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# Treatment of idiopathic scoliosis with conservative methods based on exercises: a systematic review and meta-analysis

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**Introduction:** This systematic review and meta-analysis aimed to systematically assess the effect size of conservative methods based on exercise for respondents with idiopathic scoliosis.

**Methods:** This study was developed in accordance with the PRISMA guidelines. The PubMed, Cochrane Library, Web of Science, and Google Scholar databases were searched in May 2023. The key search terms were "Idiopathic scoliosis", "Adolescent idiopathic scoliosis", "Cobb angle", "Angle of trunk rotation", "Quality of life", "Schroth method", and "Core stabilization exercises". Risk of bias was assessed for each randomized trial using the Cochrane risk of bias tool, and the methodological index for non-randomized studies. The outcomes included Cobb angle, angle of trunk rotation (ATR), forced vital capacity (FVC), forced expiratory volume in 1 s (FEV1), and quality of life (QoL). R 4.0.5 software was used, and standardized mean differences (SMD) and 95% confidence intervals (CIs) were calculated for continuous outcomes using a random model.

**Results:** In total, 23 studies were included. Depending on the outcome measured, the effect size of the different methods in the treatment of idiopathic scoliosis ranged from small to large as follows: Cobb angle (SMD = -0.43, p < 0.0001), ATR (SMD = -0.25, p = 0.06), FVC (SMD = 0.48, p = 0.03), FEV1 (SMD = 0.51, p = 0.004), and QoL (SMD = 0.95, p < 0.0001).

**Conclusion:** Our meta-analysis indicates the positive effects of applying conservative methods based on therapeutic exercises on patients with idiopathic scoliosis.

**Systematic Review Registration:** https://www.crd.york.ac.uk/prospero/display\_record.php?RecordID=373554, PROSPERO (CRD42022373554).

#### KEYWORDS

conservative methods, idiopathic scoliosis, Cobb angle, ATR, meta-analysis

# Introduction

Idiopathic scoliosis (IS) is a complex three-dimensional (3D) deformity of the spine and can develop in healthy children at any stage of growth (1, 2). IS is classified according to the age of the patient at the time of diagnosis (3). The condition is divided into three types: infantile scoliosis (under 3 years old), juvenile scoliosis (3–9 years old), and adolescent scoliosis (10–18 years old) (4). The adolescent form accounts for most cases of idiopathic scoliosis (5). Curvature in the spine can develop at any level of the non-cervical spine, and depending on the vertebrae that are affected, it is called thoracic, thoracolumbar, or lumbar scoliosis (6). When a diagnosis of scoliosis is made, the primary concern is whether there is an underlying cause and whether the curve will progress. The three main determinants of progression are the gender of the patient, future growth potential, and the size of the curve at the time of diagnosis (7).

There are surgical and non-surgical (conservative) treatment methods in the treatment of IS. There is consensus on surgical treatment in the minority of patients with spinal curvature greater than 45°, particularly in patients with severe rotational abnormalities (8). The vast majority of adolescents with idiopathic scoliosis receive conservative treatments. The most common interventions used in the conservative treatment of adolescent idiopathic scoliosis (AIS) are bracing, and exercise therapy (8, 9). Conservative therapies such as physiotherapy scoliosis-specific exercises (PSSEs), with or without simultaneous external bracing, are used as an alternative for patients who have a curvature below 50° (10). Some studies using PSSEs have shown improvement in neuromotor control (11, 12), respiratory functions (13), back muscle strength, and cosmetic appearance (13). The Scientific Exercise Approach to Scoliosis (SEAS) is a scoliosis treatment method that focuses on restoring postural control and improving stability through exercises that include active 3D self-correction of scoliotic posture. Active 3D selfcorrection is achieved first through patient education and increasing patient awareness of their deformity (14). The largest number of studies that provide quantitative results focus on therapies that use therapeutic exercise as a form of treatment for idiopathic scoliosis, and the Schroth method and core stabilization exercises are the most often used treatments in these studies (15, 16).

Previous research confirms that these methods have positive effects in reducing the Cobb angle (13, 17–19). A reduction in the Cobb angle is also followed by a decrease in the angle of trunk rotation (ATR) (20–22), and patients' subjective condition, as assessed through Scoliosis Research Society (SRS) questionnaires, showed significant improvement (22–24) Some studies (25–27) also confirm that pulmonary function results significantly improve with the application of these methods. Previous meta-analyses (15, 16) confirm the positive effects of the Schroth method and core stabilization exercises in treating idiopathic scoliosis.

The reason for the increasing use of non-surgical methods is that surgical procedures carry significant risks. Neurological complications can lead to nerve root damage, spinal cord deficit, extrinsic spinal compression, epidural hematoma or abscess, nerve element injury, or spinal cord distraction during correction (28). Reported risk factors for neurological complications during AIS surgery include a Cobb angle greater than 90°, kyphosis correction, vertebral osteotomies, combined anterior and posterior fusions, and reoperation (29, 30). There may also be delayed neurological complications caused by progressive ischemia of the spinal cord resulting in the development of an epidural hematoma (31). The reported prevalence of nonneurological complications after AIS surgery ranges from 0% to 30% (30, 32-34). These are only a few of the reasons that lead patients to turn more and more to conservative (non-surgical) treatment methods, and researchers to better quantify the effects of such methods. For this reason, our previously mentioned research studies related to idiopathic scoliosis and other problems related to the spine (35, 36) are based on conservative (non-surgical) treatment.

Despite promising evidence, there are significant limitations in the current literature, such as small sample sizes, heterogeneity in exercise protocols, and a low number of outcomes in studies. These limitations make it difficult to establish a standardized, evidence-based approach for idiopathic scoliosis. A systematic review and meta-analysis are necessary to address these gaps by synthesizing existing data to provide a comprehensive assessment of treatment efficacy. This approach will enable clearer conclusions on optimal exercise protocols, offer insight into long-term effectiveness, and support clinical decision-making by consolidating diverse findings into a more robust evidence base. This research aimed to find and unify the results of as many studies as possible that met the conditions for conservative methods based on therapeutic exercises, and to use a meta-analysis to show the effects of their application on different outcomes in subjects with IS.

### Methods

### Study design

This study was developed following the PRISMA guidelines (37), and Cochrane Collaboration guide (38).

#### Data sources and search strategy

The search was developed by identifying relevant studies that used different conservative methods in the treatment of IS. The search included the following databases: PubMed, Cochrane Library, Web of Science, and Google Scholar. The search was carried out in May 2023. Keywords used in the search are "Scoliosis" OR "Idiopathic scoliosis" OR "Adolescent idiopathic scoliosis" AND "Cobb angle" OR "Angle of trunk rotation" OR "Quality of life" AND "Physiotherapeutic Scoliosis Specific Exercises" OR "PSSE" OR "Schroth method" OR "Core stabilization exercises" OR "Pilates" OR "Exercise therapy" OR "Physical therapy" OR "Corrective exercise". The search diagram is shown in Figure 1.



#### TABLE 1 Description of the included studies.

Aday of al. (a)         9         10         100 angles	Study	N	Program type	Outcome	Cobb angle	Age	Exercise time	Duration
Image of the indicat excise part of the series of the se	Alayat et al. (42)	50	Direction-sensitive exercise therapy vs.	Cobb angle	$13.20^{\circ} \pm 4.1^{\circ}$	$14.1 \pm 1.6$	N/A	12 weeks
Bund product of the series of the			traditional exercises therapy		12.68° ± 3.7°	$14.4 \pm 1.7$		
(0)         5         Should service         Impaintory models remain         Service         Service </td <td>Duangkeaw et al.</td> <td>16</td> <td>Schroth 3D exercise vs. Kinesio tape with</td> <td>ATR</td> <td>N/A</td> <td>10-18</td> <td>120 min</td> <td>6 weeks</td>	Duangkeaw et al.	16	Schroth 3D exercise vs. Kinesio tape with	ATR	N/A	10-18	120 min	6 weeks
Series of the series	(20)		Schroth exercise	Inspiratory muscles				
Residue of all states in the series is a strength st				strength	-			
Kine al. (13)         2         Correction (and introduce) (and intr				Expiratory muscles				
Sinday of the series is speed of the series				strength Musels on during as of	-			
General mobility         General mobility         General mobility         Image: Constraint of the series				back				
Gir et al. (43)         25         Core stabilization vs. control (traditional rehabilization)         Cobb angle (1) (1) (1) (1) (1) (1) (1) (1) (1) (1)				General mobility				
Image in the initial initinitial initial initial initial initial initial initi	Gür et al. (43)	25	Core stabilization vs. control (traditional	Cobb angle	N/A	$14.2 \pm 1.8$	N/A	10 weeks
Image (4)         Image (4) <thimage (4)<="" th="">         Image (4)         <thimage (4)<="" th="">         Image (4)         <thimage (4)<="" th=""> <thimage (4)<="" th=""> <thima< td=""><td></td><td></td><td>rehabilitation)</td><td>Rotation</td><td></td><td><math>14 \pm 1.6</math></td><td></td><td></td></thima<></thimage></thimage></thimage></thimage>			rehabilitation)	Rotation		$14 \pm 1.6$		
$\begin{array}{ c c c c c c c c c c c c c c c c c c c$				QOL	-			
IdealPaychological factors21.2" ± 3.9718.88 ± 1.50(mode)HwagBo (21)[ASchroh exercise groupCobb angle18.88" ± 0.0920.94 ± 0.02(mode)12.00 ± 0.00Hun regionATRATR(mode)20.95 ± 1.0710.85 ± 1.1(mode)10.00 ± 0.0010.00 ± 0.00Kim et al. (45)[A)Swiss ball exerciseFVC, FEVI,	HwangBo (44)	16	Schroth exercise vs. Pilates exercise	Cobb angle	22.07° ± 6.81°	$18.14 \pm 1.6$	N/A	12 weeks
HwangBo (21)     16 Plates secretics group     Schooth exercise group     Cobb angle     18.98°±0.03°     20.94±0.32     60 min     12 weeks       Kim et al. (45)     40     Swiss ball exercise group     ATR     100.2±0.01"     21.08±1.95     100.2±0.01"     21.08±1.95     100.2±0.01"     21.08±1.95     100.2±0.01"     21.08±1.95     100.2±0.01"     21.08±1.95     100.2±0.01"     21.08±1.95     100.2±0.01"     21.08±1.95     100.2±0.01"     21.08±1.95     100.2±0.01"     100.	0			Psychological factors	21.2° ± 3.95°	18.88 ± 1.55		
Pilate service group         ATR         19.02* ± .01*         21.08 ± 1.95           Kim et al. (45) $P_1$ Swisb bal cercise $Chet capansion         N/A I.5 \pm 1.2 $	HwangBo (21)	16	Schroth exercise group	Cobb angle	18.98° ± 0.03°°	$20.94 \pm 0.32$	60 min	12 weeks
Kin et al. (45) Kin at l. (45) (46)Main and Bale exerciseChest expansion FVC, EV1, FEV1, FVC, FV, EV1, FVC, FV1, FV1/FVC, NANA18.5 ± 1.2 (17.9 ± 1.0)30 min8 weeks (18.5 ± 1.1)Kin and Hwangko (46)24Schroth exercise vs. Pilate exercise Restance exerciseCobb angle23.63°± 1.5° (15.3 ± 0.8)15.6 ± 1.1 (15.4 ± 1.1)60 min12 weeksKin and Park (17) (40)15SEME Schroth 3D exerciseCobb angle24.9°± 2.6°15.3 ± 0.860 min8 weeksKin and Park (17) (40)SEME Schroth 3D exerciseCobb angle24.9°± 1.2″15.7.5 ± 7.1 	-		Pilates exercise group	ATR	19.02° ± 9.01°°	$21.08 \pm 1.95$		
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Image: space series in the	Kim et al. (45)	40	Swiss ball exercise	FVC, FEV1, FEV1/FVC,	N/A	$18.5 \pm 1.2$	30 min	8 weeks
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	Kim and Hwangbo	24	Schroth exercise vs. Pilates exercise	Cobb angle	23.63° ± 1.5°	$15.6 \pm 1.1$	60 min	12 weeks
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$ \left  \begin{array}{c} \operatorname{ATR} \\ \operatorname{Cosmetic trunk} \\ \operatorname{deformity} \\ \operatorname{Spinal mobility} \\ \operatorname{QOL} \\ \end{array} \right  \\ \operatorname{Kumar et al. (26)} \\ \operatorname{Aff} \\ \operatorname{Cosmetic trunk} \\ \operatorname{deformity} \\ \operatorname{QOL} \\ \end{array} \right) \\ \left  \begin{array}{c} \operatorname{Cosmetic trunk} \\ \operatorname{deformity} \\ \operatorname{QOL} \\ \end{array} \right) \\ \left  \begin{array}{c} \operatorname{Cosmetic trunk} \\ \operatorname{deformity} \\ \operatorname{QOL} \\ \end{array} \right) \\ \left  \begin{array}{c} \operatorname{Cosmetic trunk} \\ \operatorname{deformity} \\ \operatorname{QOL} \\ \end{array} \right) \\ \left  \begin{array}{c} \operatorname{Cosmetic trunk} \\ \operatorname{deformity} \\ \operatorname{QOL} \\ \end{array} \right) \\ \left  \begin{array}{c} \operatorname{Cosmetic trunk} \\ \operatorname{deformity} \\ \operatorname{QOL} \\ \end{array} \right) \\ \left  \begin{array}{c} \operatorname{Cosmetic trunk} \\ \operatorname{deformity} \\ \operatorname{QOL} \\ \end{array} \right) \\ \left  \begin{array}{c} \operatorname{Cosmetic trunk} \\ \operatorname{deformity} \\ \operatorname{QOL} \\ \end{array} \right) \\ \left  \begin{array}{c} \operatorname{Cosmetic trunk} \\ \operatorname{deformity} \\ \operatorname{QOL} \\ \end{array} \right) \\ \left  \begin{array}{c} \operatorname{Cosmetic trunk} \\ \operatorname{deformity} \\ \operatorname{QOL} \\ \end{array} \right) \\ \left  \begin{array}{c} \operatorname{Cosmetic trunk} \\ \operatorname{QOL} \\ \end{array} \right) \\ \left  \begin{array}{c} \operatorname{Cosmetic trunk} \\ \operatorname{QOL} \\ \end{array} \right) \\ \left  \begin{array}{c} \operatorname{Cosmetic trunk} \\ \operatorname{QOL} \\ \end{array} \right) \\ \left  \begin{array}{c} \operatorname{Cosmetic trunk} \\ \operatorname{QOL} \\ \end{array} \right) \\ \left  \begin{array}{c} \operatorname{Cosmetic trunk} \\ \operatorname{QOL} \\ \end{array} \right) \\ \left  \begin{array}{c} \operatorname{Cosmetic trunk} \\ \operatorname{QOL} \\ \end{array} \right) \\ \left  \begin{array}{c} \operatorname{Cosmetic trunk} \\ \operatorname{QOL} \\ \end{array} \right) \\ \left  \begin{array}{c} \operatorname{Cosmetic trunk} \\ \operatorname{QOL} \\ \end{array} \right) \\ \left  \begin{array}{c} \operatorname{Cosmetic trunk} \\ \operatorname{QOL} \\ \end{array} \right) \\ \left  \begin{array}{c} \operatorname{Cosmetic trunk} \\ \operatorname{QOL} \\ \end{array} \right) \\ \left  \begin{array}{c} \operatorname{Cosmetic trunk} \\ \operatorname{QOL} \\ \end{array} \right) \\ \left  \begin{array}{c} \operatorname{Cosmetic trunk} \\ \operatorname{QOL} \\ \end{array} \right) \\ \left  \begin{array}{c} \operatorname{Cosmetic trunk} \\ \operatorname{QOL} \\ \end{array} \right) \\ \left  \begin{array}{c} \operatorname{Cosmetic trunk} \\ \operatorname{QOL} \\ \end{array} \right) \\ \left  \begin{array}{c} \operatorname{Cosmetic trunk} \\ \operatorname{QOL} \\ \end{array} \right) \\ \left  \begin{array}{c} \operatorname{Cosmetic trunk} \\ \operatorname{QOI} \\ \end{array} \right) \\ \left  \begin{array}{c} \operatorname{Cosmetic trunk} \\ \operatorname{QOI} \\ \end{array} \right) \\ \left  \begin{array}{c} \operatorname{QOI} \\ \operatorname{QOI} \\ \end{array} \right) \\ \left  \begin{array}{c} \operatorname{QOI} \\ \end{array} \right) \\ \left  \begin{array}{c} \operatorname{QOI} \\ \operatorname{QOI} \\ \end{array} \right) \\ \left  \begin{array}{c} \operatorname{QOI} \\ \end{array} \right) \\ \left  $	Kocaman et al. (22)	28	Schroth exercise vs. core exercise	Cobb angle	10°-30°	$14.07\pm2.37$	60 min	10 weeks
Cosmetic trunk deformityCosmetic trunk deformityImage: Cosmetic tru				ATR		$14.21 \pm 2.19$		
Image: binom space				Cosmetic trunk				
Spinal mobility QOLSpinal mobility QOLImage: Constant of the series of				deformity				
Image: constraint of the series of the se				Spinal mobility				
Kumar et al. (26)36Oriented ergonomics exercisesCobb angle $12.1^{\circ}\pm 1.81^{\circ}$ $12.17\pm 1.72$ 40 min $12 \text{ months}$ Spinal strengthening exercisesFVC, FEV1, FEV1/FVC, PEF, VC $12.72^{\circ}\pm 1.40^{\circ}$ $11.56\pm 1.46$ $90 \text{ min}$ $6 \text{ weeks}$ Kuru et al. (47)30Schroth 3D exercise vs. Control (no treatment)Cobb angle $10^{\circ}-60^{\circ}$ $10-18$ $90 \text{ min}$ $6 \text{ weeks}$ ATRArgmmetryQuality of life $00$ $13.6\pm 1.6$ N/A $6 \text{ months}$ Langensiepen et al.38Scoliosis-specific exercises + WBV vs. Control (scoliosis-specific exercises)Cobb angle $30.1^{\circ}\pm 9.0^{\circ}$ $13.6\pm 1.6$ N/A $6 \text{ months}$ Lee and Lee (49)15Schroth exercise vs. control (no treatment)Cobb angle $22.11^{\circ}\pm 7.38^{\circ}$ $18.88\pm 3.06$ $120 \text{ min}$ $12 \text{ weeks}$ Weight bearing in feetweight bearing in feet $10 \text{ min}$ $120 \text{ min}$ $12 \text{ weeks}$ Mohamed and34Schroth exerciseCobb angle $20.42^{\circ}\pm 2.57^{\circ}$ $14.50\pm 1.20$ $60 \text{ min}$ $6 \text{ months}$				QOL				
Kuru et al. (47)30Schroth 3D exercise vs. Control (no treatment)Cobb angle $10^{\circ}-60^{\circ}$ $10-18$ 90 min6 weeksATRATRAsymmetryQuality of life $00^{\circ}-60^{\circ}$ $10-18$ 90 min6 weeksLangensiepen et al. (48)38Scoliosis-specific exercises + WBV vs. Control (scoliosis-specific exercises)Cobb angle $30.1^{\circ} \pm 9.0^{\circ}$ $13.6 \pm 1.6$ N/A6 monthsLee and Lee (49)15Schroth exercise vs. control (no treatment)Cobb angle $22.11^{\circ} \pm 7.58^{\circ}$ $18.88 \pm 3.06$ $120 \min$ $120 \min$ $120 \min$ Wohamed and34Schroth exerciseCobb angle $20.42^{\circ} \pm 2.57^{\circ}$ $14.50 \pm 1.20$ $60 \min$ $6$ months	Kumar et al. (26)	36	Oriented ergonomics exercises	Cobb angle	12.61° ± 1.81°	$12.17 \pm 1.72$	40 min	12 months
Kuru et al. (47) A Langensiepen et al. (48)30 Schroth 3D exercise vs. Control (no treatment) A T Langensiepen et al. (48)38 Schiosis-specific exercises + WBV vs. Control (soliosis-specific exercises)Cobb angle ATR Asymmetry Quality of life10°-60° H ATR Asymmetry Quality of life10°-60° H ATR Asymmetry 20.6b° ± 8.7°10-18 H D90 min 6 weeks6 weeks amonths 6 monthsLangensiepen et al. (48)38 H Colosis-specific exercises + WBV vs. Control (soliosis-specific exercises)Cobb angle30.1° ± 9.0° 29.65° ± 8.7°13.6 ± 1.6 14.0 ± 0.9N/A6 monthsLee and Lee (49) H H H15 H <br< td=""><td></td><td></td><td>Spinal strengthening exercises</td><td>FVC, FEV1, FEV1/FVC, PEF, VC</td><td>12.72° ± 1.40°</td><td>11.56 ± 1.46</td><td></td><td></td></br<>			Spinal strengthening exercises	FVC, FEV1, FEV1/FVC, PEF, VC	12.72° ± 1.40°	11.56 ± 1.46		
$ \begin{array}{ c c c c c } \hline \begin{tabular}{ c c c } \hline \begin{tabular}{ c c c } \hline \begin{tabular}{ c c } \hline \hline \ \begin{tabular}{ c c } \hline \hline \ \ \begin{tabular}{ c c } \hline \hline \ \ \begin{tabular}{ c c } \hline \hline \ \$	Kuru et al. (47)	30	Schroth 3D exercise vs. Control (no treatment)	Cobb angle	10°-60°	10-18	90 min	6 weeks
$ \begin{array}{ c c c c c } \hline \begin{tabular}{ c c } \hline \hline \begin{tabular}{ c c } \hline tabula$				ATR	-			3 months
Langensiepen et al. (48)38 (soliosis-specific exercises + WBV vs. Control (soliosis-specific exercises)Cobb angle $30.1^{\circ} \pm 9.0^{\circ}$ $13.6 \pm 1.6$ 				Asymmetry	-			6 months
Langensiepen et al. (48)38Scoliosis-specific exercises + WBV vs. Control (scoliosis-specific exercises)Cobb angle $30.1^{\circ} \pm 9.0^{\circ}$ $13.6 \pm 1.6$ $29.65^{\circ} \pm 8.7^{\circ}$ N/A6 monthsLee and Lee (49)15Schroth exercise vs. control (no treatment)Cobb angle $22.11^{\circ} \pm 7.58^{\circ}$ $18.88 \pm 3.06$ 120 min12 weeksVertebral rotation angle $22.17^{\circ} \pm 7.27^{\circ}$ $24.14 \pm 12.69$ $24.14 \pm 12.69$ 12 weeksWeight bearing in feetEEEEEMohamed and34Schroth exerciseCobb angle $20.42^{\circ} \pm 2.57^{\circ}$ $14.50 \pm 1.20$ 60 min6 months				Quality of life				
$\begin{array}{ c c c c c c } \hline (48) & & & & & & & & & & & & & & & & & & &$	Langensiepen et al.	38	Scoliosis-specific exercises + WBV vs. Control	Cobb angle	30.1° ± 9.0°	13.6 ± 1.6	N/A	6 months
Image: Lee (49)15Schroth exercise vs. control (no treatment)Cobb angle $22.11^{\circ} \pm 7.58^{\circ}$ $18.88 \pm 3.06$ $120 \text{ min}$ $12 \text{ weeks}$ Weight bearing in feet $22.17^{\circ} \pm 7.27^{\circ}$ $24.14 \pm 12.69$ $24.14 \pm 12.69$ $120 \text{ min}$ $120 \text{ min}$ $120 \text{ min}$ Mohamed and34Schroth exerciseCobb angle $20.42^{\circ} \pm 2.57^{\circ}$ $14.50 \pm 1.20$ $60 \text{ min}$ $6 \text{ months}$	(48)		(scollosis-specific exercises)		29.65° ± 8.7°	14.0 ± 0.9		
$\frac{120 \text{ min}}{120 \text{ min}} = \frac{15}{120 \text{ min}} = \frac{15}{120 \text{ min}} = \frac{120 \text{ min}}{120  $	Loo and Loo (40)	1.5	Schroth oronging and control (as tracting the	Cobb anala	22 110 1 7 500	10 00 + 2 07	120!	12
Weight bearing in feet         Z2.17 ± 7.27         Z4.14 ± 12.09           Weight bearing in feet         Mohamed and         34         Schroth exercise         Cobb angle         20.42° + 2.57°         14.50 + 1.20         60 min         6 months	Lee and Lee (49)	15	schoul exercise vs. control (no treatment)	Vertebral rotation angle	$22.11 \pm 7.58^{\circ}$ $22.17^{\circ} \pm 7.27^{\circ}$	$10.00 \pm 3.00$ $24.14 \pm 12.40$	120 min	12 weeks
Mohamed and     34     Schroth exercise     Cobb angle     20.42° + 2.57°     14.50 + 1.20     60 min     6 months				Weight bearing in feet	22.17 ±7.27	24.14 ± 12.09		
Mohamed and     34     Schroth exercise     Cobb angle     20.42° + 2.57°     14.50 + 1.20     60 min     6 months				Rotation volume				
	Mohamed and	34	Schroth exercise	Cobb angle	20 42° + 2 57°	14 50 + 1 20	60 min	6 months
Yousef (50) Proprioceptive neuromuscular facilitation ATR 20.21° + 2.80° 14.90 + 1.40	Yousef (50)		Proprioceptive neuromuscular facilitation	ATR	$20.21^{\circ} + 2.80^{\circ}$	14.90 + 1.40	00 1111	
Plantar Pressure				Plantar Pressure		0 = 1.10		
Distribution				Distribution				
Functional Capacity				Functional Capacity				

(Continued)

#### TABLE 1 Continued

Study	N	Program type	Outcome	Cobb angle	Age	Exercise time	Duration
Monticone et al. (24)	110	Task-oriented spinal exercises and vs. control	Cobb angle	19.3° ± 3.9°	$12.5\pm1.1$	60 min +	N/A
		(traditional spinal exercises)	QOL	19.2° ± 2.5°	$12.4 \pm 1.1$	30-min in home	Follow-up
							12 months
Noh et al. (51)	32	Corrective spinal technique vs. control	Cobb angle	$21.6^{\circ} \pm 10.1^{\circ}$	$13.8\pm2.8$	60 min	4 months
		(conventional exercise)	Vertebral rotation	19° ± 7°	$14.9 \pm 2.3$		
			Thoracic kyphosis				
			Lumbar lordosis				
			Pelvic tilt				
			Pelvic incidence				
Park et al. (52)	51	Core strengthening vs. home program	Cobb angle	10°-20°	20 ± 2	50 min	10 weeks
			Muscle strength		$20.6 \pm 1.8$		
Park et al. (53)	33	Core stabilization vs. control (manual massage)	Cobb angle	15.76° ± 2.72°	≥20	50 min	8 weeks
			Balance	17.81° ± 2.99°	$14 \pm 1.3$		
Qi et al. (27)	38	Core stabilization vs. control (no treatment)	Cobb angle	24.06° ± 3.84°	$13.94 \pm 1.30$	60 min	12 weeks
			FVC, FEV1, FEV1/FVC,	23.88° ± 2.37°	13.61 ± 1.33		
			MIP, MEP				
Schreiber et al. (23)	50	Schroth exercise	Quality of life	10°-45°	10-18	60 min	3 months
		Standard of care	Back extensor strength	1			6 months
Schreiber et al. (19)	50	Schroth exercise	Cobb angle	10°-45°	10-18	60 min	6 months
		Standard of care	Sum of curves	1			
Won et al. (54)	20	Neuromuscular stabilization technique vs. home	Cobb angle	16.56° ± 2.50°	$14.50\pm2.50$	30 min	6 months
		exercise program		18.90° ± 5.24°	$15.90\pm2.69$		

N, number of subjects in the group; ATR, angle of trunk rotation; QOL, quality of life; ATI, angle of trunk inclination; VC, vital capacity; FVC, forced vital capacity; FEV1, forced expiratory volume in 1 s; MIP, maximum inspiratory pressure; MEP, maximum expiratory pressure; SERME, Schroth's three-dimensional exercises in combination with respiratory muscle exercise; WBV, whole body vibration; N/A, no answer; PEF, peak expiratory flow; VC, vital capacity; TIS, trunk impairment scale.

### Study selection

All studies had to meet PICOS (Population, Interventions, Comparators, Outcomes, Study Designs) criteria (39). P (population): diagnosed subjects with idiopathic scoliosis; I (intervention): different conservative methods based on exercises; C (comparison): control group received no treatment or received some other conservative treatment based on exercise; O (outcome): Cobb angle, angle of trunk rotation, forced vital capacity (FVC), forced expiratory volume in 1 s (FEV1), and quality of life (QoL).; S (study design): comparative studies published after 2000. There was no language restriction. Studies excluded were systematic reviews, meta-analyses, study protocols, books, book reviews, and conference publications. The process selection of studies was performed by two researchers (BO and DV), and decisions were made with consultation and consensus.

#### Data extraction and quality assessment

After selecting studies based on all inclusion and exclusion criteria in the meta-analysis, two investigators independently performed data extraction. The table contains the following data: authors, year of publication, program type, number of participants, age, Cobb angle, outcomes, exercise time, and duration.

The quality of the studies was independently assessed by two investigators (BR and VD). For randomized studies, the Cochrane risk of bias tool (38) was used. Each study was assessed as low risk, unclear risk, or high risk. To ascertain the quality of non-randomized studies, the methodological index for non-randomized studies (MINORS) was used (40).

### Data synthesis and analysis

R 4.0.5 software with the "meta" package was used. The effect size was estimated for each of the outcomes. For each study, standardized mean difference (SMD) and 95% confidence intervals (CIs) were calculated for continuous outcomes using a random model. Although the same measurement scales were used for all the outcomes in our study and the same method was used to determine the scoliotic curve via the Cobb angle, we used SMD due to possible differences in the use of different devices in radiography, which may have different specifications and parameters. Furthermore, differences could also occur due to the accuracy and consistency of body position, which is crucial for obtaining accurate and reliable radiographs, since even small deviations can lead to changes in the appearance of anatomical structures, which can affect the accuracy of the diagnosis. Spirometers from different manufacturers may have differences in sensitivity, measurement accuracy, and calibration, which can affect the results. Thus, we used SMD for these reasons. According to Cohen's guide, values of  $\geq 0.2$ ,  $\geq 0.5$ , and  $\geq 0.8$  indicate small, medium, and large effect sizes, respectively (41). p <0.05 was considered statistically significant.

Five subgroup analyses were performed for the Cobb angle outcome. Based on the reported treatment durations in the included studies, our assessment was that three subgroups could be formed. A subgroup analysis was performed for the duration of treatment factor for the Cobb angle outcome and three subgroups were formed: 8-10, 12, and >12 weeks. Subgroup analysis was performed for factor risk of bias and three subgroups were formed: low, moderate, and high. For the factor method, three subgroups were formed: Schroth exercise, core stabilization, and combined therapy, which included studies that used some other exercises or combined several types of exercises. Since some studies had respondents older than 18 years, we performed a subgroup analysis for the age factor and formed two subgroups: the younger group and the older group. A subgroup analysis was also performed in relation to whether the control group had treatment or not, and two subgroups were formed: treatment and nontreatment. A sensitivity analysis was also performed to observe how each study affected the overall effect size for the Cobb angle outcome. An analysis was also performed within the experimental and control groups, and within the control group, a subgroup analysis was performed, depending on whether the control group did or did not have treatment. Higgins' I2 test was used to assess heterogeneity. Egger's test evaluated the publication bias for the Cobb angle outcome.

## Results

#### Study selection and characteristics

Initially, 774 studies were selected from the four databases and 237 studies were immediately excluded because they were duplicates. Thus, 537 studies were selected for further analysis. After screening the titles and abstracts, 65 studies were screened in full. Of these, 42 studies were excluded and the remaining 23 studies were included in the qualitative and quantitative analysis. The study selection flow process is presented in Figure 1. Table 1 shows some of the characteristics of the studies we included. A total of 796 respondents participated in the 23 studies. In the selected studies, the sample size was between 15 and 110 subjects. The treatment lasted from 6 weeks to 6 months.

#### Risk of bias

Figures 2, 3 show the risk of bias for the non-randomized and randomized studies, respectively. Of the 23 included studies, 3 were non-randomized, while 20 were randomized. Of the randomized studies, eight had a high risk in the item "Concealment of allocation" to the group. Participants and physiotherapists could not be blinded to the treatment due to the very nature of the treatment, although some studies (42, 43) report blinding in this item, while eight studies report blinding in the item "Blinding of outcome assessment". A study (47) presented the data as median (min-max), which represents a problem for data processing, and this study was assessed as high risk in the item "Selective reporting". Out of a total of 140 items, there were 97 (69.3%) low-risk items, 34 (24.3%) moderate-risk items, and 9 (6.4%) high-risk items. To ascertain whether the quality of the studies affected the effect size, we performed a subgroup analysis for the risk of bias for the Cobb angle outcome and presented the results in the results of the meta-analysis. All three non-randomized studies were comparative and had a minimum score of 18 and a maximum score of 22 out of a possible 24. In the subgroup analysis, two studies (51, 54) were in the moderate-risk subgroup, while one study (18) was in the high-risk subgroup.

## Cobb angle

Of the 23 included studies, 19 used the Cobb angle as an outcome. After the analysis, statistical significance was found (SMD = -0.50; 95% CI = -0.65 to -0.34; p < 0.0001) and there was no heterogeneity (I2 = 0%, p = 0.81). Subgroup analysis for the duration factor showed the following results: 8-10 weeks subgroup : (SMD = -0.58; 95% CI = -0.86 to -0.30; p < 0.0001; p = 0.85);heterogeneity I2 = 0%, 12 weeks subgroup: (SMD = -0.47; 95% CI = -0.75 to -0.20;*p* < 0.0001; heterogeneity  $I^2 = 0\%$ , p = 0.83; >12 weeks subgroup: (SMD = -0.46; 95% CI = -0.65 to -0.34; p < 0.0001;heterogeneity  $I^2 = 24\%$ , p = 0.23) (Figure 4). Subgroup analysis for the age factor showed the following results: younger subgroup: (SMD = -0.48; 95% CI = -0.65 to -0.31; *p* < 0.0001; heterogeneity  $I^2 = 0\%$ , p = 0.61; older subgroup: (SMD = -0.56; 95% CI = -0.89 to -0.23; p < 0.0001; heterogeneity  $I^2 = 0\%$ , p = 0.85). Subgroup analysis for the risk of bias showed the following results: low subgroup: (SMD = -0.62; 95% CI = -0.82

					Meth	odological	items						
Study	1	2	3	4	5	6	7	8	9	10	11	12	Total score
Ko & Kang 2017	2	2	2	2	0	0	0	2	2	2	2	2	18
Noh 2014	2	2	2	2	0	2	2	2	2	2	2	2	22
Won 2021	2	2	2	2	0	2	2	1	2	2	2	2	21

FIGURE 2

Risk of bias-non-randomized studies.



to -0.41; p < 0.0001; heterogeneity  $I^2 = 0\%$ , p = 0.67); moderate subgroup: (SMD = -0.38; 95% CI = -0.65 to -0.12; p < 0.0001; heterogeneity  $I^2 = 0\%$ , p = 0.87); high subgroup : (SMD = -0.23; 95% CI = -0.67 to -0.20; p < 0.0001; heterogeneity  $I^2 = 0\%$ ,

p = 0.62). Subgroup analysis for the different exercise methods showed the following results: combined therapy subgroup: (SMD = -0.45; 95% CI = -0.74 to -0.15; p < 0.0001;heterogeneity  $I^2 = 13\%$ , p = 0.33; core stabilization subgroup: (SMD = -0.50; 95% CI = -0.77 to -0.24; p < 0.0001;heterogeneity  $I^2 = 0\%$ , p = 0.50; Schroth exercise subgroup: (SMD = -0.53; 95% CI = -0.79 to -0.27; p < 0.0001;heterogeneity  $I^2 = 0\%$ , p = 0.88). Subgroup analysis for treatment usage in the control group showed the following results: treatment subgroup: (SMD = -0.53; 95% CI = -0.72 to -0.34; p < 0.0001; heterogeneity  $I^2 = 0\%$ , p = 0.83); nontreatment subgroup: (SMD = -0.43; 95% CI = -0.70 to -0.15;p < 0.0001; heterogeneity  $I^2 = 0\%$ , p = 0.44) (Figure 5). Analysis within groups showed the following results: experimental (SMD = 1.13; 95% CI = 0.69–1.57; *p* < 0.0001; group: heterogeneity  $I^2 = 83\%$ , p < 0.01) (Supplementary Material, Figure 6); control group: (SMD = 0.45; 95% CI = 0.18 to -0.71; p < 0.0001; heterogeneity  $I^2 = 65\%$ , p < 0.01). Subgroup analysis for treatment usage in the control group showed the following results: treatment subgroup: (SMD = 0.62; 95% CI = 0.28-0.96; p < 0.0001; heterogeneity  $I^2 = 67\%$ , p < 0.01); non-treatment subgroup: (SMD = 0.08; 95% CI = -0.2 to -0.39; p < 0.0001; heterogeneity  $I^2 = 19\%$ , p = 0.29) (Supplementary Material, Figure 7). Egger's test showed that there was no obvious publication bias of statistical significance (intercept -0.03; 95% CI = -2.06 to 2.12; p = 0.98) (Supplementary Material, Figure 1).

### ATR, FVC, FEV1, and QoL

Four studies used ATR as an outcome. After the analysis, statistical significance was observed (SMD = -0.48; 95% CI = -0.83 to -0.13; p = 0.01) and there was no heterogeneity ( $I^2 = 0\%$ , p = 0.62) (Supplementary Material, Figure 2). Three studies used FVC as an outcome. After the analysis, no statistical significance was shown (SMD = 0.58; 95% CI = -0.04 to 1.20; p = 0.07) and there was heterogeneity ( $I^2 = 49\%$ , p = 0.14) (Supplementary Material, Figure 3). Three studies used FEV1 as an outcome. After the analysis, statistical significance was shown (SMD = 0.61; 95% CI = 0.19-1.03; p = 0.005) and there was no heterogeneity ( $I^2 = 0\%$ , p = 0.53) (Supplementary Material, Figure 4). Four studies used QoL as an outcome. After the analysis, statistical significance was shown (SMD = 1.17; 95% CI = 0.88-1.45; p < 0.0001) and there was no heterogeneity ( $I^2 = 0\%$ , p = 0.39) (Supplementary Material, Figure 8).

# Discussion

This research aimed to use a meta-analysis to determine the effect size of the conservative methods based on exercises on patients of IS. In total, 23 studies, involving 796 subjects, were included in the meta-analysis. The effect size was assessed in five outcomes. The effect size for the Cobb angle outcome was moderate and ATR had an almost moderate effect size. Furthermore, the QoL outcome had a large effect size, the FVC

12 weeks         Alayat 2017       -0.6066       0.2898         HwangBo 2016       -0.5884       0.5139         HwangBo 2016       -0.5540       0.4174         Ko & Kang (1) 2017       -0.0068       0.3716         Ko & Kang (2) 2017       -0.2040       0.3727         Lee & Lee 2020       -0.3810       0.523         Qi 2022       -0.8482       0.3497         Sim & Park 2017       -0.0666       0.3899         Gür (1) 2017       -0.6362       0.4120         Gür (2) 2017       -0.2620       0.4023         Kocaman (2) 2021       -0.6666       0.3899         Park 2016       -0.8554       0.2948         Park 2016       -0.8554       0.2948         Heterogeneity: $l^2 = 0\%, p = 0.85$ -0.4467       0.3532         Kumar 2017       -1.1975       0.3652         Langensiepen MIC 2017       0.1227       0.3258         Langensiepen MIC 2017       0.1227       0.3252         Mohamed Xrousef 2021       -0.6157       0.4601         Noh 2014       -0.2451       0.2045       0.2836         Langensiepen MIC 2017       0.1227       0.3555         Schreieber 2016       -0.2045 <t< th=""><th>Study</th><th>g</th><th>SE</th><th>Difference</th><th>SMD</th><th>95%-CI</th><th>Weight</th></t<>	Study	g	SE	Difference	SMD	95%-CI	Weight
Alayat 2017 - 0.6066 0.2898 HwangBo 2016 -0.5884 0.5139 HwangBo 2018 -0.4959 0.5099 Kim & HwangBo 2016 -0.5540 0.4174 Ko & Kang (1) 2017 -0.0068 0.3716 Ko & Kang (2) 2017 -0.2040 0.3727 Lee & Lee 2020 -0.3810 0.5237 Qi 2022 -0.8482 0.3497 Random effects model Heterogeneity: $I^2 = 0\%, p = 0.83$ 8-10 weeks Gür (1) 2017 -0.6362 0.4120 Gür (2) 2017 -0.2620 0.4023 Kim & Park 2017 -0.117 0.5180 Park 2017 -0.2620 0.4467 0.3532 Random effects model Heterogeneity: $I^2 = 0\%, p = 0.85$ >12 weeks Kumar 2017 -1.1975 0.3652 Langensiepen MIC 2017 -0.1227 0.3252 Mohamed & Yousef 2021 -1.0456 0.3863 Langensiepen MIC 2017 -0.1227 0.3252 Mohamed & Yousef 2021 -1.055 0.3665 Schreiber 2016 -0.2045 0.2836 -0.205 [-1.07; 0.301] -2 -1.5 -1 -0.5 0 0.55 1	12 weeks						
HwangBo 2016 $-0.5844 \ 0.5139$ $-0.59 \ [-1.60; 0.42] \ 2$ HwangBo 2018 $-0.4959 \ 0.5099$ $-0.55 \ [-1.37; 0.26] \ 3$ Kim & HwangBo 2016 $-0.5540 \ 0.4174$ $-0.55 \ [-1.37; 0.26] \ 3$ Ko & Kang (1) 2017 $-0.0068 \ 0.3716$ $-0.01 \ [-0.74; \ 0.72] \ 4$ Ko & Kang (2) 2017 $-0.2040 \ 0.3727$ $-0.3810 \ 0.5237$ Qi 2022 $-0.8482 \ 0.3497$ $-0.38 \ [-1.41; \ 0.65] \ 2$ Random effects model $-0.47 \ [-0.75; \ -0.20] \ 31$ Heterogeneity: $I^2 = 0\%, p = 0.83$ $-0.64 \ [-1.44; \ 0.17] \ 3$ Sho weks $-0.64 \ [-1.44; \ 0.17] \ 3$ Gür (2) 2017 $-0.6666 \ 0.3899$ $-0.64 \ [-1.43; \ 0.28] \ 3$ No coaman (1) 2021 $-0.6666 \ 0.3899$ $-0.67 \ [-1.43; \ 0.28] \ 3$ Park 2021 $-0.4467 \ 0.3532$ $-0.28 \ [-1.43; \ 0.28] \ 4$ Random effects model $-0.3507 \ 0.3863$ $-0.26 \ [-1.07; \ 0.37] \ 4$ Heterogeneity: $I^2 = 0\%, p = 0.85$ $-1.20 \ [-1.91; -0.48] \ 4$ Kumar 2017 $-1.1975 \ 0.3652$ $-1.20 \ [-1.91; -0.48] \ 4$ Kumar 2017 $-0.3507 \ 0.3863$ $-0.26 \ [-1.07; \ 0.37] \ 4$ Langensiepen MIC 2017 $-0.1990 \ 0.3258$ $-0.26 \ [-0.98; \ 0.42] \ 4$ Langensiepen MIC 2017 $-0.2813 \ 0.3555 \ -1.01 \ [-1.72; \ 0.29] \ 4$ Nohamed & Yousef 2021 $-0.6157 \ 0.4601 \ -0.2815 \ 0.2836 \ -0.20 \ [-0.65; \ -0.34] \ 100.$ Won 2021 $-0.6157 \ 0.4601 \ -0.2815 \ 0.2836 \ -0.20 \ [-0.65; \ -0.34] \ 100.$ Won 2021 $-0.6157 \ 0.4601 \ -0.2815 \ 0.2836 \ -0.20 \ [-0.65; \ -0.34] \ 100.$ Heterogeneity: $I^2 = 24\%, p = 0.$	Alayat 2017	-0.6066	0.2898		-0.61	[-1.17; -0.04]	7.2%
HwangBo 2018 -0.4959 0.5099 Kim & HwangBo 2016 -0.554 0.4174 Ko & Kang (1) 2017 -0.0068 0.3716 Ko & Kang (2) 2017 -0.2040 0.3727 Lee & Lee 2020 -0.3810 0.5237 Qi 2022 -0.8482 0.3497 Random effects model Heterogeneity: $l^2 = 0\%$ , $p = 0.83$ 8-10 weeks Gür (1) 2017 -0.6362 0.4120 Gür (2) 2017 -0.2620 0.4023 Kim & Park 2017 -0.1017 0.5180 Kocaman (1) 2021 -0.7152 0.3917 Heterogeneity: $l^2 = 0\%$ , $p = 0.85$ >12 weeks Kuma 2017 -1.1975 0.3652 ×12 weeks Kuma 2017 -0.1227 0.3252 Mohamed & Yousef 2021 -1.055 0.3665 ×12 weeks Kuma 2017 -0.1227 0.3252 Mohamed & Yousef 2021 -1.055 0.3665 ×12 weeks Kuma 2017 -0.1227 0.3252 Mohamed & Yousef 2021 -0.6157 0.4601 Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ Random effects model	HwangBo 2016	-0.5884	0.5139		-0.59	[-1.60; 0.42]	2.3%
Kim & HwangBo 2016 $-0.5540 0.4174$ Ko & Kang (1) 2017 $-0.0068 0.3716$ Ko & Kang (2) 2017 $-0.2040 0.3727$ Lee & Lee 2020 $-0.3810 0.5237$ Qi 2022 $-0.8482 0.3497$ Random effects model Heterogeneity: $l^2 = 0\%$ , $p = 0.83$ <b>8-10 weeks</b> Gür (1) 2017 $-0.2620 0.4023$ Kim & Park 2017 $-0.2620 0.4023$ Kim & Park 2017 $-0.2620 0.4023$ Kim & Park 2017 $-0.1017 0.5180$ Kocaman (1) 2021 $-0.7152 0.3917$ Kocaman (2) 2021 $-0.6666 0.3899$ Park 2016 $-0.8554 0.2948$ Park 2016 $-0.8554 0.2948$ Park 2021 $-0.4467 0.3532$ Heterogeneity: $l^2 = 0\%$ , $p = 0.85$ >12 weeks Kuma 2017 $-1.1975 0.3652$ Kuma 2017 $-0.1999 0.3258$ Langensiepen MAC 2017 $-0.1999 0.3258$ Langensiepen MAC 2017 $-0.1999 0.3258$ Noh 2014 $-0.2813 0.3555$ Schreiber 2016 $-0.2045 0.2836$ Noh 2014 $-0.2813 0.3555$ Schreiber 2016 $-0.2045 0.2836$ Noh 2021 $-0.6157 0.4601$ Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ Random effects model Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ Random effects model Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ Random effects model Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ Random effects model	HwangBo 2018	-0.4959	0.5099		-0.50	[-1.50; 0.50]	2.3%
Ko & Kang (1) 2017 - 0.0068 0.3716 Ko & Kang (2) 2017 - 0.2040 0.3727 Lee & Lee 2020 - 0.3810 0.5237 Qi 2022 - 0.8482 0.3497 Random effects model Heterogeneity: $l^2 = 0\%$ , $p = 0.83$ <b>8-10 weeks</b> <b>9</b> <b>9</b> <b>9</b> <b>1</b> <b>1</b> <b>1</b> <b>1</b> <b>1</b> <b>1</b> <b>1</b> <b>1</b>	Kim & HwangBo 2016	-0.5540	0.4174		<b>-0</b> .55	[-1.37; 0.26]	3.5%
Ko & Kang (2) 2017 -0.2040 0.3727 Lee & Lee 2020 -0.3810 0.5237 Qi 2022 -0.8482 0.3497 Arr down effects model Heterogeneity: $l^2 = 0\%$ , $p = 0.83$ <b>8-10 weeks</b> <b>G</b> $\ddot{u}$ (1) 2017 -0.6362 0.4120 G $\ddot{u}$ (2) 2017 -0.2620 0.4023 Kim & Park 2017 -0.1017 0.5180 Kocaman (1) 2021 -0.7152 0.3917 Kocaman (2) 2021 -0.6666 0.3899 Park 2016 -0.8554 0.2948 Park 2021 -0.4467 0.3532 Random effects model Heterogeneity: $l^2 = 0\%$ , $p = 0.85$ >12 weeks Kuma 2017 -1.1975 0.3652 Kuma 2017 -0.1929 0.3258 Langensiepen MAC 2017 -0.1929 0.3258 Langensiepen MAC 2017 -0.1227 0.3252 Mohamed & Yousef 2021 -1.0055 0.3665 Noh 2014 -0.2813 0.3555 S-12 weeks Kuma 2017 -0.1227 0.3252 Mohamed & Yousef 2021 -0.6157 0.4601 Random effects model Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ Random effects mode	Ko & Kang (1) 2017	-0.0068	0.3716		-0.01	[-0.74; 0.72]	4.4%
Lee & Lee 2020 -0.3810 0.5237 Qi 2022 -0.8482 0.3497 Random effects model Heterogeneity: $l^2 = 0\%$ , $p = 0.83$ 8-10 weeks Gür (1) 2017 -0.6362 0.4120 Gür (2) 2017 -0.2620 0.4023 Kim & Park 2017 -0.1017 0.5180 Kocaman (1) 2021 -0.7152 0.3917 Kocaman (2) 2021 -0.6666 0.3899 Park 2016 -0.8554 0.2948 Park 2016 -0.8554 0.2948 Park 2021 -0.4467 0.3532 Kumar 2017 -1.1975 0.3652 Kumar 2017 -1.1975 0.3652 Kumar 2017 -0.1929 0.3258 Langensiepen MIC 2017 -0.1227 0.3252 Mohamed & Yousef 2021 -1.0055 0.3665 Langensiepen MIC 2017 -0.1227 0.3252 Mohamed & Yousef 2021 -0.6157 0.4601 Random effects model Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ Random effects model Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ Random effects model Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ Random effects model Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ Random effects model Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ Random effects model Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ Random effects model Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ Random effects model Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ Random effects model	Ko & Kang (2) 2017	-0.2040	0.3727		-0.20	[-0.93; 0.53]	4.3%
Qi 2022 -0.8482 0.3497 Random effects model Heterogeneity: $l^2 = 0\%$ , $p = 0.83$ 8-10 weeks Gür (1) 2017 -0.6362 0.4120 Gür (2) 2017 -0.2620 0.4023 Kim & Park 2017 -0.1017 0.5180 Kocaman (1) 2021 -0.7152 0.3917 Kocaman (2) 2021 -0.6666 0.3899 Park 2016 -0.8554 0.2948 Park 2021 -0.6466 0.3899 Park 2021 -0.6467 0.3532 Random effects model Heterogeneity: $l^2 = 0\%$ , $p = 0.85$ >12 weeks Kuru 2016 -0.3507 0.3663 Langensiepen MAC 2017 -0.1227 0.3252 Mohamed & Yousef 2021 -1.0055 0.3665 Noh 2014 -0.2813 0.3555 Schreiber 2016 -0.2045 0.2836 Won 2021 -0.6157 0.4601 Random effects model Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ Random effects model Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ Random effects model Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ Random effects model Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ Random effects model Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ Random effects model Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ Random effects model Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ Random effects model Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ Random effects model Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ Random effects model Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ Random effects model Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ Random effects model Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ Random effects model Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ Random effects model Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ Random effects model Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ Random effects model Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ Random effects model Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ Random effects model Random ef	Lee & Lee 2020	-0.3810	0.5237		-0.38	[-1.41; 0.65]	2.2%
Random effects model Heterogeneity: $l^2 = 0\%$ , $p = 0.83$ 8-10 weeks Gür (1) 2017 - 0.6362 0.4120 Gür (2) 2017 - 0.2620 0.4023 Kim & Park 2017 - 0.1017 0.5180 Kocaman (1) 2021 - 0.7152 0.3917 Kocaman (2) 2021 - 0.6666 0.3899 Park 2016 - 0.8554 0.2948 Park 2016 - 0.8554 0.2948 Park 2021 - 0.4467 0.3532 Random effects model Heterogeneity: $l^2 = 0\%$ , $p = 0.85$ >12 weeks Kumar 2017 - 1.1975 0.3652 Kumar 2017 - 0.1999 0.3258 Langensiepen MIC 2017 - 0.1999 0.3258 Langensiepen MIC 2017 - 0.1999 0.3258 Langensiepen MIC 2017 - 0.1999 0.3258 Kumar 2014 - 0.2813 0.3555 Shohamed & Yousef 2021 - 0.6157 0.4601 Random effects model Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ Random effects model Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ Random effects model Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ Random effects model Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ Random effects model Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ Random effects model Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ Random effects model Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ Random effects model Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ Random effects model Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ Random effects model Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ Random effects model	Qi 2022	-0.8482	0.3497		<b>-0.8</b> 5	[-1.53; -0.16]	4.9%
Heterogeneity: $l^2 = 0\%$ , $p = 0.83$ <b>8-10 weeks</b> Gür (1) 2017 - 0.6362 0.4120 Gür (2) 2017 - 0.2620 0.4023 Kim & Park 2017 - 0.1017 0.5180 Kocaman (1) 2021 - 0.7152 0.3917 Kocaman (2) 2021 - 0.6666 0.3899 Park 2016 - 0.8554 0.2948 Park 2016 - 0.8554 0.2948 Park 2021 - 0.4467 0.3532 <b>Random effects model</b> Heterogeneity: $l^2 = 0\%$ , $p = 0.85$ >12 weeks Kuma 2017 - 1.1975 0.3652 Kuma 2017 - 0.1227 0.3252 Mohamed & Yousef 2021 - 1.0055 0.3665 Noh 2014 - 0.2813 0.3555 Schreiber 2016 - 0.2045 0.2836 Noh 2014 - 0.2813 0.3555 Schreiber 2016 - 0.2045 0.2836 Noh 2014 - 0.2813 0.3555 Random effects model Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ <b>Random effects model</b> -2 -1.5 -1 -0.5 0 0.5 1	Random effects model				-0.47	[-0.75; -0.20]	31.0%
<b>8-10 weeks</b> Gür (1) 2017 - 0.6362 0.4120 Gür (2) 2017 - 0.2620 0.4023 Kim & Park 2017 - 0.1017 0.5180 Kocaman (1) 2021 - 0.7152 0.3917 Kocaman (2) 2021 - 0.6666 0.3899 Park 2016 - 0.8554 0.2948 Park 2016 - 0.8554 0.2948 Park 2021 - 0.4467 0.3532 <b>Random effects model</b> Heterogeneity: $l^2 = 0\%$ , $p = 0.85$ ×12 weeks Kumar 2017 - 1.1975 0.3652 Kumar 2017 - 0.1227 0.3252 Mohamed & Yousef 2021 - 1.0055 0.3665 Noh 2014 - 0.2813 0.3555 Schreiber 2016 - 0.2045 0.2836 Noh 2014 - 0.2813 0.3555 Random effects model Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ <b>Random effects model</b> -2 -1.5 -1 -0.5 0 0.5 1	Heterogeneity: $I^2 = 0\%$ , $p =$	0.83					
Gür (1) 2017 $-0.6362$ $0.4120$ $-0.64$ $[-1.44;$ $0.17]$ $3$ Gür (2) 2017 $-0.2620$ $0.4023$ $-0.664$ $[-1.44;$ $0.17]$ $3$ Kim & Park 2017 $-0.1017$ $0.5180$ $-0.26$ $[-1.05;$ $0.53]$ $3$ Kocaman (2) 2021 $-0.6666$ $0.3899$ $-0.72$ $[-1.48;$ $0.05]$ $3$ Kocaman (2) 2021 $-0.6666$ $0.3899$ $-0.72$ $[-1.43;$ $0.10]$ $4$ Park 2016 $-0.8554$ $0.2948$ $-0.66$ $[-1.43;$ $0.28]$ $-0.45$ $[-1.44;$ $0.28]$ Park 2021 $-0.4467$ $0.3532$ $-0.45$ $[-1.44;$ $0.28]$ $-0.45$ $[-1.44;$ $0.28]$ $-0.45$ $[-1.43;$ $0.28]$ $-0.66$ $[-1.43;$ $0.28]$ $-0.45$ $[-1.44;$ $0.28]$ $-0.45$ $[-1.43;$ $0.28]$ $-0.45$ $[-1.43;$ $0.28]$ $-0.45$ $[-1.43;$ $0.28]$ $-0.45$ $[-1.43;$ $0.28]$ $-0.45$ $[-1.43;$ $0.28]$ $-0.45$ $[-1.44;$ $0.28]$ $-0.45$ $[-1.43;$ $0.28]$ $-0.45$ $[-1.43;$ $0.28]$ $-0.45$ $[-1.43;$ $0.28]$ $-0.45$ $[-1.43;$ $0.28]$ $-0.45$ $[-1.43;$ $0.28]$ $-0.45$ $[-1.43;$ $0.28]$ $-0.45$ $[-1.43;$ $0.28]$ $-0.58$ $[-0.86;$ $-0.35]$ $-0.28$ $-0.28$ $-0.28$ $-0.28$ $-0.28$ $-0.28$ $-0.28$ $-0.28$ $-0.28$ $-0.28$ $-0.28$ $-0.28$ $-0.28$ $-0.28$ <	8-10 weeks						
Gür (2) 2017 $-0.2620 \ 0.4023$ $-0.266 \ [-1.05; 0.53] \ 3$ Kim & Park 2017 $-0.1017 \ 0.5180$ $-0.10 \ [-1.12; 0.91] \ 2$ Kocaman (1) 2021 $-0.7152 \ 0.3917$ $-0.72 \ [-1.48; 0.05] \ 3$ Kocaman (2) 2021 $-0.6666 \ 0.3899$ $-0.67 \ [-1.43; 0.10] \ 4$ Park 2016 $-0.8554 \ 0.2948$ $-0.467 \ 0.3532$ Park 2021 $-0.4467 \ 0.3532$ $-0.4467 \ 0.3532$ Random effects model $-0.4467 \ 0.3532$ $-0.45 \ [-1.14; 0.25] \ 4$ Heterogeneity: $I^2 = 0\%, p = 0.85$ $-0.45 \ [-1.14; 0.25] \ 4$ >12 weeks $-0.3507 \ 0.3663$ $-0.58 \ [-0.86; -0.30] \ 29$ Kumar 2017 $-1.1975 \ 0.3652$ $-1.20 \ [-1.91; -0.48] \ 4$ Langensiepen MIC 2017 $-0.1227 \ 0.3252$ $-0.20 \ [-0.84; 0.44] \ 5$ Langensiepen MIC 2017 $-0.1227 \ 0.3252$ $-0.12 \ [-0.76; 0.51] \ 5$ Mohamed & Yousef 2021 $-0.06157 \ 0.4601$ $-0.2045 \ 0.2836$ Noh 2014 $-0.2813 \ 0.3555$ $-0.2045 \ 0.2836$ Won 2021 $-0.6157 \ 0.4601$ $-0.2045 \ 0.2836$ Won 2021 $-0.6157 \ 0.4601$ $-0.50 \ [-0.76; 0.35] \ 7$ Heterogeneity: $I^2 = 24\%, p = 0.23$ $-2 \ -1.5 \ -1 \ -0.5 \ 0 \ 0.5 \ 1$ Random effects model $-2 \ -1.5 \ -1 \ -0.5 \ 0 \ 0.5 \ 1$	Gür (1) 2017	-0.6362	0.4120		-0.64	[-1.44; 0.17]	3.5%
Kim & Park 2017 $-0.1017 \ 0.5180$ Kocaman (1) 2021 $-0.7152 \ 0.3917$ Kocaman (2) 2021 $-0.6666 \ 0.3899$ Park 2016 $-0.8554 \ 0.2948$ Park 2021 $-0.4467 \ 0.3532$ Random effects model Heterogeneity: $I^2 = 0\%$ , $p = 0.85$ >12 weeks Kumar 2017 $-1.1975 \ 0.3652$ Langensiepen MAC 2017 $-0.1999 \ 0.3258$ Langensiepen MIC 2017 $-0.1227 \ 0.3252$ Mohamed & Yousef 2021 $-1.0055 \ 0.3665$ Schreiber 2016 $-0.2045 \ 0.2836$ Noh 2014 $-0.2813 \ 0.3555$ Kumar 2017 $-0.2045 \ 0.2836$ Mohamed & Yousef 2021 $-1.0055 \ 0.3665$ Kumar 2016 $-0.2045 \ 0.2836$ Mohamed & Yousef 2021 $-1.0055 \ 0.3665$ Random effects model Heterogeneity: $I^2 = 24\%$ , $p = 0.23$ Random effects model Heterogeneity: $I^2 = 24\%$ , $p = 0.23$ Random effects model	Gür (2) 2017	-0.2620	0.4023		-0.26	[-1.05; 0.53]	3.7%
Kocaman (1) 2021 -0.7152 0.3917 Kocaman (2) 2021 -0.6666 0.3899 Park 2016 -0.8554 0.2948 Park 2021 -0.4467 0.3532 Random effects model Heterogeneity: $I^2 = 0\%$ , $p = 0.85$ >12 weeks Kumar 2017 -1.1975 0.3652 Kuru 2016 -0.3507 0.3683 Langensiepen MAC 2017 -0.1999 0.3258 Langensiepen MIC 2017 -0.1227 0.3252 Mohamed & Yousef 2021 -1.0055 0.3665 Noh 2014 -0.2813 0.3555 Schreiber 2016 -0.2045 0.2836 Noh 2014 -0.2813 0.3555 Schreiber 2016 -0.2045 0.2836 Noh 2021 -0.6157 0.4601 Heterogeneity: $I^2 = 24\%$ , $p = 0.23$ Random effects model Heterogeneity: $I^2 = 24\%$ , $p = 0.23$ Random effects model Heterogeneity: $I^2 = 24\%$ , $p = 0.23$ Random effects model	Kim & Park 2017	-0.1017	0.5180		-0.10	[-1.12; 0.91]	2.2%
Kocaman (2) 2021 -0.6666 0.3899 Park 2016 -0.8554 0.2948 Park 2021 -0.4467 0.3532 Random effects model Heterogeneity: $l^2 = 0\%$ , $p = 0.85$ >12 weeks Kumar 2017 -1.1975 0.3652 Kuru 2016 -0.3507 0.3683 Langensiepen MAC 2017 -0.1999 0.3258 Langensiepen MIC 2017 -0.1227 0.3252 Mohamed & Yousef 2021 -1.0055 0.3665 Noh 2014 -0.2813 0.3555 Schreiber 2016 -0.2045 0.2836 Noh 2014 -0.2813 0.3555 Schreiber 2016 -0.2045 0.2836 Noh 2021 -0.6157 0.4601 Random effects model Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ Random effects model Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ Random effects model Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ Random effects model Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ Random effects model	Kocaman (1) 2021	-0.7152	0.3917		-0.72	[-1.48; 0.05]	3.9%
Park 2016 $-0.8554 \ 0.2948$ Park 2021 $-0.4467 \ 0.3532$ Random effects model Heterogeneity: $l^2 = 0\%, p = 0.85$ >12 weeks Kumar 2017 $-1.1975 \ 0.3652$ Kuru 2016 $-0.3507 \ 0.3683$ Langensiepen MAC 2017 $-0.1999 \ 0.3258$ Langensiepen MIC 2017 $-0.1227 \ 0.3252$ Mohamed & Yousef 2021 $-1.0055 \ 0.3665$ Noh 2014 $-0.2813 \ 0.3555$ Schreiber 2016 $-0.2045 \ 0.2836$ Won 2021 $-0.6157 \ 0.4601$ Random effects model Heterogeneity: $l^2 = 24\%, p = 0.23$ Random effects model Heterogeneity: $l^2 = 24\%, p = 0.23$ Random effects model	Kocaman (2) 2021	-0.6666	0.3899		-0.67	[-1.43; 0.10]	4.0%
Park 2021 -0.4467 0.3532 Random effects model Heterogeneity: $l^2 = 0\%$ , $p = 0.85$ >12 weeks Kumar 2017 -1.1975 0.3652 Kuru 2016 -0.3507 0.3683 Langensiepen MAC 2017 -0.1999 0.3258 Langensiepen MIC 2017 -0.1227 0.3252 Mohamed & Yousef 2021 -1.0055 0.3665 Noh 2014 -0.2813 0.3555 Schreiber 2016 -0.2045 0.2836 Won 2021 -0.6157 0.4601 Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ Random effects model Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ Random effects model Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ Random effects model	Park 2016	-0.8554	0.2948		-0.86	[-1.43; -0.28]	6.9%
Random effects model       -0.58 [-0.86; -0.30] 29.         Heterogeneity: $l^2 = 0\%$ , $p = 0.85$ -1.20 [-1.91; -0.48] 4         ×12 weeks       -0.3507 0.3683         Kuru 2016       -0.3507 0.3683         Langensiepen MAC 2017 -0.1999 0.3258       -1.20 [-1.91; -0.48] 4         Langensiepen MIC 2017 -0.1227 0.3252       -0.20 [-0.84; 0.44] 5         Mohamed & Yousef 2021 -1.0055 0.3665       -0.12 [-0.76; 0.51] 5         Noh 2014       -0.2813 0.3555         Schreiber 2016       -0.2045 0.2836         Won 2021       -0.6157 0.4601         Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ Random effects model         Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ Random effects model         -2       -1.5       -1         -2       -1.5       -1	Park 2021	-0.4467	0.3532	<b>#</b>	-0.45	[-1.14; 0.25]	4.8%
Heterogeneity: $l^2 = 0\%$ , $p = 0.85$ >12 weeks Kumar 2017 -1.1975 0.3652 Kuru 2016 -0.3507 0.3683 Langensiepen MAC 2017 -0.1999 0.3258 Langensiepen MIC 2017 -0.1227 0.3252 Wohamed & Yousef 2021 -1.0055 0.3665 Nohamed & Yousef 2021 -1.0055 0.3665 Nohamed & Yousef 2021 -0.2813 0.3555 Schreiber 2016 -0.2045 0.2836 Non 2021 -0.6157 0.4601 Random effects model Heterogeneity: $l^2 = 24\%$ , $p = 0.23$ Random effects model $leterogeneity: l^2 = 24\%$ , $p = 0.23$ Random effects model	Random effects model				-0.58	[-0.86; -0.30]	<b>29.1%</b>
>12 weeksKumar 2017-1.19750.3652Kuru 2016-0.35070.3683Langensiepen MAC 2017-0.19990.3258Langensiepen MIC 2017-0.12270.3252Mohamed & Yousef 2021-1.00550.3665Noh 2014-0.28130.3555Schreiber 2016-0.20450.2836Won 2021-0.61570.4601Heterogeneity: $I^2 = 24\%$ , $p = 0.23$ -0.50Random effects model-2-1.5-1-0.5-2-1.5-1-3-1.5-3-3-4-3-5-3-5-3<	Heterogeneity: $I^2 = 0\%$ , $p =$	0.85					
Kumar 2017 $-1.1975$ $0.3652$ $-1.20$ $[-1.91; -0.48]$ 4Kuru 2016 $-0.3507$ $0.3683$ $-0.35$ $[-1.07; 0.37]$ 4Langensiepen MAC 2017 $-0.1227$ $0.3252$ $-0.20$ $[-0.84; 0.44]$ 5Langensiepen MIC 2017 $-0.1227$ $0.3252$ $-0.12$ $[-0.76; 0.51]$ 5Mohamed & Yousef 2021 $-1.0055$ $0.3665$ $-0.12$ $[-0.76; 0.51]$ 5Noh 2014 $-0.2813$ $0.3555$ $-0.28$ $[-0.98; 0.42]$ 4Schreiber 2016 $-0.2045$ $0.2836$ $-0.20$ $[-0.76; 0.35]$ 7Won 2021 $-0.6157$ $0.4601$ $-0.62$ $[-1.52; 0.29]$ 2Random effects model $-2$ $-1.5$ $-1$ $-0.5$ $0$ $0.50$ $[-0.65; -0.34]$ $100.$	>12 weeks						
Kuru 2016 $-0.3507$ $0.3683$ $-0.35$ $[-1.07;$ $0.37]$ $4$ Langensiepen MAC 2017 $-0.1999$ $0.3258$ $-0.20$ $[-0.84;$ $0.44]$ $5$ Langensiepen MIC 2017 $-0.1227$ $0.3252$ $-0.12$ $[-0.76;$ $0.51]$ $5$ Mohamed & Yousef 2021 $-1.0055$ $0.3665$ $-0.2813$ $0.3555$ $-0.12$ $[-0.76;$ $0.51]$ $5$ Noh 2014 $-0.2813$ $0.3555$ $-0.28$ $[-0.98;$ $0.42]$ $4$ Schreiber 2016 $-0.2045$ $0.2836$ $-0.20$ $[-0.76;$ $0.35]$ $7$ Won 2021 $-0.6157$ $0.4601$ $-0.62$ $[-1.52;$ $0.29]$ $2$ Random effects model $-0.23$ $-0.50$ $[-0.65;$ $-0.34]$ $100.$ Heterogeneity: $I^2 = 24\%$ , $p = 0.23$ $-2$ $-1.5$ $-1$ $-0.5$ $0$ $0.5$ $1$	Kumar 2017	-1.1975	0.3652		-1.20	[-1.91; -0.48]	4.5%
Langensiepen MAC 2017 -0.1999 0.3258 Langensiepen MIC 2017 -0.1227 0.3252 Mohamed & Yousef 2021 -1.0055 0.3665 Noh 2014 -0.2813 0.3555 Schreiber 2016 -0.2045 0.2836 Won 2021 -0.6157 0.4601 Heterogeneity: $I^2 = 24\%$ , $p = 0.23$ Random effects model Heterogeneity: $I^2 = 24\%$ , $p = 0.23$ Random effects model Heterogeneity: $I^2 = 24\%$ , $p = 0.23$ Random effects model	Kuru 2016	-0.3507	0.3683		<b>-0</b> .35	[-1.07; 0.37]	4.4%
Langensiepen MIC 2017 $-0.1227 \ 0.3252$ Mohamed & Yousef 2021 $-1.0055 \ 0.3665$ Noh 2014 $-0.2813 \ 0.3555$ Schreiber 2016 $-0.2045 \ 0.2836$ Won 2021 $-0.6157 \ 0.4601$ Heterogeneity: $I^2 = 24\%, p = 0.23$ Random effects model $-2 -1.5 -1 -0.5 \ 0 \ 0.5 \ 1$ $-0.12 \ [-0.76; \ 0.51] \ 5$ $-1.01 \ [-1.72; -0.29] \ 4$ $-0.28 \ [-0.98; \ 0.42] \ 4$ $-0.20 \ [-0.76; \ 0.35] \ 7$ $-0.62 \ [-1.52; \ 0.29] \ 2$ $-0.46 \ [-0.74; \ -0.18] \ 39$ . $-0.50 \ [-0.65; \ -0.34] \ 100.$	Langensiepen MAC 2017	-0.1999	0.3258		-0.20	[-0.84; 0.44]	5.7%
Mohamed & Yousef 2021 $-1.0055$ $0.3665$ $-1.01$ $[-1.72; -0.29]$ $4$ Noh 2014 $-0.2813$ $0.3555$ $-0.28$ $[-0.98; 0.42]$ $4$ Schreiber 2016 $-0.2045$ $0.2836$ $-0.20$ $[-0.76; 0.35]$ $7$ Won 2021 $-0.6157$ $0.4601$ $-0.62$ $[-1.52; 0.29]$ $2$ Random effects model $-2$ $-1.5$ $-1.5$ $0.50$ $[-0.65; -0.34]$ $100.50$	Langensiepen MIC 2017	-0.1227	0.3252		-0.12	[-0.76; 0.51]	5.7%
Noh 2014 -0.2813 0.3555 Schreiber 2016 -0.2045 0.2836 Won 2021 -0.6157 0.4601 -0.62 [-0.76; 0.35] 7 Random effects model Heterogeneity: $I^2 = 24\%$ , $p = 0.23$ Random effects model -2 -1.5 -1 -0.5 0 0.5 1	Mohamed & Yousef 2021	-1.0055	0.3665		-1.01	[-1.72; -0.29]	4.5%
Schreiber 2016 Won 2021 Random effects model Heterogeneity: $I^2 = 24\%$ , $p = 0.23$ Random effects model -2 -1.5 -1 -0.5 0 0.5 1 -0.20 [-0.76; 0.35] 7 -0.20 [-0.76; 0.35] 7 -0.62 [-1.52; 0.29] 2 -0.46 [-0.74; -0.18] 39 -0.50 [-0.65; -0.34] 100	Noh 2014	-0.2813	0.3555		-0.28	[-0.98; 0.42]	4.8%
Won 2021       -0.6157 $0.4601$ -0.62 $[-1.52; 0.29]$ 2         Random effects model       -0.46 $[-0.74; -0.18]$ 39.         Heterogeneity: $I^2 = 24\%$ , $p = 0.23$ -0.50 $[-0.65; -0.34]$ 100.         Random effects model       -2       -1.5       -1       -0.5       0       0.5       1	Schreiber 2016	-0.2045	0.2836		-0.20	[-0.76; 0.35]	7.5%
Random effects model       -0.46 [-0.74; -0.18] 39.         Heterogeneity: $I^2 = 24\%$ , $p = 0.23$ -0.50 [-0.65; -0.34] 100.         Random effects model       -2 -1.5 -1 -0.5 0 0.5 1	Won 2021	-0.6157	0.4601		-0.62	[-1.52; 0.29]	2.8%
Random effects model -2 -1.5 -1 -0.5 0 0.5 1	Random effects model	0.00		-	-0.46	[-0.74; -0.18]	39.9%
Random effects model $-2 -1.5 -1 -0.5 0 -0.5 1$	Heterogeneity: $I^2 = 24\%$ , $p =$	= 0.23					400.00/
-2 -1.5 -1 -0.5 0 0.5 1	Random effects model				-0.50	[-0.65; -0.34]	100.0%
			-	2 -15 -1 -05 0 05 1			
Heterogeneity: $I^2 = 0\%$ , $p = 0.81$	Heterogeneity: $I^2 = 0\%$ , $p =$	0.81					
Test for subgroup differences: $\chi_2^2 = 0.44$ , df = 2 (p = 0.80)	Test for subgroup difference	s: χ <sub>2</sub> <sup>2</sup> = 0.4	44, df = 2	(p = 0.80)			

outcome had a moderate effect size, and the FEV1 outcome had a moderate effect size. Sensitivity analysis for the Cobb angle showed that the results range from 0.46 to 0.52 (Figure 9).

In our meta-analysis, the respondents were diagnosed with IS, and different types of conservative (non-surgical) treatment based on exercises were used as treatment methods. In addition to the Schroth method, which was the most used treatment, a certain number of studies used the core stabilization method, while the rest of the studies used other treatments. For this reason, we classified all other studies into the combined therapy subgroup so that we could compare them with the aforementioned methods, which may represent bias in the decision-making process. Combined therapy led to moderate improvements in Cobb angle outcome. This indicates a synergistic effect when different exercise techniques are combined, which may cater to the diverse needs of individuals with IS. Clinicians should consider combining therapies as a versatile strategy, especially for patients who may benefit from a more comprehensive and multifaceted treatment plan. Core stabilization exercises showed a moderate effect, suggesting they target essential muscular control and spinal alignment, critical for managing scoliosis. In clinical settings, core stabilization exercises should be emphasized, particularly for patients with weakened core muscles or those requiring enhanced postural control. Schroth exercises demonstrated the greatest effect size among the subgroups, highlighting their targeted approach in IS management. Given their strong and consistent efficacy, Schroth exercises should be prioritized as a primary intervention for IS (Figures 7 and 10). Training practitioners in this specialized technique could enhance treatment outcomes. The significant and consistent results across all subgroups underscore the critical role of exercise-based conservative methods in the treatment of IS. Individualized treatment plans can be developed by leveraging the unique strengths of each approach, potentially combining therapies for patients with diverse needs or focusing on Schroth or core stabilization exercises for targeted

Study	g	SE	Standardised Mean Difference	SMD	95%-Cl	Weight
Treatment						
Alayat 2017	-0.6066	0.2898		-0.61	[-1.17; -0.04]	7.2%
Gür (1) 2017	-0.6362	0.4120		-0.64	[-1.44; 0.17]	3.5%
Gür (2) 2017	-0.2620	0.4023		-0.26	[-1.05; 0.53]	3.7%
HwangBo 2016	-0.5884	0.5139		-0.59	[-1.60; 0.42]	2.3%
HwangBo 2018	-0.4959	0.5099	· · · · · · · · · · · · · · · · · · ·	-0.50	[-1.50; 0.50]	2.3%
Kim & HwangBo 2016	-0.5540	0.4174		-0.55	[-1.37; 0.26]	3.5%
Kim & Park 2017	-0.1017	0.5180		-0.10	[-1.12; 0.91]	2.2%
Kocaman (1) 2021	-0.7152	0.3917		-0.72	[-1.48; 0.05]	3.9%
Kocaman (2) 2021	-0.6666	0.3899		-0.67	[-1.43; 0.10]	4.0%
Kumar 2017	-1.1975	0.3652		-1.20	[-1.91; -0.48]	4.5%
Langensiepen MAC 2017	-0.1999	0.3258		-0.20	[-0.84; 0.44]	5.7%
Langensiepen MIC 2017	-0.1227	0.3252		-0.12	[-0.76; 0.51]	5.7%
Mohamed & Yousef 2021	-1.0055	0.3665		-1.01	[-1.72; -0.29]	4.5%
Noh 2014	-0.2813	0.3555		-0.28	[-0.98; 0.42]	4.8%
Park 2021	-0.4467	0.3532		-0.45	[-1.14; 0.25]	4.8%
Won 2021	-0.6157	0.4601		-0.62	[-1.52; 0.29]	2.8%
Random effects model				-0.53	[-0.72; -0.34]	65.4%
Heterogeneity: $I^2 = 0\%$ , $p =$	0.83					
Non treatment						
Ko & Kang (1) 2017	-0.0068	0.3716		-0.01	[-0.74; 0.72]	4.4%
Ko & Kang (2) 2017	-0.2040	0.3727		-0.20	[-0.93; 0.53]	4.3%
Kuru 2016	-0.3507	0.3683		-0.35	[-1.07; 0.37]	4.4%
Lee & Lee 2020	-0.3810	0.5237		-0.38	[-1.41; 0.65]	2.2%
Park 2016	-0.8554	0.2948		-0.86	[-1.43; -0.28]	6.9%
Qi 2022	-0.8482	0.3497		-0.85	[-1.53; -0.16]	4.9%
Schreiber 2016	-0.2045	0.2836		-0.20	[-0.76; 0.35]	7.5%
Random effects model				-0.43	[-0.70; -0.15]	34.6%
Heterogeneity: $I^2 = 0\%$ , $p =$	0.44					
Random effects model			<u> </u>	0.50	[-0.65; -0.34]	100.0%
				I		
		-	2 -1.5 -1 -0.5 0 0.5	1		
Heterogeneity: $I^2 = 0\%$ , $p =$	0.81					
Test for subgroup difference	s: $\chi_1^- = 0.3$	35, df = 1	(p = 0.55)			
5						

interventions. These findings advocate for the inclusion of these exercise modalities in standard clinical guidelines and emphasize the importance of further training and resource allocation to implement these strategies effectively.

The majority of respondents were of adolescent age, while some studies had respondents older than 18 years and for these reasons, we performed a subgroup analysis for age. The results suggest that starting exercise-based treatment earlier in life may yield consistent effects. Younger patients might benefit from their greater musculoskeletal plasticity and the potential for spinal growth modification. Despite reduced skeletal growth potential, exercisebased conservative treatments are still highly effective in managing IS in older patients. This suggests that such interventions are beneficial regardless of age, although mechanisms such as improved muscle support and spinal alignment may play a more prominent role in older patients. The slightly larger effect size in the older group may indicate that older patients achieve greater observable improvement, possibly due to better adherence to treatment protocols. The differences between these two populations in the variation in curve progression in spinal flexibility, rigidity, and muscle elasticity would likely lead to opposite results.

The application of the treatment ranged between 6 weeks and 6 months. Subgroup analysis suggests that treatment duration plays a significant role, with the most significant improvements observed in interventions lasting 8–10 weeks. This finding is clinically relevant as it provides practitioners with an optimal time frame for structuring exercise programs. This suggests that intensive, shortterm programs may be as effective as longer ones, offering a feasible treatment period for patients and reducing the risk of intervention fatigue. Longer programs also demonstrate moderate effects. Sustained therapy may still be valuable for patients requiring gradual improvements or those with more severe curvatures. The lack of significant subgroup differences indicates that treatment duration (within the examined timeframes) does not drastically alter effectiveness. This provides flexibility for clinicians to tailor programs based on patient availability, preferences, and adherence

Study	g	SE	Difference	SMD	95%-CI	Weight
Low						
Alayat 2017	-0.6066	0.2898	<b></b>	-0.61	[-1.17; -0.04]	7.2%
Gür (1) 2017	-0.6362	0.4120		-0.64	[-1.44; 0.17]	3.5%
Gür (2) 2017	-0.2620	0.4023		-0.26	[-1.05; 0.53]	3.7%
HwangBo 2016	-0.5884	0.5139		-0.59	[-1.60; 0.42]	2.3%
Kim & Park 2017	-0.1017	0.5180		0.10	[-1.12; 0.91]	2.2%
Kocaman (1) 2021	-0.7152	0.3917		-0.72	[-1.48; 0.05]	3.9%
Kocaman (2) 2021	-0.6666	0.3899		-0.67	[-1.43; 0.10]	4.0%
Kumar 2017	-1.1975	0.3652	<b>I</b>	-1.20	[-1.91; -0.48]	4.5%
Mohamed & Yousef 2021	-1.0055	0.3665	<b>_</b>	-1.01	[-1.72; -0.29]	4.5%
Park 2016	-0.8554	0.2948		-0.86	[-1.43; -0.28]	6.9%
Park 2021	-0.4467	0.3532		-0.45	[-1.14; 0.25]	4.8%
Schreiber 2016	-0.2045	0.2836		-0.20	[-0.76; 0.35]	7.5%
Random effects model			<b>~</b>	-0.62	[-0.82; -0.41]	55.0%
Heterogeneity: $I^2 = 0\%$ , $p =$	0.67					
Moderate						
HwangBo 2018	-0.4959	0.5099	<b>÷</b>	-0.50	[-1.50; 0.50]	2.3%
Kuru 2016	-0.3507	0.3683		-0.35	[-1.07; 0.37]	4.4%
Langensiepen MAC 2017	-0.1999	0.3258		-0.20	[-0.84; 0.44]	5.7%
Langensiepen MIC 2017	-0.1227	0.3252		-0.12	[-0.76; 0.51]	5.7%
Lee & Lee 2020	-0.3810	0.5237		-0.38	[-1.41; 0.65]	2.2%
Noh 2014	-0.2813	0.3555		-0.28	[-0.98; 0.42]	4.8%
Qi 2022	-0.8482	0.3497		-0.85	[-1.53; -0.16]	4.9%
Won 2021	-0.6157	0.4601		-0.62	[-1.52; 0.29]	2.8%
Random effects model				-0.38	[-0.65; -0.12]	32.8%
Heterogeneity: $I^2 = 0\%$ , $p =$	0.87					
High						
Kim & HwangBo 2016	-0.5540	0.4174		-0.55	[-1.37; 0.26]	3.5%
Ko & Kang (1) 2017	-0.0068	0.3716		-0.01	[-0.74; 0.72]	4.4%
Ko & Kang (2) 2017	-0.2040	0.3727		-0.20	[-0.93; 0.53]	4.3%
Random effects model				-0.23	[-0.67; 0.20]	12.1%
Heterogeneity: $I^2 = 0\%$ , $p =$	0.62					
Random effects model				0.50	[-0.65; -0.34]	100.0%
				4		
Hotomonomity: $l^2 = 0.0(-\pi) = -$	0.04	-	: -1.5 -1 -0.5 0 0.5	1		
Heterogeneity: $I = 0\%$ , $p =$	0.81 10.9 <sup>2</sup> - 27	17 df - 0	(n = 0.18)			
rescror subgroup unterence	$x_2 - 3.4$	17, ui – 2	(p = 0.16)			

potential. Low heterogeneity across most subgroups indicates robustness in the findings, which enhances confidence in applying these results to diverse patient populations.

Exercise-based treatments can effectively reduce ATR, a key marker of IS severity, addressing both cosmetic and postural concerns. These outcomes enhance patient satisfaction and indicate the value of incorporating exercises into IS management. The large effect size and statistical significance highlight the positive impact of exercise-based treatments on patients' quality of life. This includes physical, emotional, and social dimensions, which are often affected by IS. These interventions may serve as holistic strategies to enhance patient wellbeing beyond physical improvements. Our meta-analysis highlights that conservative exercise-based treatments can positively influence respiratory function in patients with idiopathic scoliosis, particularly FEV1, suggesting better expiratory flow and lung efficiency. However, the variable results for FVC indicate a need for further investigation into factors influencing lung capacity outcomes. The lack of statistical significance suggests that the impact of exercise-based interventions on lung capacity is inconsistent. These findings underscore the importance of incorporating pulmonary-focused exercises to optimize respiratory health in scoliosis management. The findings, in addition to all of the above, confirm that conservative exercise-based treatments are beneficial regardless of whether the control group receives alternative treatments or no treatment at all, and justify prioritizing these treatments in clinical practice. Furthermore, the within-group results support the use of conservative exercise-based treatments as an effective evidence-based approach in the management of IS while simultaneously emphasizing the necessity of active interventions. In the 23 studies, we were able to calculate the effects on five outcomes, which represents a good source for drawing conclusions regarding the application of conservative methods based on exercise in the treatment of IS. Patients using conservative methods based on exercise for IS may be encouraged by these results.

Study	q	SE	Difference	SMD	95%-Cl	Weight
	-					-
Combining therapy	0.0000	0 2000		0.64	[447:004]	7.00/
Alayat 2017	-0.0000	0.2898		-0.01	[-1.17; -0.04]	1.2%
Kim & Park 2017	-0.1017	0.5180		-0.10	[-1.12; 0.91]	2.2%
Kumar 2017	-1.1970	0.3052		-1.20	[-1.91, -0.48]	4.5%
Langensiepen MAC 2017	-0.1999	0.3258		-0.20	[-0.84; 0.44]	5.7%
Langensiepen MIC 2017	-0.1227	0.3252		-0.12	[-0.76; 0.51]	5.7%
Non 2014	-0.2813	0.3555		-0.28	[-0.98; 0.42]	4.8%
Won 2021	-0.6157	0.4601		-0.62	[-1.52; 0.29]	2.8%
Random effects model				-0.45	[-0.74; -0.16]	32.9%
Heterogeneity: $I^{-} = 13\%$ , $p = 0$	0.33					
Core stabilization	0.6262	0 4420		0.64	[ 4 44: 0 47]	2 50/
Gur (1) 2017	-0.0302	0.4120		-0.04	[-1.44, 0.17]	3.3%
Gur (2) 2017	-0.2020	0.4023		-0.20	[-1.05, 0.55]	3.1%
Ko & Kang (1) 2017	-0.0000	0.3710		-0.01	[-0.74, 0.72]	4.4%
No & Kang (2) 2017	-0.2040	0.3727		-0.20	[-0.95, 0.55]	4.3%
Park 2010	-0.8004	0.2948		-0.80	[-1.43, -0.28]	0.9%
Park 2021	-0.4407	0.3032		-0.45	[-1.14; 0.25]	4.8%
QI 2022	-0.8482	0.3497		-0.85	[-1.53, -0.16]	4.9%
Random effects model	0.50			-0.50	[-0.77; -0.24]	32.070
Heterogeneity: $T = 0\%$ , $p =$	0.50					
HwangBo 2016	0 5994	0.5120		0.50	1160:0421	2 20/
HwangBo 2018	0.0004	0.5155		0.59	[1.00, 0.42]	2.0%
Kim & HwangBo 2016	0.5540	0.3099		-0.50	[1.30, 0.30]	2.5%
Kocaman (1) 2021	0.7152	0.917		0.33	[1.37, 0.20]	3.0%
Kocaman (2) 2021	0.6666	0.3917		0.72	[-1.40, 0.00]	4.0%
Kuru 2016	0.3507	0.3683		-0.07	[-1.43, 0.10]	4.070
	0.3810	0.5005		0.38	[1.07, 0.07]	2 20%
Mohamed & Yousef 2021	1 0055	0.3257		-0.30	[-1.41, 0.00]	1.5%
Schreiber 2016	-0.2045	0.2836		-0.20	[-1.72, -0.25] [-0.76: 0.35]	7.5%
Random effects model	-0.2040	0.2000		-0.20	[-0.70, 0.00]	34.5%
Heterogeneity: $I^2 = 0\%$ , $n =$	0.88			-0.00	[-0.73, -0.27]	04.070
Random effects model	0.00		📥 🛛	-0.50	L0 65: -0 341	100.0%
Random enects model				7 -0.00	[-0.00, -0.04]	100.070
		_	2 -15 -1 -05 0 05	1		
Heterogeneity: $l^2 = 0\% n =$	0.81					
Test for subgroup difference	$s_{1}^{2} \chi_{2}^{2} = 0$	15. df = 2	(p = 0.93)			
	- x <sub>2</sub> 0.		u,			

Three studies were non-randomized, while the other 20 studies were randomized. Of the randomized trials, none had high risk in more than one item. The most frequent high-risk item was "allocation concealment". All the non-randomized studies were comparable with sufficient test scores to be included in the study. Heterogeneity in the Cobb angle, ATR, QoL, and FEV1 outcomes was 0% while for the outcome FVC it was 49%, so the results give a true depiction of the effect size. Studies whose results led to heterogeneity were immediately excluded from further analysis. Thus, the results of one study (50), for the ATR outcome, were immediately excluded because analyses in our previous study (15) show that they led to increased heterogeneity. For the Cobb angle outcome, one study (24) also had the effect of increasing heterogeneity, so results from this study for this outcome were excluded.

Studies with a low risk of bias showed the most substantial reduction in scoliosis curvature, emphasizing the importance of high-quality research in determining the true effectiveness of exercise therapy. While less impactful than low-risk studies, moderate-quality evidence also supported the benefits of exercise therapy, suggesting its applicability even in less controlled settings. Studies with a high risk of bias reported the smallest effect size, which may reflect overestimation or underestimation of outcomes due to methodological flaws. Clinicians should critically appraise such evidence before incorporating it into practice. High-quality studies show more substantial benefits, reaffirming the need for rigorous research designs in this field. Despite variations in quality, exercise therapy consistently demonstrates moderate effects in reducing scoliosis curvature, supporting its role as a conservative treatment option.

The search included four databases without language restrictions. Since we have been studying this topic for years, we believe that no study that would meet the conditions for inclusion was left out. The number of studies evaluating the Cobb angle outcome was at a satisfactory level, while the number

-0.6066 -0.6362	0.2898		-0.61	1447:0041	
-0.6066 -0.6362	0.2898	<b>_</b>	-0.61	1447:0041	
-0.6362	0 4400			1-1.170.041	7.2%
	0.4120		-0.64	[-1.44: 0.17]	3.5%
-0.2620	0.4023		-0.26	[-1.05; 0.53]	3.7%
-0.5540	0.4174		-0.55	[-1.37; 0.26]	3.5%
-0.0068	0.3716		-0.01	[-0.74; 0.72]	4.4%
-0.2040	0.3727		-0.20	[-0.93; 0.53]	4.3%
-0.7152	0.3917		-0.72	[-1.48; 0.05]	3.9%
-0.6666	0.3899		-0.67	[-1.43; 0.10]	4.0%
-1.1975	0.3652	<b>_</b>	-1.20	[-1.91; -0.48]	4.5%
-0.3507	0.3683		-0.35	[-1.07; 0.37]	4.4%
7 -0.1999	0.3258		-0.20	[-0.84; 0.44]	5.7%
-0.1227	0.3252		-0.12	[-0.76; 0.51]	5.7%
1 -1.0055	0.3665		-1.01	[-1.72; -0.29]	4.5%
-0.2813	0.3555		-0.28	[-0.98; 0.42]	4.8%
-0.8482	0.3497	<b>_</b>	-0.85	[-1.53; -0.16]	4.9%
-0.2045	0.2836		-0.20	[-0.76; 0.35]	7.5%
-0.6157	0.4601		-0.62	[-1.52; 0.29]	2.8%
		→	-0.48	[-0.65; -0.31]	79.2%
= 0.61					
-0.5884	0.5139		-0.59	[-1.60; 0.42]	2.3%
-0.4959	0.5099	• • • • • • • • • • • • • • • • • • •	-0.50	[-1.50; 0.50]	2.3%
-0.1017	0.5180		0.10	[-1.12; 0.91]	2.2%
-0.3810	0.5237		-0.38	[-1.41; 0.65]	2.2%
-0.8554	0.2948		-0.86	[-1.43; -0.28]	6.9%
-0.4467	0.3532	<b></b>	-0.45	[-1.14; 0.25]	4.8%
			-0.56	[-0.89; -0.23]	20.8%
= 0.85					
		🔶 🔶	-0.50	[-0.65; -0.34]	100.0%
	-0.5540 -0.0068 -0.2040 -0.7152 -0.6666 -1.1975 -0.3507 7 -0.1999 -0.1227 1 -1.0055 -0.2813 -0.8482 -0.2045 -0.6157 = 0.61 -0.5884 -0.4959 -0.1017 -0.3810 -0.8554 -0.4467 = 0.85	-0.5540 0.4174 -0.0068 0.3716 -0.2040 0.3727 -0.7152 0.3917 -0.6666 0.3899 -1.1975 0.3652 -0.3507 0.3683 7 -0.1999 0.3258 -0.1227 0.3252 1 -1.0055 0.3665 -0.2813 0.3555 -0.8482 0.3497 -0.2045 0.2836 -0.6157 0.4601 = 0.61 -0.5884 0.5139 -0.4959 0.5099 -0.1017 0.5180 -0.3810 0.5237 -0.8554 0.2948 -0.4467 0.3532 = 0.85	-0.5540 0.4174 -0.0068 0.3716 -0.2040 0.3727 -0.7152 0.3917 -0.6666 0.3899 -1.1975 0.3652 -0.3507 0.3683 7 -0.1999 0.3258 -0.1227 0.3252 1 -1.0055 0.3665 -0.2813 0.3555 -0.8482 0.3497 -0.2045 0.2836 -0.6157 0.4601 = 0.61 -0.5884 0.5139 -0.4959 0.5099 -0.1017 0.5180 -0.3810 0.5237 -0.8554 0.2948 -0.4467 0.3532 = 0.85	-0.5540 0.4174 -0.0068 0.3716 -0.2040 0.3727 -0.6666 0.3899 -1.1975 0.3652 -0.3507 0.3683 7 -0.1999 0.3258 -0.20 -0.1227 0.3252 1 -1.0055 0.3665 -0.2836 -0.29 -0.6157 0.4601 -0.5884 0.5139 -0.599 -0.4959 0.5099 -0.501 -0.3810 0.5237 -0.385 -0.285 -0.28 -0.59 -0.50 -0	-0.5540 0.4174 -0.0068 0.3716 -0.2040 0.3727 -0.7152 0.3917 -0.6666 0.3899 -1.1975 0.3652 -0.3507 0.3683 7 -0.1999 0.3258 -0.3507 0.3683 7 -0.1999 0.3258 -0.3507 0.3683 7 -0.1999 0.3258 -0.2813 0.3555 -0.2813 0.3555 -0.2812 0.3497 -0.2045 0.2836 -0.205 [-1.37; 0.26] -0.20 [-0.93; 0.53] -0.20 [-1.43; 0.10] -1.20 [-1.91; -0.48] -0.35 [-1.07; 0.37] -0.20 [-0.84; 0.44] -0.12 [-0.76; 0.51] -1.01 [-1.72; -0.29] -0.28 [-0.98; 0.42] -0.20 [-0.76; 0.35] -0.20 [-0.76; 0.35] -0.20 [-0.76; 0.35] -0.20 [-0.76; 0.35] -0.20 [-1.50; 0.50] -0.20 [-1.50; 0.50] -0.38 [-1.41; 0.65] -0.38 [-1.41; 0.65] -0.38 [-1.41; 0.28] -0.4467 0.3532 -0.50 [-0.65; -0.34] -0.50 [-0.65; -0.34]

for ATR, QoL, FVC, and FEV1 outcomes was small, and the results obtained may be limited by this. Of all the included studies, only one study (47) did not present certain results as required for a meta-analysis, but this problem was resolved according to the method proposed by Higgins et al. (38), Furukawa et al. (55), and Hozo et al. (56). In this case, a sensitivity analysis was not performed because these recommendations gave good results.

Compared with previous meta-analyses, our results are closely aligned with those reported by other investigators in terms of Cobb angle (15, 16, 57–59), ATR (15, 16, 58), and QoL (15, 16, 58, 60), reinforcing the established efficacy of these non-surgical approaches for the management of IS. The smaller variations in effect sizes across studies likely reflect differences in the size and design of the included studies, such as the number of participants and the specific treatment protocols used. In particular, our study included a broader range of conservative treatments beyond the Schroth method, including core stabilization and combined therapy, which offers a more comprehensive view of exercisebased approaches. This broader perspective is particularly valuable for clinical practice, as it highlights that several exercise-based methods can produce similar improvements in key outcomes, although the Schroth method may offer a slight advantage. Our meta-analyses on other spinal problems (35, 36) also show the positive effects of applying certain conservative methods based on exercise. In our discussion, we did not compare our results with those of the individual studies included in our analysis because it was methodologically unjustified as they were focused on two different methodologies and the goal of a meta-analysis is to unify the results of many studies.

The main limitation of this study is the inclusion of nonadolescent subjects in the analysis, and we addressed this issue through subgroup analysis. Another limitation of this study is the



Subgroup	Studies	P-value	(Standardised N	lean Difference) SMD	95%-CI
Age			_		
Younger group	17	0.67		-0.48	[-0.65; -0.31]
Older group	6			-0.56	[-0.89; -0.23]
Duration					
12 weeks	8	0.80	<b>t</b>	-0.47	[-0.75; -0.20]
8-10 weeks	7			-0.58	1-0.86: -0.301
>12 weeks	8			-0.46	[-0.74: -0.18]
Risk of bias					
Low	12	0 18		-0.62	[-0.82 <sup>·</sup> -0.41]
Moderate	8	0.10		-0.38	[-0.65] -0.12]
High	3 3			-0.23	[-0.67 <sup>-</sup> 0.20]
r ng n	č		_	-0.20	[-0.01, 0.20]
Methods	_		_		
Combining therapy	<u> </u>	0.93		-0.45	[-0.74; -0.16]
Core stabilization	(			-0.50	[-0.77; -0.24]
Schroth exercise	9			-0.53	[-0.79; -0.27]
Treatment					
Treatment	16	0.55		-0.53	[-0.72; -0.34]
Non treatment	7			-0.43	[-0.70; -0.15]
				I I	
			-1 -0.5 (	0.5 1	

heterogeneity of treatments used in the combined therapy subgroup. The third limitation of our meta-analysis is the heterogeneity of treatment duration in the included studies, which we attempted to address with three subgroups. Although the pooled and subgroup results suggest a clear homogeneity of the included studies, the results for the FVC outcome showed a heterogeneity of 49%, and this may be a limitation in terms of the true effect size for this outcome. For the outcomes, ATR, QoL, FVC, and FEV1, the number of included studies was relatively small, but only these studies met the inclusion criteria. Of the 23 included studies, 19 (82.6%) used the Cobb angle as an outcome, 4 (17.4%) used ATR and QoL as the outcomes, and 3 (13%) FVC and FEV1 as the outcomes. Thus, a recommendation for future research in the treatment of IS is that it should be conducted in relation to the measurement of these neglected outcomes. Primarily, it should include outcomes that diagnose the pulmonary function of patients with IS. Our results encourage future researchers to do so.

# Conclusion

This study indicates that conservative methods based on exercise overall have positive effects on patients with IS. The effect size ranged from 0.48 to 1.17 for different measured outcomes. In our opinion, our analysis included a sufficient number of studies and had a sufficient number of outcomes. The limitations of this study should be worked on in the future. Our results send an encouraging message primarily to patients that they can use conservative methods based on exercise for IS, and also to physiotherapists and kinesiotherapists who encounter such problems in practice.

# Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author.

### Author contributions

VD: Data curation, Formal Analysis, Methodology, Software, Writing - original draft, Visualization. BR: Project administration,

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# Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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# Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fspor.2024. 1492241/full#supplementary-material

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