



Effectiveness of Dynamic Elastic Bracing Compared to Hard Rigid Bracing for Improving Physical, and Psychosocial Outcomes in Adolescent Idiopathic Scoliosis (AIS): A Systematic Review of Mixed Methods Studies

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Abstract

Background: Adolescent idiopathic scoliosis (AIS) is a 3D helical spinal deformity which develops in healthy adolescents without a known cause. Bracing is prescribed to limit curve progression and improve spine and torso shape, but there has been limited research on what type of brace is most effective in these roles.

Purpose: To investigate which brace; rigid or elastic, is most effective in AIS over several different outcomes.

Study design: Systematic review with meta-analyses.

Methods: Electronic databases (PubMed, MEDLINE, EMBASE, EMCARE, Cinahl & PsycInfo) and Clinical Trial Registries (ISRCTN, International Clinical Trials Registry Platform ICTRP & clinicaltrials.gov) were searched from inception to February 2021. The Scoliosis Research Society (SRS) standardised inclusion criteria were used, with the intervention as elastic bracing (SpineCor) compared to rigid bracing for physical and psychosocial outcomes. GRADE and Effective Public Health Practice Project tools were implemented as part of the quality assessment.

Results: Eleven studies with a total pool of 772 participants were included: 363 (47.0%) in the elastic brace intervention and 409 (53.0%) in the rigid bracing. Most studies slightly favoured rigid bracing for:

1. The mean size of the curve following bracing (Mean Difference MD = 1.16, 95% CI = 1.91 to 4.22, p=0.46).
2. The risk of the curve size increasing by >5° curve progression (Risk Ratio =1.86, 95% CI 1.11 to 3.09, p=0.02).

However, elastic bracing was favoured for improving self-image (MD = 0.42, 95% CI 0.09 to 0.75, p=0.01). There were no differences in functional, gait and pulmonary function found (no statistical analysis available).

Overall GRADE was at very low quality and individually, studies were either deemed moderate or low quality with only one high quality study.

Conclusion: Due to the low quality of the evidence, it is not possible to be certain that elastic bracing is more effective than rigid bracing in all the assessed criteria, whilst noting that rigid bracing reports better rates of prevention of progression and elastic bracing reports a better self-image outcome. Further studies are required to draw a definitive conclusion.

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Keywords:

AIS; Systematic review; Bracing; Spinal orthosis; SpineCor; Level of Evidence: II

Introduction

Adolescent idiopathic scoliosis (AIS) is a three-dimensional deformity of the spine developed in otherwise normal children of unknown cause between the ages of 10 and 18 years [1-3]. The diagnosis of AIS is made once all other causes of scoliosis are ruled out [1] and is confirmed with a standing coronal radiograph showing Cobb angle of at least 10° [1,4,5]. AIS accounts for approximately 90% of cases of idiopathic scoliosis in children [6]. The prevalence of AIS is approximately 0.47-5.2%, with the condition more frequent in females than males (ratios range from 1.5:1 to 3:1) [6]. Prevalence studies have shown that the ratio between males and females changes along with the curve size with ratios of 1.4:1 in smaller curves (10° to 20°) up to 7.2:1 in curves greater than 40° [6].

Description of the intervention

Bracing is a conservative treatment for AIS and is defined by Negrini S, et al. [7] as the application of external corrective forces to the trunk where rigid or elastic soft bracing can be used to halt scoliosis progression and improve spine and torso shape.

Rigid brace: Rigid bracing uses a three-point triangulation pressure principle enabling forces to be placed above and below the curve with three pads [8], which are customised and moulded dependent on the curvature severity and location of the curve [8]. Examples of rigid braces include the Milwaukee which controls the neck along with the rest of the spine [9,10] and the Boston brace [11] which is a thoracolumbar sacral orthosis.

Elastic bracing: The SpineCor brace is a dynamic, flexible, and soft elastic brace, with a base that is worn around the pelvis, thighs, and crotch. A further cotton bolero and four corrective elastic bands of different sizes act to pull against the scoliosis, correcting all spine curvatures, rotations, and imbalances [12]. Patients are instructed to wear the Spinecor brace at least 20 hours a day, with breaks for 2 hours in the morning and evening.

Why is it important to do this review?

The Bracing in Adolescent Idiopathic Scoliosis Trial (BrAIST) [13] is a key trial which reported on rigid bracing compared to no bracing in moderate AIS and showed that rigid bracing reduced the number of participants who later required surgery. Compliance was also reported, as braces worn 13 hours per day, or more were more likely to be defined as successful by the trial criteria of a Cobb angle of less than 50° at skeletal maturity. While BrAIST concluded that rigid bracing is more effective than a watch-and-wait policy in AIS [13], there has been limited research comparing different brace types, including for soft elastic bracing. Furthermore, the James Lind Alliance Priority Setting Partnership for scoliosis identified as priority research: ‘Which type of brace (e.g., rigid, or dynamic) is most effective in the treatment of (a) early onset scoliosis and (b) adolescent idiopathic scoliosis? (JLA PSP Priority 7)’ [14]. Likewise, this systematic review also updates the Cochrane review of 2015 [15] which included a review of rigid *versus* elastic bracing in scoliosis.

Methods and Materials

This review reports on the effectiveness of different type of bracing (dynamic soft elastic bracing compared to hard rigid bracing) for AIS and is registered at PROSPERO, CRD York, CRD42021221749 (Protocol 2.4 in supplementary material information 1). Furthermore, the reporting review undertaken adheres to the principles and guidelines for the conduct of systematic review as laid in the PRISMA statement [16].

Study design

The review is a mixed method, systematic review of quantitative studies consisting of randomised controlled trials (RCTs), prospective controlled cohort trials, cross-sectional studies, and retrospective cohort studies. Qualitative studies were also selected if they were relevant to the systematic review. The inclusion and exclusion criteria are shown in table 1.

Outcomes

This paper investigated the outcomes listed in table 2 in a hierarchical form with the size of the scoliosis, measured using the Cobb angle [5] and with the Scoliosis Research Society 22 (SRS-22)

Inclusion criteria:	
Population	- Participants diagnosed with AIS. - Scoliosis Research Society (SRS) standardized inclusion criteria for studies on bracing is AIS: - Both genders are considered with all participants aged 10 and above until the end of bone growth or maturity (usually aged 14 years old) - Bone age Risser 0-2 - Primary major curve magnitude 25°-40° - No prior treatment In females, either pre-menarche or one-year or less post-menarche.
Intervention	Dynamic soft elastic bracing (known as a SpineCor brace). SpineCor is the only soft or elastic brace available on the market and thus the terms “SpineCor” and elastic bracing are used interchangeably in this paper.
Comparative interventions	Hard rigid bracing of a thoracolumbar orthosis type (e.g., Boston and Cheneau brace). For this paper, this is known as Rigid bracing. The Milwaukee brace was excluded as it is a cervicothoracic orthosis and is not comparable.
Exclusion criteria:	
Population	Infantile, juvenile, or adult scoliosis, or scoliosis secondary to other causes such as congenital spinal deformities, neurological or metabolic conditions or following trauma.
Study Format	Editorial and letters.
Date Range	As Spine Cor was first described in 1995, searches are from 1995 and onwards only.

Table 1: Eligibility criteria.

Outcomes	• Size of scoliosis (measured using the Cobb angle) • Scoliosis Research Society-22 (SRS-22) with the following domains: • Function/Activity • Pain • Self-image • Mental health • Satisfaction with treatment • Body image e.g., spinal appearance questionnaire (SAQ) • Pulmonary function • Disability e.g., functional outcomes such as gait • Bracing Questionnaire (BrQ) with the following domains: • General health perception • Physical functioning • Emotional functioning • Self-esteem and aesthetics • Vitality • School activity • Bodily pain • Social functioning
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Table 2: Measured outcomes which are identified in a hierarchy.

Assessment of brace effectiveness
1. The percentage of patients who have $\leq 5^\circ$ curve progression and the percentage of patients who have $\geq 6^\circ$ progression at skeletal maturity.
2. Percentage of patients with curves exceeding 45° at skeletal maturity and percentage who have had surgery recommended/undertaken.
3. 2-year follow-up post skeletal maturity to determine the percentage of patients who subsequently undergo surgery.

Table 3: SRS standardised criteria for the outcome of bracing treatment [21].

questionnaire [17,18] as the primary outcomes. Secondary outcomes were body image using the Spinal Appearance Questionnaire (SAQ) [19], psychosocial outcome using the Bracing Quality of Life Questionnaire (BrQ) [20], pulmonary function and other functional outcome such as gait. Furthermore, variables associated with outcomes such as study characteristics, study design, participant information, intervention characteristics, outcome definitions and funding were sought (Table 2).

The size of the scoliosis is a measured continuous outcome, whilst dichotomous outcomes include the number of participants whose scoliosis had progressed greater than 5° (a minimal clinically important difference) (MCID) [7] This, alongside the defined successful endpoint of the number of participants at the end of treatment who did not need surgery nor pass a curve size of more than 45° [15]. The Scoliosis Research Society standardised criteria outcomes for assessing bracing treatment [21] are seen in table 3.

Data sources and searches

Electronic searches: The lead author (EL) completed a systematic search to identify relevant studies in PubMed, Medline, EMBASE, Cinahl, PsycInfo and EMCARE in November 2020. Furthermore, the following clinical trial registries were also searched: ISRCTN

registry, International Clinical Trials Registry Platform (ICTRP) and clinicaltrials.gov. The searches were developed around the eligibility criteria PICO with combination of keywords and MeSH terms (see supplementary material information 2). Searches were limited to English Language only and the initial search precision was confirmed with an information specialist. All searches were run once more prior to final analysis in February 2021.

Data collection and analysis

Selection of studies: Once duplicates were removed, the titles and abstracts were screened independently by two main reviewers (EL and SR) using Endnote reference manager [22] and Rayyan software [23]. The reviewers were blinded in the review process. Any disagreements were mediated by the third independent reviewer (AG). The second reviewer screened 10% of the titles and abstracts and these were selected alphabetically by author name.

Data extraction and management: Using an adapted Cochrane data extraction form (see supplementary material information 7), data were extracted by the main reviewer (EL). The second reviewer (SR) checked a random 10% of studies. Study characteristics and all individual population data were extracted. Again, any disagreements were mediated by the third reviewer (AG).

Quality and risk of bias assessment: Methodological quality was assessed (by EL with SR confirming 10% of studies) using the Effective Public Health Practice Project (EPHPP) [24]. This quality appraisal takes into consideration different study designs, and when compared to the Cochrane Collaboration Risk of Bias Tool (CCRB), shows fair/reasonable inter-rater agreement for individual categories and excellent agreement for the final global rating [25]. Furthermore, the Grading of Recommendations Assessment, Development and Evaluation of Systems (GRADE) were also employed using GRADEpro (2020) [26] to assess the overall quality of evidence.

Data synthesis: The data was synthesised in a narrative format and, if homogenous, was included in a meta-analysis. Dichotomous outcomes (the number of events and participants in each treatment group) were calculated to generate a risk ratio (RR) and associated confidence intervals (CI). Additionally, the mean difference (MD) and standard deviation (SD) with 95% CI were extracted.

To allow for differences in the treatment effect from the various studies, all meta-analyses were performed using a random effects model [27] with the RevMan 5.4 software (Cochrane IMS, 2020).

Assessment of heterogeneity: Significant heterogeneity was defined as a probability value of >0.05 as assessed using the Chi-Squared test. The I^2 statistic was also used to assess heterogeneity, with the following interpretation guidelines: I^2 of 0% - 30% as unimportant heterogeneity; I^2 of 30% to 60% as moderate heterogeneity; I^2 of 50% to 90% substantial heterogeneity; and I^2 of 75% to 100% as considerable heterogeneity [28].

Results

Description of studies

Search results: There were 2043 records identified in an electronic search using the search terms described in figure 1 (see supplementary material information 2). After removing all duplicates, 1486 titles were screened with 262 were excluded by title using an automation tool and 10 by hand - rechecked to remove the ten. There were 1201 records excluded after reviewing the abstracts and 13 studies were retrieved for further analysis, all of which were quantitative in design. There were 2 studies which used the same cohort ($n=2$), and we only used the unique results in each study and presented as only one to remove double counting. In total, 11 studies were included in the systematic review.

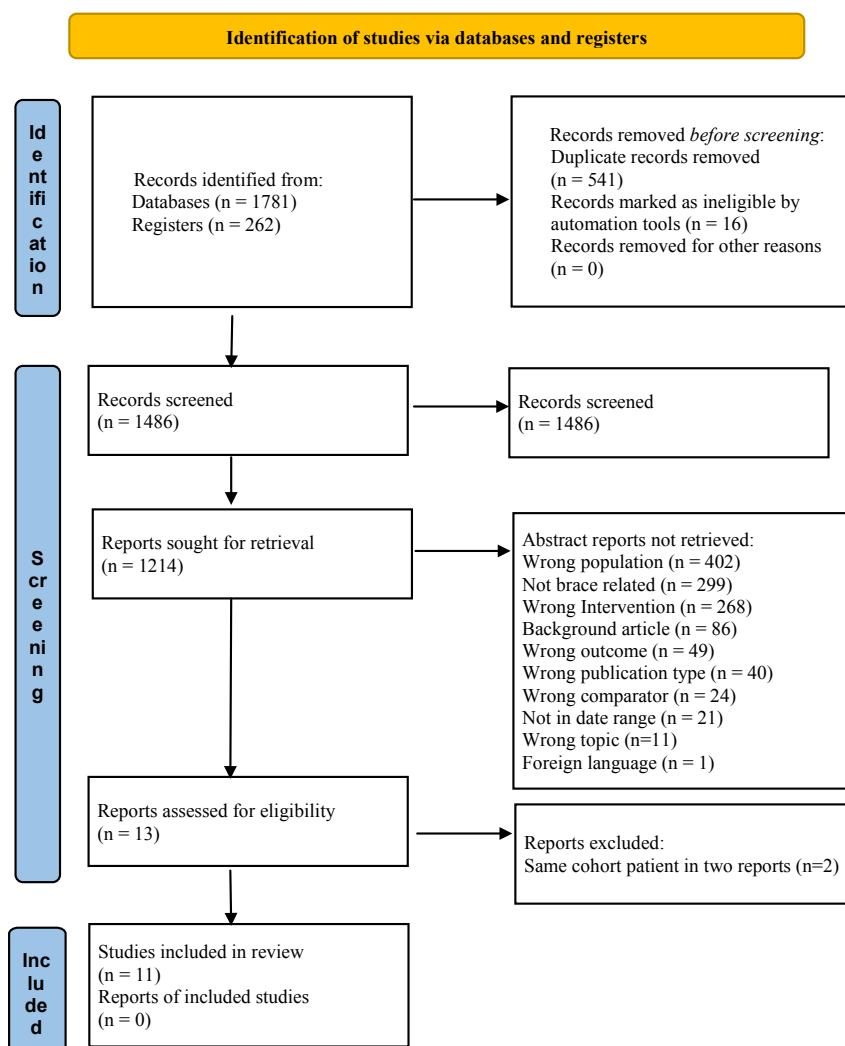


Figure 1: PRISMA 2020 flow diagram for searches of databases and registers [16].

	Elastic	Rigid	Total No.
Female	305*	356*	661*
Male	38*	40*	78*
Total No.	363 (47.0%)	409 (53.0%)	772
Age (years) (Mean, SD and range)	12.5 ± 0.3 (12.3-13)	12.6 ± 0.4 (12.3-13)	
Curve type			
Thoracic	65	109	174
Thoracolumbar	23	29	52
Lumbar	27	19	46
Double	44	62	106

*Excludes missing data from one study.

Table 4: Baseline Characteristics of studies.

Included studies: Eleven quantitative studies were identified and included in the systematic review. Characteristics of the included studies are described in supplementary information 4.

There were three RCTs identified [29-31]. The length of the follow up for the primary outcome varied, with Ersen Ö, et al. [32] recording immediate change in pulmonary function in the brace to Guo J, et al. [29] recording the Cobb angle at 48 months post-skeletal maturity.

The sample sizes ranged from 21 to 243, with a total of 772 participants recruited into all studies; These included 363 (47.0%) in the elastic brace intervention group and 409 (53.0%) in the rigid brace comparator group, with no statistically significant difference found when compared elastic total group to rigid brace group ($p=0.38$). Apart from one study that did not provide sex demographics, this systematic review consists of 661 females and 78 males: with the total mean age of 12.54 (Elastic brace) and 12.64 years old (Rigid brace) (Table 4).

The majority (7 out of the 11 studies) [29-30,33-37] recorded an increase in the curve size of $>5^\circ$ as the primary outcome. Whilst the quality of life was assessed by the SRS-22 by two studies [38,39], the specific outcome of body image was only assessed by one paper [39]. Studies were conducted across the world including Hong Kong [29-31], Turkey [32,38], Germany [35], Italy [36,37], USA [33] and Canada [34]. All studies were single centred except for one [39] which was based over 2 centres in Poland.

Baseline characteristics

Baseline characteristics of the pooled participants in all studies are shown in table 4. The majority were female in both elastic and rigid bracing groups. The ratio of female to males were typical of the population of AIS [6].

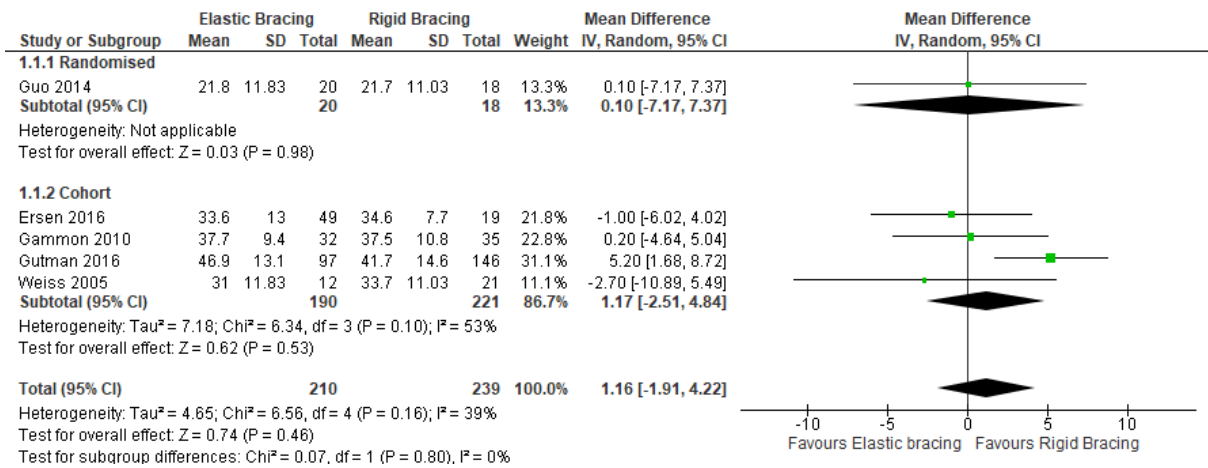


Figure 2: A Forest plot showing the mean Cobb angle after bracing treatment.

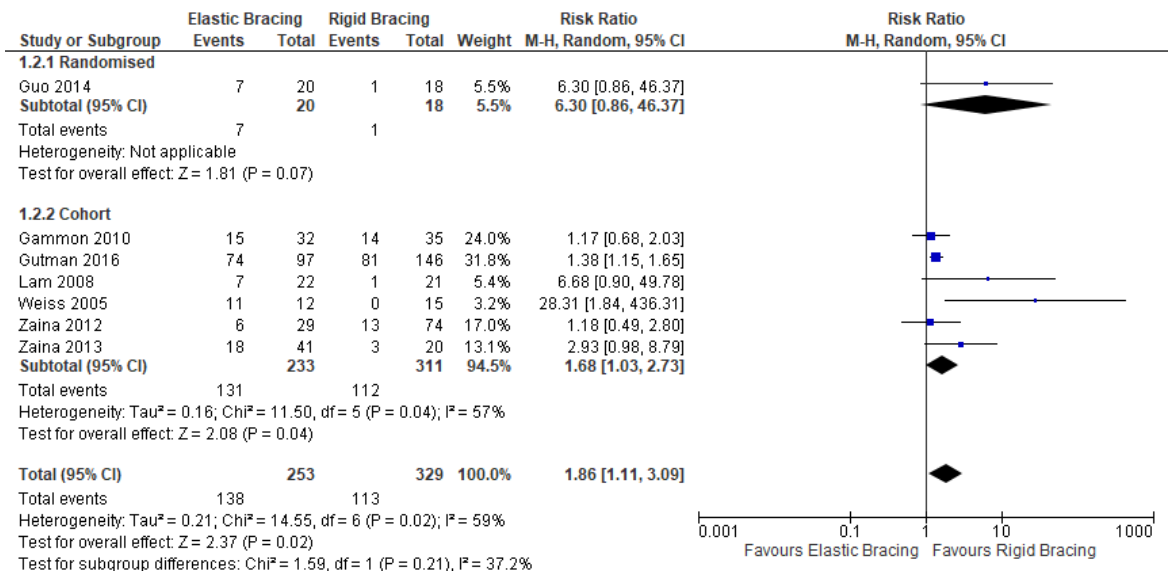


Figure 3: Forest plot showing number of patients with a >5° Cobb angle progression before or after skeletal maturity after bracing.

This is despite excluding the demographics data from one study. The lead author (Dr Ersen) was written to requesting further demographics but was unable to provide any more details.

Furthermore, not all the studies reported the curvature type. Those papers that did record curve type reported that most participants had a thoracic curve type followed by a double curvature, a thoracolumbar curve and then a lumbar curve type.

Methodological assessment

The results of the methodological assessment using the Effective Public Health Practice Project (EPHPP) tool are shown in supplementary information 5. Overall, the global rating identified only one study of strong quality [29] and five moderates in quality [30,33-34,38-39] of which most had different study designs including cohort; retrospective cohort, cross-sectional and prospective RCT. The remaining studies were graded as weak in quality [32,35-37].

Effects of the Intervention

Spinal curvature (Cobb angle)

The change in curve size showed the clinical effectiveness for bracing of any type in AIS. This is shown by five studies measured the

mean Cobb angle post-intervention with a total of 449 participants (elastic bracing n=210, rigid bracing n=239) where all studies show a reduction in curve size regardless of the type of brace used.

The mean Cobb angle after both types of treatment (Figure 2) was similar. There is a slight trend that favours rigid bracing, although this was not significant, with mean difference (MD) of 1.16 (95% CI 1.91 to 4.22) and overall heterogeneity of I²=39%. It should be noted that the highest quality study [29] shows that there is almost no difference in the mean Cobb angle after treatment for both rigid and elastic bracing.

Disease progression: Seven out of eleven studies [29-30,33-37] investigated the percentage of participants who progressed >5° in spinal curvature despite bracing of any type.

Figure 3 shows a significant difference between rigid and elastic bracing, favouring rigid bracing with less patients progressing more than 5° (RR=1.86, 95% CI 1.11 to 3.09). Guo J, et al. [29], an RCT and the only study which ranked high quality in EPHPP study assessment, agreed with this finding and had shown a significant difference favouring rigid bracing; RR=6.30 (95% CI 0.86 to 46.37). The remaining cohort studies also showed this, particularly Weiss HR, et al. 2005 [35] (RR=28.31, 95% CI 1.84 to 436.31).

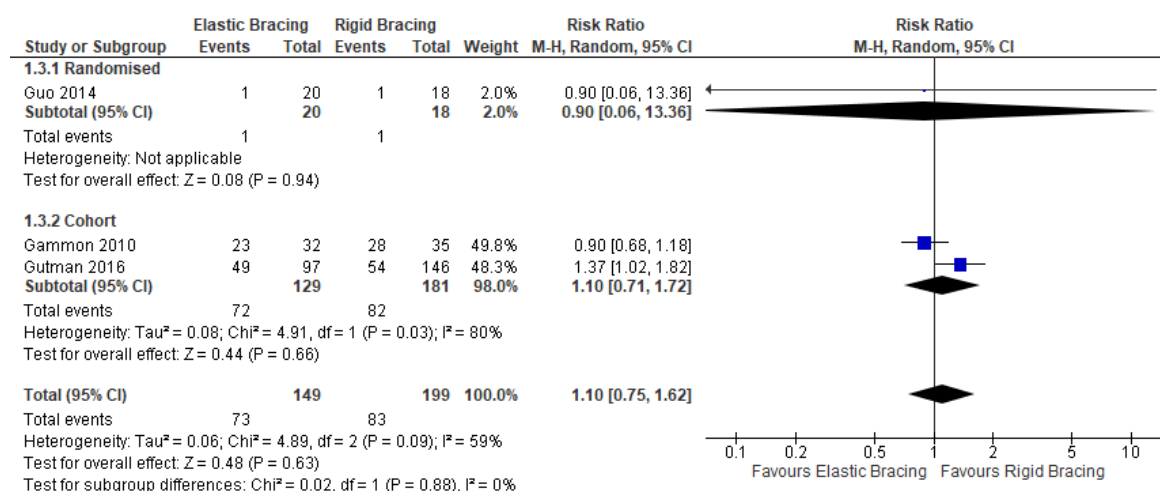


Figure 4: Forest plot showing the number of patients who have reached >45° Cobb angle after bracing.

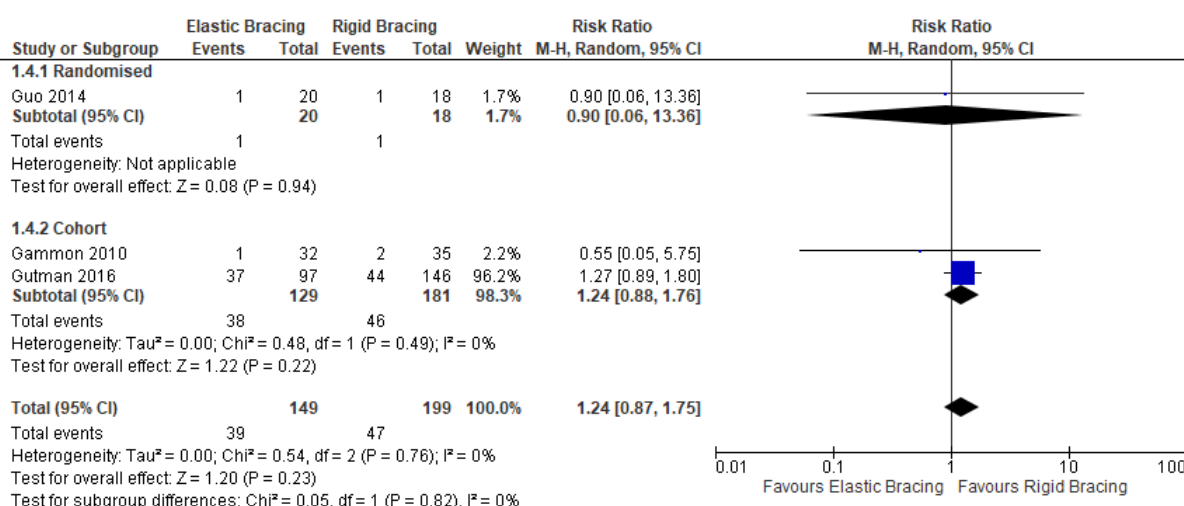


Figure 5: Forest plot showing the number of patients who have been recommended or have undergone surgery before or during skeletal maturity.

Additionally, this review has also investigated the other SRS standardised bracing treatment outcomes - the number of patients who have reached >45° Cobb angle and number of patients who have been recommended or has undergone surgery before or during skeletal maturity. Figures 4 and 5 suggests the forest plots had found that there was no significant difference between rigid and elastic bracing for the two outcomes (RR=1.10 and RR=1.24 respectively). Figure 4 also shows there is moderate heterogeneity I²=59% whilst figure 5 shows non-significant heterogeneity I²=0%.

Quality of life (QoL)/ SRS-22 questionnaire

Similarly, there is no clear significance in the difference between elastic and rigid bracing for the SRS-22 Quality of Life questionnaire in terms of total score and all domain scores. There was substantial heterogeneity (I²=73%) as these were sub-categorised; MD = 0.15 (95% CI -0.04 to -0.34 overall). Except for self-image (95% CI 0.09 to 0.75) with moderate heterogeneity I²=48% (Figure 6).

Body image

The only paper that assessed body image using the spinal appearance questionnaire (SAQ) [39] noted a mean SAQ score of

2.10 in rigid bracing compared to 2.53 elastic bracing (p=0.024) and concludes that elastic bracing was better than rigid bracing for improving the individuals own view of their curve. The other variables of the SAQ were not statistically significant elastic bracing was compared the rigid bracing.

Bracing questionnaire

Misterska E, 2019 [39] was also the only paper which recorded the results of bracing questionnaire (BrQ) (Figure 1). Rigid bracing scored slightly higher in the self-esteem and aesthetics subcategory (p=0.087). This conflicts with the SRS-22 self-image (as shown in figure 6 SRS-22, Misterska self-image domain MD = 0.26, 95% CI -0.06 to 0.58 overall). Emotional functioning and social functioning scored higher in rigid bracing than in elastic bracing (p=0.014, p=0.048 respectively). Overall, the mean total scored higher in the rigid bracing than that of the elastic bracing with a possible score out of 100, (mean=77.36, 74.45 respectively, p=0.346).

Physical functioning

Using the Bracing Questionnaire (BrQ), in the only paper to report this [39], physical functioning was similar for both braces

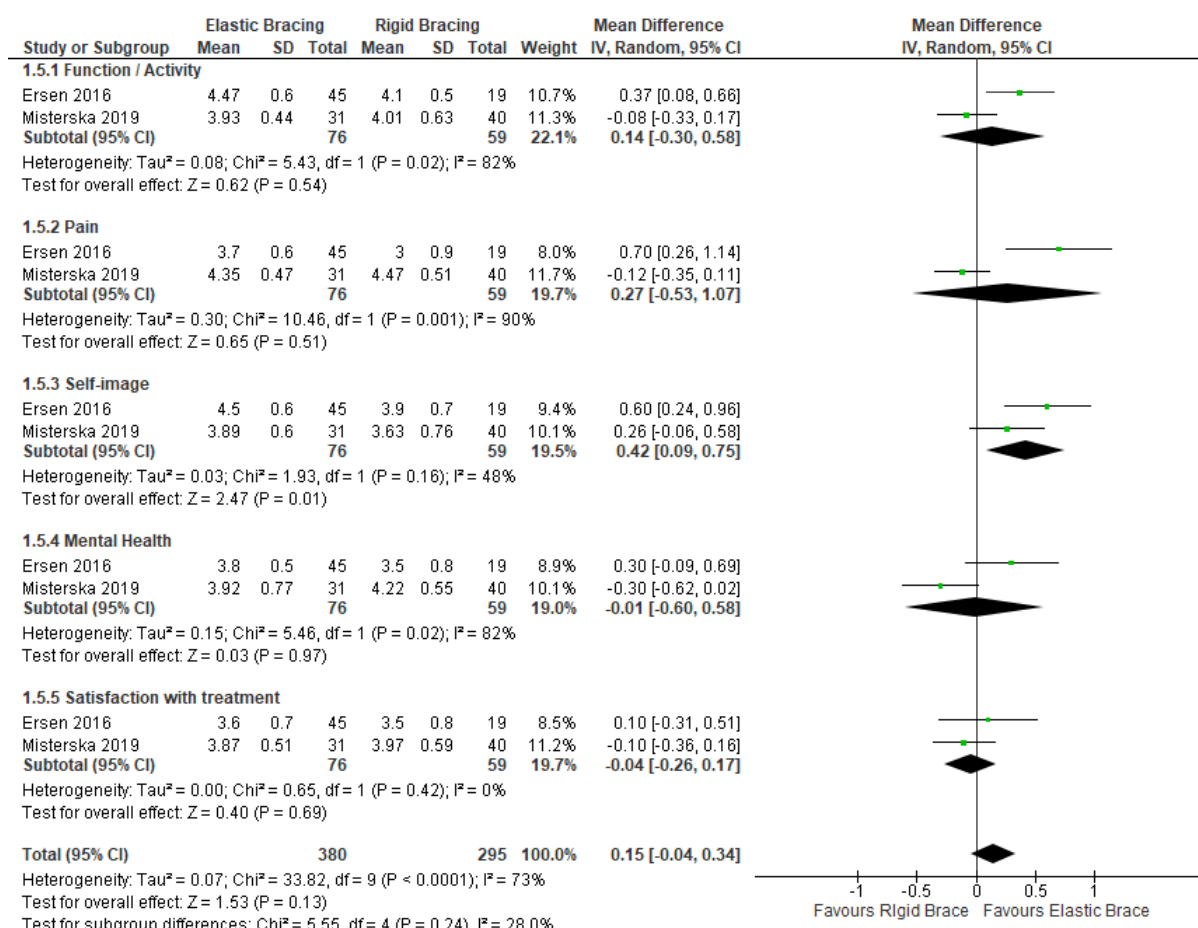


Figure 6: Forest plot showing SRS-22 Questionnaire mean scores for elastic bracing and rigid bracing for AIS.

(Elastic bracing BrQ = 3.69, Rigid bracing BrQ = 3.96 demonstrating relatively good scores and no statistically significance ($p = 0.103$). Ersen Ö, (2013) [32] who investigated pulmonary function also showed that both rigid and elastic bracing had restricted function from immediate wearing of brace using spirometer readings. No statistics and findings were reported in this study with only an abstract available.

On the contrary, Wong MS, 2008 [31] identified that, when followed up to one year of the intervention, neither group of elastic bracing nor rigid bracing showed gait asymmetry when compared to the convex or concave sides of the scoliotic curve. However, both braces reduced the pelvic obliquity abduction-adduction of the hip.

Bracing adherence

Although treatment adherence was not an outcome measure for this review, it was reported in the paper that prescribed hours of brace wear ranged from 18 to 23 hours with rigid bracing and elastic bracing was to be often worn for 20 hours. Cheow X, et al. (2010) [40] identified that elastic bracing was worn for 17.1 ± 5.17 hours (range: 8-20) while for the Boston brace was 9.79 ± 4.37 hours (range: 1-20). Misterska E, (2019) [39] showed in elastic bracing, a positive association between the hours of brace wear with participants' self-image ($p < 0.05$). Furthermore, a strong negative association between the SAQ and the duration (in hours) that the elastic brace was worn was found showing the longer the elastic brace was worn in a day, the less the reported prominence of the thorax ($p < 0.05$). Contrary to this, the rigid brace had a high SAQ with the hours worn ($p < 0.05$), as the light plastic material felt cumbersome, and it is suggested that this reason why the rigid brace was worn for less hours.

GRADE assessment

The table in supplementary information 6 summarises the quality

assessment according to the GRADE criteria (GRADEpro 2020) [26] for the top 7 outcomes assessed in the meta-analyses and shows that the quality of evidence was very low.

Discussion

This review was conducted to identify which type of spinal brace (rigid or elastic) is most effective in AIS using both physical and psychological outputs. The importance of this question was highlighted as top priority question 7 for scoliosis by the James Lind Alliance Priority Setting Partnership for scoliosis (2017) [14]. This review, which assessed the efficacy of elastic bracing when compared to rigid bracing in AIS, had reported similar pulmonary restrictive function and reduced pelvic obliquity in both types of bracing. There was a slightly more favourable outcome for rigid bracing in the following: Cobb angle, Bracing Questionnaire (BrQ) and Spinal Acceptance Questionnaire (SAQ). However, there were slightly favourable results for elastic bracing in scoliosis specific questionnaire SRS-22, in particular self-image.

Bracing adherence is a key factor for successful treatment for AIS [13] and this review had found that rigid bracing had adhered to less hours compared to elastic bracing and still be able to produce slightly favourable results for the treatment of AIS. This suggests further studies (such as BASIS [41]) are required to investigate whether reducing the time the brace is worn and altering how the forces are applied (such as a night-time, over bending brace) produces as good results as full-time brace wear in AIS.

While this review was intended to be mixed method review, only quantitative studies were found. Overall, the methodological quality of studies was moderate to poor according to the EPHPP

quality appraisal assessment with only one high quality as an RCT. Low quality studies were found, as most records were cohort studies, and brief abstracts with no statistical analysis was also included. RCTs are ranked gold standard, however there is also an issue with RCTs in AIS bracing studies as historically, parents often want to choose their preferred treatment for their child [15] and therefore challenge the clinical equipoise of the study. As a result, low recruitment rate and selection bias may occur and not considering this baseline confounding variable may also have an impact.

As mentioned, there were no qualitative studies found and there is a need to investigate qualitative research and patient reported outcomes studies. This is particularly because AIS is a non-life-threatening condition where great importance is placed on quality of life, self-image, and mental health around adolescent age.

One limitation of this paper was that only English papers were reviewed and any foreign languages were not searched for. Furthermore, there could be potential publication bias in the results as grey literature was not searched. The meta-analysis conducted found wide confidence intervals suggesting we have little knowledge about the precise effects of bracing in the underlying population, and that further information is needed [42]. We were also reliant on data which was moderately heterogeneous and at high risk of bias. The limited number of studies and limited sample size therefore question generalisability. The GRADE assessment also deemed the papers as very low-quality overall. This paper therefore shares similarities to the findings from the Cochrane Systematic Review on Bracing on AIS [15] in that there is a need for higher quality studies in this area (noting that Cochrane systematic review includes only the gold standard RCTs which differs from this review which includes other study designs).

The need for high quality RCTs to be conducted that fully comply to the CONSORT TIDieR [43] which checklists and guides trials to a high standard is recommended. Furthermore, the use of the SRS standardised criteria guidelines [21], as well as use scoliosis specific quality of life SRS-22 and BrQ followed up with a minimum of 2 years post-skeletal maturity is to be recommended. Abundant data could also be provided in qualitative and mixed method studies to identify the reasons for brace non-compliance.

Conclusion

While the overall review and meta-analyses were of very low GRADE, it is questionable to conclusively draw which brace is more effective in AIS. Statistically, rigid bracing, compared to elastic bracing, was more effective in limiting scoliosis progression. While functional outcomes were similar across the bracing types, self-image improved in elastic bracing compared to those wearing rigid bracing. Therefore, this JLA priority question still requires further well-conducted studies evaluating the physical and psychosocial outcomes. Qualitative studies investigating the effectiveness of both braces focusing on patient reported outcomes and compliancy with wearing braces prescribed could also have an impact on Cobb angle progression and or other outcomes.

Declaration

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Ethical Approval

There was no ethical approval sought as this was a systematic review and meta-analysis.

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Availability of Data and Materials

All data generated or analysed during this study are included in this published article.

Authors Contributions

EL performed the data collection, writing the original draft preparation and approval of the final version of the manuscript. SR performed the data collection and LT was involved in writing the original draft preparation and approval of the final manuscript. AG also performed the data collection and approval of the final manuscript. All authors agree to be accountable for the work.

Supporting Information

- SI1 – Supplementary information 1 protocol v2.4_CLEAN
- SI2 – Supplementary information 2 Search strategy
- SI3 – Supplementary information 3 Removed full articles
- SI4 – Supplementary information 4 Table of summaries
- SI5 – Supplementary information 5 EPHPP
- SI6 – Supplementary information 6 GRADE
- SI7 – Supplementary information 7 Data Extraction Form COMPLETED

References

- Weinstein SL, Dolan LA, Cheng JC, Danielsson A, Morcuende JA (2008) Adolescent idiopathic scoliosis. *Lancet* 371: 1527-1537.
- Karavidas N (2019) Bracing in the Treatment of Adolescent Idiopathic Scoliosis: Evidence to Date. *Adolesc Health Med Ther* 10: 153-172.
- Stokes IA (1994) Three-dimensional terminology of spinal deformity: report presented to the Scoliosis Research Society by the Scoliosis Research Society working group on 3-D terminology of spinal deformity. *Spine (Phila Pa 1976)* 19: 236-248.
- Kane WJ (1977) Scoliosis prevalence: a call for a statement of terms. *Clin Orthop Relat Res* 43-46.
- Cobb J (1948) Outline for the study of scoliosis. *Instr Course Lect AAOS* 5: 261-275.
- Konieczny MR, Senyurt H, Krauspe R (2013) Epidemiology of adolescent idiopathic scoliosis. *J Child Orthop* 7: 3-9.
- Negrini S, Minozzi S, Bettany-Saltikov J, Zaina F, Chockalingam N, et al. (2010) Braces for idiopathic scoliosis in adolescents. *Spine (Phila Pa 1976)* 35: 1285-1293.
- Scoliosis Association UK. Bracing.
- Blount WP, Schmidt AC, Bidwell RG (1958) Making the Milwaukee brace. *J Bone Joint Surg Am* 40: 526-528.
- Fayssoux RS, Cho RH, Herman MJ (2010) A history of bracing for idiopathic scoliosis in North America. *Clin Orthop Relat Res* 468: 654-664.
- Watts HG, Hall JE, Stanish W (1977) The Boston brace system for the treatment of low thoracic and lumbar scoliosis by the use of a girdle without superstructure. *Clin Orthop Relat Res* 126: 87-92.
- Coillard C, Circo A, Rivard CH (2008) A new concept for the non-invasive treatment of adolescent idiopathic scoliosis: The corrective movement principle integrated in the spinecor system. *Disabil Rehabil Assist Technol* 3: 112-119.
- Weinstein SL, Dolan LA, Wright JG, Dobbs MB (2013) Design of the bracing in adolescent idiopathic scoliosis trial (BrAIST). *Spine (Phila Pa 1976)* 38: 1832-1841.

14. James Lind Alliance (2017) Priority 7 from the Scoliosis PSP.
15. Negrini S, Minozzi S, Bettany-Saltikov J, Chockalingam N, Grivas TB, et al. (2015) Braces for idiopathic scoliosis in adolescents. *Cochrane Database Syst Rev*.
16. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, et al. (2021) The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ* 372: n71.
17. Haher TR, Gorup JM, Shin TM, Homel P, Merola AA, et al. (1999) Results of the Scoliosis Research Society instrument for evaluation of surgical outcome in adolescent idiopathic scoliosis. A multicenter study of 244 patients. *Spine (Phila Pa 1976)* 24: 1435-1440.
18. Lai SM, Asher M, Burton D (2006) Estimating SRS-22 quality of life measures with SF-36: application in idiopathic scoliosis. *Spine (Phila Pa 1976)* 31: 473-478.
19. Sanders JO, Harrast JJ, Kuklo TR, Polly DW, Bridwell KH, et al. (2007) The Spinal Appearance Questionnaire: results of reliability, validity, and responsiveness testing in patients with idiopathic scoliosis. *Spine (Phila Pa 1976)* 32: 2719-2722.
20. Vasiladis E, Grivas TB, Gkoltsiou K (2006) Development and preliminary validation of Brace Questionnaire (BrQ): a new instrument for measuring quality of life of brace treated scoliotics. *Scoliosis* 1: 7.
21. Richards BS, Bernstein RM, D'Amato CR, Thompson GH (2005) Standardization of criteria for adolescent idiopathic scoliosis brace studies: SRS Committee on Bracing and Nonoperative Management. *Spine (Phila Pa 1976)* 30: 2068-2075.
22. Clarivate Analytics (2013) Endnote (EndNote X9) [Computer software]. Philadelphia, PA.
23. Ouzzani M, Hammady H, Fedorowicz Z, Elmagarmid A (2016) Rayyan-a web and mobile app for systematic reviews. *Syst Rev* 5: 210.
24. Thomas BH, Ciliska D, Dobbins M, Micucci S (2004) A process for systematically reviewing the literature: providing the research evidence for public health nursing interventions. *Worldviews Evid Based Nurs* 1: 176-184.
25. Armijo-Olivo S, Stiles CR, Hagen NA, Biondo PD, Cummings GG (2012) Assessment of study quality for systematic reviews: a comparison of the Cochrane Collaboration Risk of Bias Tool and the Effective Public Health Practice Project Quality Assessment Tool: methodological research. *J Eval Clin Pract* 18: 12-18.
26. GRADEpro GDT: GRADEpro Guideline Development Tool. McMaster University (developed by Evidence Prime, Inc.) 2020.
27. Riley RD, Higgins JP, Deeks JJ (2011) Interpretation of random effects meta-analyses. *BMJ* 342: d549.
28. Deeks JJ, Higgins JPT, Altman DG (2022) Chapter 10: Analysing data and undertaking meta-analyses. In: Higgins JPT, Thomas J, Chandler J, Cumpston M, Li T, et al. (eds) *Cochrane Handbook for Systematic Reviews of Interventions* version 6.3, Cochrane.
29. Guo J, Lam TP, Wong MS, Ng BK, Lee KM, et al. (2014) A prospective randomized controlled study on the treatment outcome of SpineCor brace *versus* rigid brace for adolescent idiopathic scoliosis with follow-up according to the SRS standardized criteria. *Eur Spine J* 23: 2650-2657.
30. Lam TP, Wong MS, Ng BKW, Sin SW, Kwok RHK, et al. (2008) A randomized controlled trial on treatment outcome and patient's acceptance of the SpineCor *vs* rigid bracing system for AIS girls. *Studies in Health Technology and Informatics* 140: 374.
31. Wong MS, Cheng CY, Ng BK, Lam TP, Sin SW, et al. (2008) The effect of rigid *versus* flexible spinal orthosis on the gait pattern of patients with adolescent idiopathic scoliosis. *Gait Posture* 27: 189-195.
32. Ersen Ö, Can N, Oguz E, Bilgic S, Sehirlioglu A ((2013)) Effect of Spinecor brace on pulmonary functions. *Scoliosis* 8: O46.
33. Gammon SR, Mehlman CT, Chan W, Heifetz J, Durrett G, et al. (2010) A comparison of thoracolumbosacral orthoses and SpineCor treatment of adolescent idiopathic scoliosis patients using the scoliosis research society standardized criteria. *J Pediatr Orthop* 30: 531-538.
34. Gutman G, Benoit M, Joncas J, Beauséjour M, Barchi S, et al. (2016) The effectiveness of the SpineCor brace for the conservative treatment of adolescent idiopathic scoliosis. Comparison with the Boston brace. *Spine J* 16: 626-631.
35. Weiss HR, Weiss G (2005) Brace treatment during pubertal growth spurt in girls with idiopathic scoliosis (IS): A prospective trial comparing two different concepts. *Pediatr Rehabil* 8: 199-206.
36. Zaina F, Digiacomo F, Donzelli S, Romano M, Negrini A, Lusini M, et al. (2013) SpineCor *vs* rigid brace for Adolescent Idiopathic Scoliosis: End of growth results from a retrospective controlled study. *Scoliosis* 8: O56.
37. Zaina F, Donzelli S, Negrini A, Romano M, Negrini S (2012) SpineCor, exercise and SPoRT rigid brace: What is the best for adolescent idiopathic scoliosis? Short term results from 2 retrospective studies. *Stud Health Technol Inform* 176: 361-364.
38. Ersen O, Bilgic S, Koca K, Ege T, Oguz E, et al. (2016) Difference between Spinecor brace and Thoracolumbosacral orthosis for deformity correction and quality of life in adolescent idiopathic scoliosis. *Acta Orthop Belg* 82: 710-714.
39. Misterska E, Glowacki J, Kołban M (2019) Does rigid spinal orthosis carry more psychosocial implications than the flexible brace in AIS patients? A cross-sectional study. *J Back Musculoskelet Rehabil* 32: 101-109.
40. Cheow X, Tay GT, Teo A (2010) Compliance of the boston brace *vs* the spinecor in adolescent idiopathic scoliosis. *Proceedings of Singapore Healthcare*.
41. NHS Health Research Authority. Bracing Adolescent Idiopathic Scoliosis (BASIS).
42. Schunemann HJ, Vist, GE, Higgins JPT, Santesso N, Deeks JJ, et al. (2021) Chapter 15: Interpreting results and drawing conclusions. In: Higgins J, Thomas J, Chandler J, Cumpston M, Li T, et al. (eds) *Cochrane Handbook for Systematic Reviews of Interventions* version 6.2. Cochrane.
43. Hoffmann TC, Glasziou PP, Boutron I, Milne R, Perera R, et al. (2014) Better reporting of interventions: template for intervention description and replication (TIDieR) checklist and guide. *BMJ* 348: g1687.