4.48 4.5 4.5 5 5 4.5 5 4.5 5 4.5 5 5 5	0 29 24 04 04 04 05 00 05 021 1/2 08 00 05 022 14 0.6 02 0.5 0.25 14 0.6 0.5 0.25 14 0.6 0.5 0.25 14 0.6 0.5 0.25 11 0.5 0.25 11 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5	Total Total Total Total Total Total Total Total Total	35.0% 33.6% 28.6% 28.6% 28.6% 28.6% 36.0% 36.0% 36.0% 29.7% 29.7% 29.7% 29.7% 29.7% 29.7% 29.7% 29.7% 29.7% 29.7% 29.7% 29.7% 20.7%	-0.231-0.42, 0.04 0.30 [-215, 2.75] -0.40 [-0.76, -0.64] -0.66 [-0.51, 0.36] Wean difference IV, Random, 95% CI 0.60 [-0.09, 2.112] 0.60 [-0.01, 0.00] 0.30 [-0.01, 0.012] 0.31 [-0.37, -1.60] Wean difference IV, Random, 95% CI 0.70 [0.55, 0.86] -0.21 [-0.27, 0.08] 0.30 [-0.40, 2.00] -0.30 [-0.66, 0.06]	Pavors QE Pavors PSSE Mean difference IV, Random, 95% CI Favors PSSE Mean difference IV, Random, 95% CI Mean difference IV, Random, 95% CI Favors PSSE Mean difference Mean difference Mean difference Mean difference

Quality assessment

There was no evidence of publication bias (Supplemental Figures S1-S4) in the funnel plot analysis. Egger's regression test could not be performed due to the number of included studies (<10), as per Cochrane recommendations. The most RCTs were considered at low for risk of bias **Table 3.** The risk of bias of randomized control study according to the RoB2 tool, only Kim et al...was considered some concerns based on the domain of the randomization process (Table 3). Two Observational studies had a moderate risk of bias based predominantly on the risk of confounding factors. Only Noh et al.., had a serious risk of bias (Table 4).

Study	Bias from the randomiza tion process	Bias due to deviations from intended	Bias due to missing outcome data	Bias in the measure ment of the	Bias in the selection of the reported result	The overall risk of bias
Kocaman et al., 2021	Low	Low	Low	Low	Low	Low
Yagcki et al., 2018	Low	Low	Low	Low	Low	Low
Kim et al., 2016	Some concerns	Low	Low	Low	Low	Some concerns
Monticone at al., 2014	Low	Low	Low	Low	Low	Low
Moubarak et al., 2022	Low	Low	Low	Low	Low	Low
Mohamed et al., 2021	Low	Low	Low	Low	Low	Low

Legend: Risk of bias of prospective randomized controlled studies.

Table 4. Risk of bias of Observation studies

Study	Bias due to confounding	Bias in the selection of participants	Bias in the classification of interventions	Bias due to deviation s from intended interventions	Bias due to missing data	Bias in the measurement of outcomes	Bias in the selection of the reported result	The overall risk of bias judgement
Negrini et al., 2019	Moderate	Moderate	Low	Moderate	Moderate	Low	Low	Moderate
Karavidas et al., 2024	Moderate	Moderate	low	Low	Moderate	Low	Low	Moderate
Noh et al., 2014	High	Moderate	Moderate	Moderate	Low	Low	Low	Serious

DISCUSSION

This comprehensive meta-analysis of 6 RCTs and 3 observational studies enrolled 749 patients and examined the efficacy of PSSE versus general exercises in AIS. As compared with general exercises, PSSE reduced Cobb angle and ATR. In contrast, there was no difference between PSSE and GE in the outcomes SRS-22.

Scoliosis is associated with increased rates of pain, mental health issues, and reduced body image and function that, if not treated appropriately, may lead to pulmonary complications and the need for surgery (23-27). Many conservative therapies are used to stop the progression and reduce the deformity of AIS (8). However, which therapy is best for treating children and adolescents with scoliosis remains unclear. Clinical trials comparing PSSE with conventional therapy in patients with scoliosis have shown that 3D correction therapies, in association with breathing techniques, lead to better results in reducing deformity compared with general exercise (28). In our study, we focused on including studies reporting outcomes at the peak of growth, when the risk of progression is high.

Our findings favor PSSE over GE in reducing Cobb angle and ATR, which may imply their effectiveness in reducing or stopping the deformity of adolescents with idiopathic scoliosis. Despite the statistical significance, however, the angles should be analyzed in terms of clinical significance, as slight angle reductions may not imply significant clinical changes. Measurement errors can occur when assessing the Cobb angle, with a variability of up to $\pm -5^{\circ}$ (5). PSSE ultimately aims to delay or stop the progression of the Cobb angle and bracing. The success rate in achieving these favorable outcomes has been reported as 82% to 87% with PSSE, as compared with 23 to 26% in GE (10,17). Moreover, these studies have reported mild scoliosis, ages 10-18 years old, and Risser signs 0 to 3 as categories with a higher risk of progression, which may derive a stronger benefit from PSSE. In our meta- analysis, we could not perform a dedicated analysis of the success rate due to limited reporting of this outcome in individual studies.

These findings are consistent with other studies, such as Khaledi et al. (29), which show that Schroth therapy is effective in reducing the Cobb angle with a moderate level of evidence. Similarly, Burger et al. (30), suggested that Schroth exercises have a significant effect on reducing the Cobb angle with a level of evidence L2. Other studies that support our findings include those by Schriber et al. (7), Kuru et al. (31), Park et al. (32), and Seleviciene et al. (33), which demonstrate that PSSE therapies are more effective in improving deformities and enhancing the quality of life. Statistical significance showing the superiority of PSSE compared to general exercises was also reported by Karavidas et al. (10), who found that PSSE is better at improving the Cobb angle, trunk rotation, and quality of life.

Our study builds on prior meta-analysis by excluding studies not directly comparing PSSE versus GE. In the previous meta-analysis, patients in the control group received standard care or observation (8,9). We also included a study that used the PSSE Schroth technique on AIS. This new technique is focused on correction in three dimensions, corrective/rotational breathing, muscle activation, and stabilization. It brings a new classification system and a novel concept of overcorrection, fundamentally altering the patient approach (10).

According to the SOSORT guidelines, all PSSE schools should be based on 3D autocorrection, self-elongation, and patient training for activities of daily living (5). Different PSSE schools like Schroth, Lyon School, Scientific Exercise Approach to Scoliosis (SEAS), Barcelona Scoliosis Physical Therapy School (BSPTS), Side Shift, Functional Individual, Therapy Scoliosis (FITS), DoboMed, and FED (Fixation, Elongation, Derotation) are focused in the treatment of AIS (34). More recently, a method was developed as a new PSSE school and PSSE-Schroth (10). All those schools use PSSE but their methodology, classification, and frequency are different (8). Regarding general exercises, many therapies are used also like, core muscle, pilates, and conventional therapies. These differences may in part explain the high heterogeneity of our findings.

PSSE is designed specifically for scoliosis, focusing on the three-dimensional nature of the spinal deformity. These exercise aim to address specific curve patterns, improve postural alignment, and reduce asymmetries, directly influencing quality of life domains, such as selfimage and function in the SRS 22. By correcting visible asymmetries and improving posture, PSSE can enhance self-esteem and body image, critical components of the self-image, and mental health domains in the SRS-22. Nevertheless, we did not find а statistically significant improvement in the of quality of life between the PSSE group and the general exercise group. These results may have been driven by the high heterogeneity, low sample size, and null results in some of the included studies.

PSSE integrates breathing techniques, muscle activation, and functional movements, which can reduce discomfort, improve lung capacity, and enhance physical function. These benefits contribute to higher scores in the function/activity and pain domains. PSSE programs are customized to each patient's specific curve type and severity, making the exercises more effective compared to GE, which does not address the particular biomechanics of scoliosis. PSSE emphasizes active participation, teaching patients how to manage and maintain their condition. This fosters a sense of control and contributes to better outcomes in the mental health domain of the SRS-22. PSSE not only aims at curve stabilization but also at improving overall spinal health and preventing progression. This longterm focus can result in sustained improvements in quality of life compared to GE.

Our study has limitations. First, the inclusion of observational studies prompts the analysis for confounding factors and bias. Second, the study is limited by a small sample size and a short follow-up period, and null results may be due to a lack of power. Third, the definition and type of exercises applied in the PSSE and the GE groups were not homogeneous across studies. Fourth, due to the absence of patient-level data, we were unable to assess the impact of key factors, such as treatment adherence, the proportion of patients using braces, and the percentage of clinically significant angle changes (e.g., changes exceeding 5°).

This study highlights the need for adequately powered randomized studies to analyze the efficacy of PSSE therapies in a longer follow-up period.

CONCLUSION

In this meta-analysis of 6 RCTs and 3 observational studies including 749 patients with AIS. PSSE therapy is associated with a statistically significant reduction in Cobb angle and ATR compared to GE, albeit with a small magnitude of improvement, falling short of a threshold of substantial clinical benefit.

Acknowledgements: None declared.

Conflict of Interest Statement: The authors affirm that there are no conflicts of interest related to this work.

REFERENCES

1. Fan Y, To MKT, Yeung EHK, et al. Does curve pattern impact on the effects of physiotherapeutic scoliosis specific exercises on Cobb angles of participants with adolescent idiopathic scoliosis: A prospective clinical trial with two years followup. PLoS One 2021;16(1):e0245829. doi: 10.1371/journal.pone.0245829.

PMID: 33493172; PMCID: PMC7833215.

2. Negrini S, Aulisa L, Ferraro C, Fraschini P, Masiero S, Simonazzi P, Tedeschi C, Venturin A. Italian guidelines on rehabilitation treatment of adolescents with scoliosis or other spinal deformities. Eura Medicophys 2005;41(2):183-201. PMID: 16200035.

3. Negrini S, Aulisa AG, Aulisa L, Circo AB, de Mauroy JC et al. 2011 SOSORT guidelines: Orthopaedic and Rehabilitation treatment of idiopathic scoliosis during growth. Scoliosis 2012;7(1):3. doi: 10.1186/1748-7161-7-3. PMID: 22264320; PMCID: PMC3292965.

4. Lonstein JE, Carlson JM. The prediction of curve progression in untreated idiopathic scoliosis during growth. J Bone Joint Surg Am 1984;66(7):1061-71. PMID: 6480635.

5. Negrini S, Donzelli S, Aulisa AG et al. 2016 SOSORT Guidelines: Orthopaedic and Rehabilitation Treatment of Idiopathic Scoliosis during Growth. Scoliosis and Spinal Disorders 2018;13,3. https://doi.org/10.1186/s13013-017-0145-8.

6. Dimitrijević V, Viduka D, Šćepanović T, Maksimović N, Giustino V, Bianco A, Drid P. Effects of Schroth method and core stabilization exercises on idiopathic scoliosis: a systematic review and meta-analysis. Eur Spine J 2022;31(12):3500-3511. doi: 10.1007/s00586-022- 07407-4. Epub 2022 Oct 14. PMID: 36229615.

7. Schreiber S, Whibley D, Somers EC. Schroth Physiotherapeutic Scoliosis- Specific Exercise (PSSE) Trials-Systematic Review of Methods and Recommendations for Future Research. Children (Basel) 2023;10(6):954.

doi: 10.3390/children10060954.

PMID: 37371186; PMCID: PMC10297476.

8. You MJ, Lu ZY, Xu QY, Chen PB, Li B, Jiang SD, Jiang LS, Xia J, Zheng XF. Effectiveness of Physiotherapeutic Scoliosis-Specific Exercises on 3- Dimensional Spinal Deformities in Patients With Adolescent Idiopathic Scoliosis: A Systematic Review and Meta-analysis. Arch Phys Med Rehabil 2024;6:S0003-9993(24)00953-5. doi:10.1016/j.apmr.2024.04.011. Epub ahead of print. PMID: 38719166.

9. Dong H, You M, Li Y, Wang B, Huang H. Physiotherapeutic Scoliosis- Specific Exercise for the treatment of adolescent idiopathic scoliosis: A systematic review and network metaanalysis. Am J Phys Med Rehabil 2024;10. doi: 10.1097/PHM.00000000002524. Epub ahead of print. PMID: 38726971.

10. Karavidas N, Iakovidis P, Chatziprodromidou I, Lytras D, Kasimis K, Kyrkousis A, Apostolou T. Physiotherapeutic Scoliosis-Specific Exercises (PSSE-Schroth) can reduce the risk for progression during early growth in curves below 25°: prospective control study. Eur J Phys Rehabil Med 2024 ;60(2):331-339. doi: 10.23736/S1973-9087.24.08177-2. Epub 2024 Mar 19. PMID: 38502554; PMCID: PMC11112511.

11. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372. https://doi.org/10.1136/BMJ.N71.

12. Cochrane Handbook for Systematic Reviews of Interventions | Cochrane Training n.d. https://training.cochrane.org/handbook/current (accessed July 16, 2023).

 Sterne JAC, Savović J, Page MJ, Elbers RG, Blencowe NS, Boutron I, et al. RoB 2: a revised tool for assessing risk of bias in randomized trials. BMJ 2019;366.

https://doi.org/10.1136/BMJ.L4898.

 Sterne J A, HernÃin M A, Reeves B C, Savović J, Berkman N D, Viswanathan M et al. ROBINS-I: a tool for assessing risk of bias in non-randomised studies of interventions BMJ 2016; 355 :i4919 doi:10.1136/bmj.i4919.

15. Kim G, HwangBo PN. Effects of Schroth and Pilates exercises on the Cobb angle and weight distribution of patients with scoliosis. J Phys Ther Sci 2016;28(3):1012-5.

doi: 10.1589/jpts.28.1012. Epub 2016;31.

PMID: 27134403; PMCID: PMC4842415..

16. Kocaman H, Bek N, Kaya MH, Büyükturan B, Yetiş M, Büyükturan Ö. The effectiveness of two different exercise approaches in adolescent idiopathic scoliosis: A single-blind, randomized-

controlled trial. PLoS One 2021; 15;16(4):e0249492.

doi: 10.1371/journal.pone.0249492.

PMID: 33857180; PMCID: PMC8049223.

17. Monticone M, Ambrosini E, Cazzaniga D, Rocca B, Ferrante S. Active self-correction and task-oriented exercises reduce spinal deformity and improve quality of life in subjects with mild adolescent idiopathic scoliosis. Results of a randomised controlled trial. Eur Spine J 2014;23(6):1204-14. doi: 10.1007/s00586-014-3241-y. Epub 2014 Feb 28. PMID: 24682356.

18. Mohamed R.A. Yousef A.M; Impact of Schroth three-dimensional vs. proprioceptive neuromuscular facilitation techniques in adolescent idiopathic scoliosis: a randomized controlled study; European Review for Medical and pharmacological Sciences 2021; 25: 7717-7725.

19. Ezzat Moubarak, Sobhy Mahmoud Aly, Mohamed K Seyam, Ahmed Abd El-Moneim Abd El-Hakim, Radwa S Abdulrahman, Amina Awad; Efficacy of core stabilization versus active self-correction exercises in the treatment of adolescents with idiopathic scoliosis; Curr Pediatr Res 2022; 26 (5): 1371-1380.

20. Negrini S, Donzelli S, Negrini A, Parzini S, Romano M, Zaina F. Specific exercises reduce the need for bracing in adolescents with idiopathic scoliosis: A practical clinical trial; Annals of Physical and rehabilitation Medicine 2019;62:69-76

doi.org/10.1016/j.rehab.2018.07.010.

21. Noh DK, You JS, Koh JH, Kim H, Kim D, Ko SM, Shin JY. Effects of novel corrective spinal technique on adolescent idiopathic scoliosis as assessed by radiographic imaging. J Back Musculoskelet Rehabil 2014;27(3):331-8. doi: 10.3233/BMR-130452. PMID: 24361823.

22. Yagci G, Yakut Y. Core stabilization exercises versus scoliosis-specific exercises in moderate idiopathic scoliosis treatment. Prosthetics and Orthotics International 2019;43(3):301-308. doi:10.1177/03093646188201

23. J. Martinez-Llorens, M. Ramirez M.J. Colomina, J. Bago, A. Molina E. Caceres and J. Gea, Muscle dysfunction and exercise limitation in adolescent idiopathic scoliosis, Eur Respir J 2010; 36: 393–400

DOI: 10.1183/09031936.00025509.

24. Goldberg CJ, Gillic I, Connaughton O, Moore DP, Fogarty EE, Canny GJ, Dowling FE. Respiratory function and cosmesis at maturity in infantile- onset scoliosis. Spine (Phila Pa 1976). 2003;15;28(20):2397-406.

doi: 10.1097/01.BRS.0000085367.24266.CA. PMID: 14560091.

25. Barois A. Respiratory problems in severe scoliosis]. Bull Acad Natl Med

1999;183(4):721-30. French. PMID: 10437294.

26. Durmala J, Tomalak W, Kotwicki T. Function of the respiratory system in patients with idiopathic scoliosis: reasons for impairment and methods of evaluation. Stud Health Technol Inform 2008;135:237-45. PMID: 18401094.

27. Kearon C, Viviani GR, Kirkley A, Killian KJ.

Factors determining pulmonary function in adolescent idiopathic thoracic scoliosis. Am Rev Respir Dis 1993;148(2):288-94. doi: 10.1164/ajrccm/148.2.288. PMID: 8342890.

28. Kumar A, Kumar S, Sharma V, Srivastava RN, Gupta AK, Parihar A, Verma V, Kumar D. Efficacy of Task Oriented Exercise Program Based on Ergonomics on Cobb's Angle and Pulmonary Function Improvement in Adolescent Idiopathic Scoliosis- A Randomized Control Trial. J Clin Diagn Res 2017;11(8):YC01-YC04. doi: 10.7860/JCDR/2017/27497.10335. Epub 2017 Aug 1. PMID: 28969262; PMCID: PMC5620903.

29. Khaledi A, Minoonejad H, Daneshmandi H, Akoochakian M, Gheitasi M. Outcomes of 12 Weeks of Schroth and Asymmetric Spinal Stabilization Exercises on Cobb Angle, Angle of Trunk Rotation, and Quality of Life in Adolescent Boys with Idiopathic Scoliosis: A Randomizedcontrolled Trial. Arch Bone Jt Surg 2024;12(1):26-35.

doi: 10.22038/ABJS.2023.71875.3356. PMID: 38318305; PMCID: PMC10838577.

30. Burger M, Coetzee W, du Plessis LZ,
Geldenhuys L, Joubert F, Myburgh E, van
Rooyen C, Vermeulen N. The effectiveness of
Schroth exercises in adolescents with idiopathic
scoliosis: A systematic review and meta- analysis.
S Afr J Physiother 2019;75(1):904. doi:
10.4102/sajp.v75i1.904. PMID: 31206094;
PMCID: PMC6556933.

31. Kuru T, Yeldan İ, Dereli EE, Özdinçler AR, Dikici F, Çolak İ. The efficacy of threedimensional Schroth exercises in adolescent idiopathic scoliosis: a randomised controlled clinical trial. Clin Rehabil 2016;30(2):181-90. doi: 10.1177/0269215515575745. Epub 2015 Mar 16. PMID: 25780260.

32. Park J, So WY. The Effect of the Schroth Rehabilitation Exercise Program on Spinal and Feet Alignment in Adolescent Patients with Idiopathic Scoliosis: A Pilot Study. Healthcare (Basel) 2022;10(2):398. doi: 10.3390/healthcare10020398. PMID: 35207011; PMCID: PMC8871911.

33. Seleviciene V, Cesnaviciute A, Strukcinskiene B, Marcinowicz L, Strazdiene N, Genowska A. Physiotherapeutic Scoliosis-Specific Exercise Methodologies Used for Conservative Treatment of Adolescent Idiopathic Scoliosis, and Their Effectiveness: An Extended Literature Review of Current Research and Practice. Int J Environ Res Public Health 2022;19(15):9240. doi: 10.3390/ijerph19159240. PMID: 35954620; PMCID: PMC9368145.

34. Berdishevsky H, Lebel VA, Bettany-Saltikov J, Rigo M, Lebel A, Hennes A, Romano M, Białek M, M'hango A, Betts T, de Mauroy JC, Durmala J. Physiotherapy scoliosis-specific exercises - a comprehensive review of seven major schools. Scoliosis Spinal Disord 2016;11:20. doi: 10.1186/s13013-016-0076-9. PMID: 27525315; PMCID: PMC4973373.