Meta-Analysis: Effectiveness of Scoliosis Brace to Reduce Scoliosis Curve Degree in Adolescent Idiopathic Scoliosis

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ABSTRACT

Background: Adolescent Idiopathic Scoliosis (AIS) is a disorder of the spine that is curved laterally which includes rotation of the spine so that there is humpback on the ribs, which occurs in children aged 10-18 years. The use of a brace is an attempt to modify the mechanical shape and control the development of curves in the curvature of the spine by applying certain pressure points on the body. The purpose of this study was to determine the magnitude of the effect of using the scoliosis brace to reduce the degree of scoliosis in adolescents with idiopathic scoliosis.

Subjects and Method: This study was conducted using a systematic review and meta-analysis study design using PICO, population: adolescent idiopathic scoliosis, intervention: using a scoliosis brace. comparison: not using a scoliosis brace, outcome: degree of scoliosis. The articles used in this study come from 3 databases, namely Google Scholar, PubMed, and Science Direct. With keywords including "Adolescent scoliosis" OR "scoliosis" AND "scoliosis brace" OR "brace" AND "degree of scoliosis" OR "Cobb Angle" AND "randomized control trial". The articles included in this study are full paper articles with experimental studies, research subjects of adolescent patients with scoliosis, articles published in the 2011-2021 period.

Results: A meta-analysis was conducted on 10 primary randomized control trials conducted from Turkey, China, Canada, Switzerland, the United States, and Hong Kong, with a total sample size of 558. The meta-analysis concluded that adolescent patients with idiopathic scoliosis who received intervention The scoliosis brace had a lower grade of scoliosis 0.27 compared to adolescents who did not use the scoliosis brace, and the difference was statistically significant (SMD= -0.27; 95% CI= -0.45 to −0.09; p= 0.003).

Conclusion: The use of a scoliosis brace can reduce the degree of scoliosis in adolescents with idiopathic scoliosis.

Keywords: adolescent idiopathic scoliosis, scoliosis brace, cobb angle

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BACKGROUND

Scoliosis comes from the Greek word "scoliosis" which means to bend or rotate. Scoliosis is a spinal disorder characterized by a lateral deviation of at least 10 degrees according to the rotation of the vertebrae. Scoliosis is often found in the planes of motion, namely sagittal, frontal and transverse. Scoliosis is a spinal disorder in which the spine is bent laterally to form the letter "S" or "C" (Frenkel, 2011).

Approximately 80% of scoliosis in the world is idiopathic. Idiopathic scoliosis with a curve of more than 10 degrees is reported with a prevalence of 0.5-3 per 100 children and adolescents. The prevalence is reported on a curve of more than 30 degrees, namely 1.5-3 per 1000 population. About 4% of children aged 10-14 years have scoliosis, 40-60% of them are girls (Konieczny et al., 2013).

Idiopathic Scoliosis can be classified into 3 groups, namely Infantile Scoliosis which develops at the age of 0-3 years, Juvenile Scoliosis which develops at the age of 4-10 years, and Adolescent Scoliosis which develops at the age of 11-18 years (Konieczny et al., 2013). Early detection is necessary for strong treatment of Adolescent Idiopathic Scoliosis (AIS). Detection is generally done by screening children and adolescents using the Adam's forward bend test.

Adolescent Idiopathic Scoliosis (AIS) is a disorder of the spine that is curved laterally which includes rotation of the spine so that there is humpback on the ribs, which occurs in children aged 10-18 years. Adolescent Idiopathic Scoliosis (AIS) is the most common type of scoliosis, occurring in 1% - 4% of adolescents worldwide. This scoliosis is an idiopathic type, namely scoliosis for which the cause is not known with certainty, in contrast to other types, namely congenital or neuromuscular which have a clear pathogenesis (Cheng et al., 2015).

Treatment of AIS in Indonesia is often delayed due to a lack of knowledge and concern by the public for the disease (Suryaningrat et al., 2017). Adolescent Idiopathic Scoliosis (AIS) ranges from 0.47%-5.2%, but the general prevalence is 2%-3%. The ratio of women to men can reach 9:1 and increases with age (Moramarco et al., 2020). Based on the degree of Cobb's angle, the prevalence of AIS is higher in girls than in boys. The ratio of women to men increases from 2:1 on a 10 degree curve to 10:1 on a curve >30 degrees (Newton et al., 2011).

Observation of scoliosis is indicated with an angle of curvature <250 in patients who are still growing and <500 in patients who have stopped growing. Examination is carried out every 6-9 months for curvature <200 and every 4-6 months for curvature >20. Some of the interventions that can be given to improve the degree of the scoliosis curve include surgery if the degree of the curve is >450 (Mangkung et al., 2021). The use of a brace is recommended for scoliosis with a curvature of >200 in patients who are still growing and with a progression of 5-100 over a 6-month period (Pelealu et al., 2014).

Conservative treatment is an attempt to prevent the development of the curve. Surgery is used for a large curve or a current progressive curve. The use of an orthosis or brace in scoliosis aims to control the curvature of the spine until it waits for permanent bone maturity. The use of a brace is an attempt to modify the mechanical shape and control the development of curves in the curvature of the spine by applying certain pressure points on the body (Kuroki, 2018).

The purpose of this study was to determine the magnitude of the effect of using the scoliosis brace to reduce the degree of scoliosis in adolescents with idiopathic scoliosis.

SUBJECTS AND METHOD

1. Study Design
This was a systematic review and meta-analysis. Article searches were conducted using 3 databases, namely Google Scholar, PubMed, and Science Direct using the keywords "adolescent scoliosis" OR "scoliosis" AND "scoliosis brace" OR "brace" AND "degree of scoliosis" OR "Cobb Angle" AND "randomized" control trial". The articles used are articles published from 2012 to 2022.

2. Steps of Meta-Analysis

Meta analysis was carried out in 5 steps as follows:

a. Formulate research questions in the PICO format (Population, Intervention, Comparison, Out Come).
b. Search for primary study articles from electronic and non-electronic databases such as PubMed, Science Direct, Google Scholar, Scopus, etc.
c. Conduct screening to determine inclusion and exclusion criteria and carry out critical assessments.
d. Extract data from primary studies and synthesize effect estimates using the revman application.
e. Interpret the results and draw conclusions.

3. Inclusion Criteria

The inclusion criteria in this study included full paper articles with experimental studies, research subjects were adolescent scoliosis patients, the relationship size used was the mean and standard deviation, the study outcome was the degree of scoliosis.

4. Exclusion Criteria

Exclusion criteria are articles published in languages other than English, and articles published before 2012.

5. Study Variables

Independent Variable: Use of scoliosis brace.

Dependent Variable: Degree of scoliosis.

6. Operational Definition of Variable

Scoliosis brace: Scoliosis brace is a device that is used outside the body to correct the degree of tilt in scoliosis patients.

Degree of scoliosis / Cobb angle: the degree of scoliosis commonly known as the cobb angle is the angle of inclination of a scoliosis patient's spine which can be measured from the top and bottom of the spine to form a scoliosis curve.

7. Instrument

This research uses Critical Appraisal Checklist for Randomized Controlled Study. The checklist questions for randomized controlled studies in this study are as follows:

a. Does this research address a clear research focus?
b. Is the Randomized Controlled Trial research method suitable for answering research questions?
c. Were there enough subjects in the study to establish that the findings were not coincidental?
d. Were the subjects randomly divided into experimental and control groups? If not, could this introduce bias?
e. Did the study use inclusion/exclusion criteria?
f. Were the two groups comparable at study entry?
g. Are the outcome criteria objective and unbiased?
h. Is the measurement method used objective and valid to measure the results? If not, was there blinding in the study?
i. Is the effect size practically relevant?
j. Were the effect estimates correct? Is there a degree of confidence interval?
k. Are there any confounding factors that have not been taken into account?
l. Are the results applicable to your research?

8. Data Analysis

From the articles that have been collected, data is processed using the Review Manager application (RevMan 5.3) issued by the Cochrane Collaboraton. Data processing is done by calculating the effect size and heterogeneity values.

RESULTS

The assessment of this research article uses the PRISMA FLOW diagram which can be seen in Figure 1. The total articles obtained are 10 articles spread across various continents, namely Asia, Europe, North America.
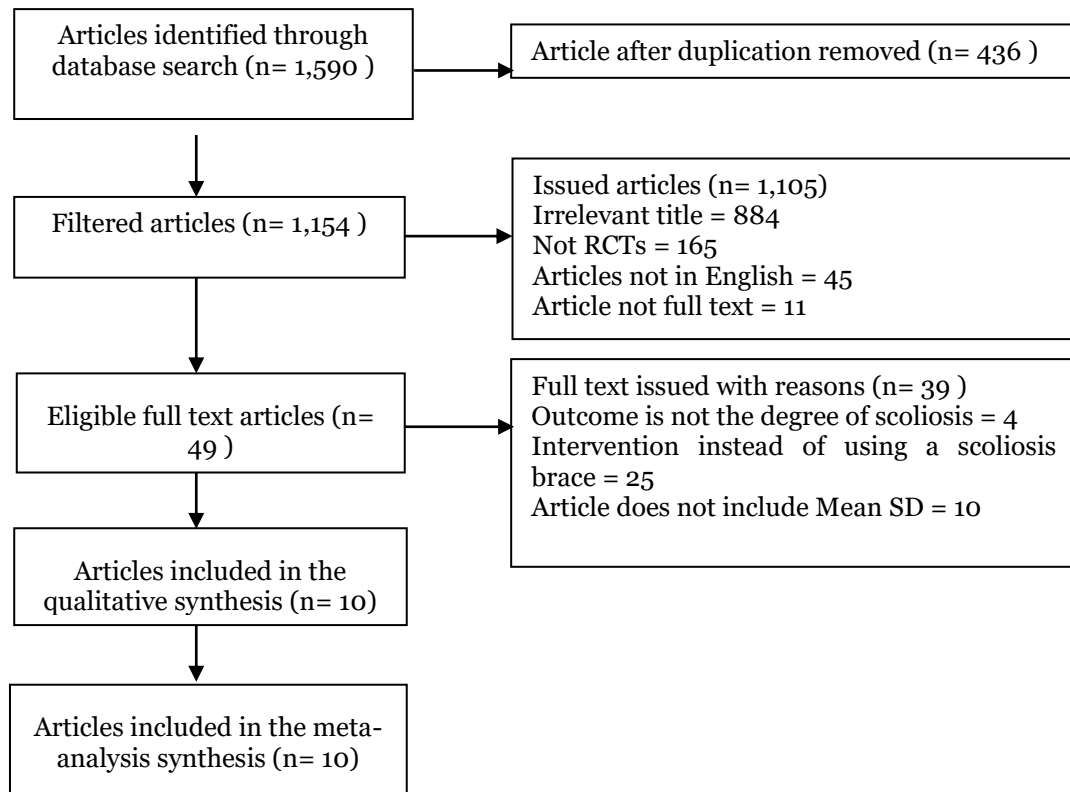
Articles identified through database search (n= 1,590)

Article after duplication removed (n= 436)

Filtered articles (n= 1,154)

Issued articles (n= 1,105)
Irrelevant title = 884
Not RCTs = 165
Articles not in English = 45
Article not full text = 11

Eligible full text articles (n= 49)

Full text issued with reasons (n= 39)
Outcome is not the degree of scoliosis = 4
Intervention instead of using a scoliosis brace = 25
Article does not include Mean SD = 10

Articles included in the qualitative synthesis (n= 10)

Articles included in the meta-analysis synthesis (n= 10)

Figure 1. PRISMA Flow Diagram

1 Study in Europe

5 Studies in Asia

Figure 2. Map of the Research Area of Meta-Analysis

Table 1. Assessment of the quality of randomized controlled trial studies "Effectiveness of Using a Scoliosis Brace to Reduce the Degree of Scoliosis in Adolescents with Idiopathic Scoliosis"

No	Author (Year)	1	2	3	4	5	6	7	8	9	10	11	12	Total
1	Gur et al. (2015)	2	2	2	2	2	2	2	2	2	2	1	2	23
2	Zheng et al. (2018)	2	2	2	2	2	2	2	2	2	2	2	2	24
3	Cobetto et al. (2015)	2	2	2	2	0	2	2	2	2	2	2	2	22
4	Fong et al. (2015)	2	2	2	2	2	2	2	2	2	2	1	2	23
5	Dufvenberg et al. (2021)	2	2	2	2	2	2	2	2	2	2	2	2	24
6	Liang et al. (2018)	2	2	2	2	2	2	2	2	2	2	2	2	24
7	Cobetto et al. (2017)	2	2	2	2	2	1	1	2	2	2	2	2	22
8	Wiemann et al. (2014)	2	2	2	2	2	2	2	2	2	2	0	2	22
9	Coillard et al. (2014)	2	2	2	2	2	2	2	2	2	2	2	2	24
10	Lin et al. (2020)	2	2	2	2	2	2	2	2	2	2	2	2	24

Table 2. Description of the primary studies included in the meta-analysis

Author (Year)	Country	Sample	P	I	C	O
Gur et al. (2015)	Turkey	63	Adolescents idiopathic scoliosis aged 12-17 years	Using a scoliosis brace	Not using braces	Scoliosis degree / Cobb Angle
Zheng et al. (2018)	China	53	Adolescent idiopathic scoliosis	Using a scoliosis brace	Not using braces	Scoliosis degree / Cobb Angle
Cobetto et al. (2015)	Canada	40	Adolescent idiopathic scoliosis Cobb Angle 200 – 450 Risser Sign 0-2	Using a scoliosis brace	Not using braces	Scoliosis degree / Cobb Angle
Fong et al. (2015)	China	48	Adolescent idiopathic scoliosis	Using a scoliosis brace	Not using braces	Scoliosis degree / Cobb Angle
Dufvenberg et al. (2021)	Switzerland	90	Adolescent idiopathic scoliosis, Cobb Angle 250 – 400	Using the scoliosis Boston brace	Not wearing the Boston brace	Scoliosis degree / Cobb Angle
Liang et al. (2018)	China	40	Adolescents idiopathic scoliosis aged 10 – 16 years, Cobb Angle 100 – 200	Using a scoliosis brace	Not using braces	Scoliosis degree / Cobb Angle
Cobetto et al. (2017)	Canada	48	Adolescent idiopathic scoliosis Cobb Angle 200 – 400 Risser Sign 0 – 2	Using the TLSO brace scoliosis	Not using the TLSO brace	Scoliosis degree / Cobb Angle
Cobetto et al. (2017)	Canada	48	Adolescent idiopathic scoliosis Cobb Angle 200 – 400 Risser Sign 0 – 2	Using the TLSO brace scoliosis	Not using the TLSO brace	Scoliosis degree / Cobb Angle
Wiemann et al. (2014)	The USA	37	Adolescent idiopathic scoliosis Cobb Angle 150 – 250 Risser Sign 0 – 2	Using the scoliosis Charleston brace	Not using the Charleston brace	Scoliosis degree/ Cobb Angle
Coillard et al. (2014)	Canada	68	Adolescent idiopathic scoliosis Cobb Angle 150 – 300	Using the SpineCor scoliosis brace	Do not use the SpineCor brace	Scoliosis degree / Cobb Angle
Lin et al. (2020)	Hong Kong	23	Adolescent idiopathic scoliosis Risser sign 0 – 2 Cobb Angle 200	Using a scoliosis brace	Not using braces	Degrees of Scoliosis / Cobb Angle

Based on Table 2, an overview of primary research regarding the effectiveness of using the scoliosis brace to reduce the degree of scoliosis in adolescents with idiopathic scoliosis, a meta-analysis of 10 articles was carried out with a total sample of 558, the research locations varied, namely from Turkey, China, Canada, Switzerland, United States, and Hong Kong. Similarities were found in this study, namely the research design used

a Randomized Controlled Trial, the research subjects were adolescents with idiopathic scoliosis, the intervention provided was the use of a scoliosis brace with the comparison not using a scoliosis brace. However, there is a difference in the number of intervention and control samples used, namely the smallest intervention sample is 12 and the most is 45 while in the control sample the smallest sample is 11 and the most is 45.

Table 3. Effect estimates (Mean SD) of all primary studies subjected to meta-analysis

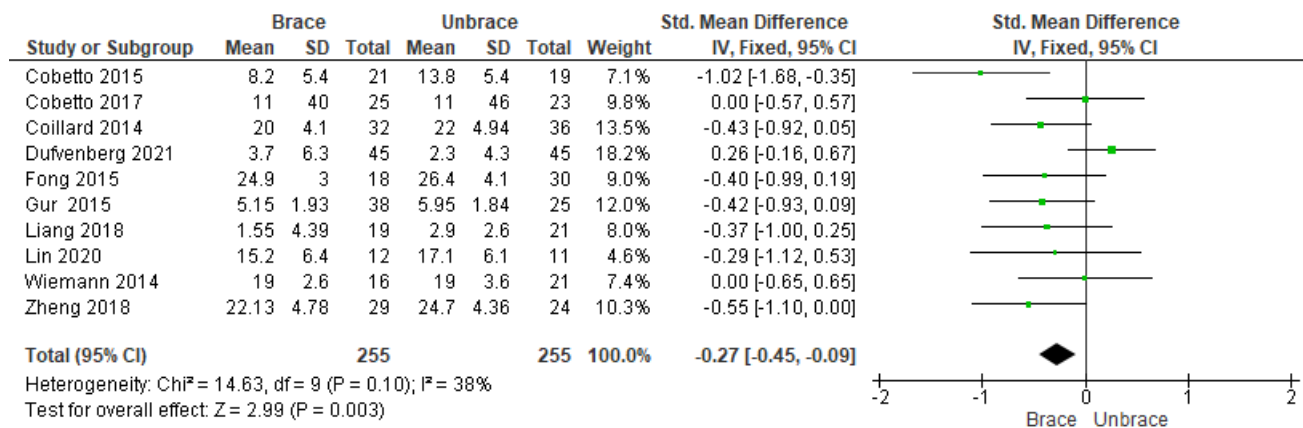| Author	Brace		Non-Brace	
(Year)	Mean	SD	Mean	SD
Gur *et al.* (2015)	5.15	1.93	5.95	1.84
Zheng *et al.* (2018)	22.13	4.78	24.70	4.36
Cobetto *et al.* (2015)	8.2	5.4	13.8	5.4
Fong *et al.* (2015)	24.9	3.0	26.4	4.1
Dufvenberg *et al.* (2021)	3.7	6.3	2.3	4.3
Liang *et al.* (2018)	1.55	4.39	2.90	2.60
Cobetto *et al.* (2017)	11	40	11	46
Wiemann *et al.* (2014)	19	2.6	19	3.6
Coillard *et al.* (2014)	20	4.10	22	4.94
Lin *et al.* (2020)	15.2	6.4	17.1	6.1

1. Forest Plot

Figure 3. Forest plot meta-analysis of the effectiveness of using the Scoliosis brace to reduce the degree of scoliosis in adolescents with idiopathic scoliosis

Based on the meta-analysis results, Figure 3 shows that the use of the scoliosis brace is effective in reducing the degree of scoliosis in adolescents with idiopathic scoliosis. Adolescents who used a scoliosis brace experienced a lower degree of scoliosis

0.27 units compared to adolescents who did not use a scoliosis brace, and the difference was statistically significant (SMD= -0.27; 95% CI = -0.45 to −0.09; p= 0.003).

The forest plot in Figure 3 also shows low heterogeneity in effect estimates be-

tween studies (I2= 38%; p= 0.100). Thus the calculation of the average estimated effect in the meta-analysis uses the fixed effect model approach.

2. Funnel Plot

The funnel plot in Figure 4 shows an asymmetric distribution of estimated effects on both sides of the vertical, the average estimated effect is located to the left of the vertical line more than to the right. Thus this funnel plot shows an indication of publication bias, because the distribution of the effect estimates is located to the left of the mean line, while the estimated effects in the funnel plot in Figure 4 are also located more to the left of the vertical line of the null hypothesis, so the publication bias tends to exceed-overestimate the actual effect (overestimation).
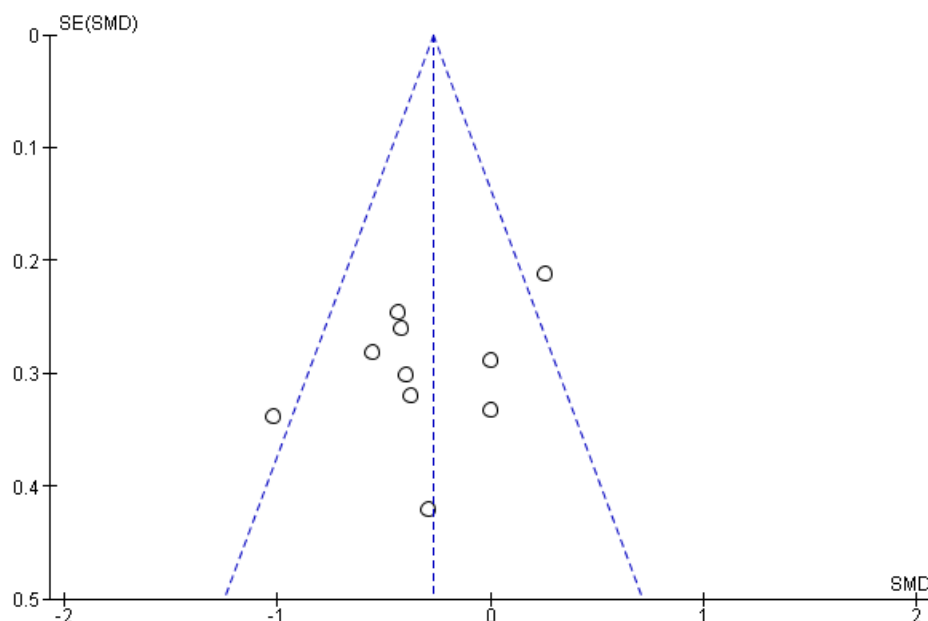

Figure 4. Funnel plot meta-analysis of the effectiveness of using the scoliosis brace to reduce the degree of scoliosis in adolescents with idiopathic scoliosis

DISCUSSION

Adolescent Idiopathic Scoliosis (AIS) is a disorder of the spine that is curved laterally which includes rotation of the spine so that there is humpback on the ribs, which occurs in children aged 10-18 years. Adoles-cent idiopathic scoliosis (AIS) is the most co-mmon type of scoliosis, occurring in 1% -4% of adolescents worldwide. (Cheng et al., 2015).

Treatment of AIS in Indonesia is often delayed due to a lack of knowledge and con-cern by the public for the disease (Surya-ningrat et al., 2017). Delayed treatment of AIS can result in the progression of spinal deformity which can trigger several pro-blems, both cosmetic and health problems, such as cardiopulmonary disorders and in-creased mortality rates (Moramarco et al., 2020).

One of the interventions that can be given to improve the degree of scoliosis cur-ve is the use of a scoliosis brace which is re-commended for scoliosis patients with a curvature of >200 who are still growing and with a progression of 5-100 in a period of 6 months (Pelealu et al., 2014). The use of the scoliosis brace is an attempt to modify the mechanical shape and also control the deve-lopment of curves in the spinal curvature by

applying pressure at certain points (Kuroki, 2018).

The use of a scoliosis brace can prevent increased progression and also reduce the magnitude of the degree of scoliosis in adolescent patients with idiopathic scoliosis by using a correction system, namely three-point pressure which works by applying pressure to the peak of the curve that is experiencing bending and according to the patient's needs and also the ability to withstand pain the patient. In order to get maximum results the scoliosis brace can be used for a period of 8 to 23 hours every day (Lusini et al., 2014).

Estimates of the effectiveness of using the scoliosis brace to reduce the degree of scoliosis in adolescents with idiopathic scoliosis were processed using the RevMan 5.3 software with the continuous method. This method is used to analyze the effect size or standardized mean difference in the bivariate data of two groups that have been controlled for by randomization for confounding factors.

Research related to the effectiveness of using the scoliosis brace to reduce the degree of scoliosis in adolescents with idiopathic scoliosis consists of several primary studies spread over 3 continents, namely Asia, Europe, and North America. The primary research included in the meta-analysis synthesis totaled 10 articles with a total sample of 558, the research locations varied, namely from Turkey, China, Canada, Switzerland, the United States, and Hong Kong.

Based on the results of 10 primary studies conducted systematic review and meta-analysis showed that there was homogeneity between experiments (I^2= 38%; p=0.100) so that the analysis used the fixed effect model (FE). The results of a meta-analysis of 10 articles stated that the use of the scoliosis brace was effective in reducing the degree of scoliosis in adolescents with idiopathic scoliosis. Adolescents who used a scoliosis brace experienced a lower degree of scoliosis 0.27 units compared to adolescents who did not use a scoliosis brace, and the difference was statistically significant (SMD= -0.27; 95% CI = -0.45 to -0.09; p= 0.003).

The results of a meta-analysis of 10 primary studies that have been conducted on the effectiveness of using the scoliosis brace to reduce the degree of scoliosis in adolescents with idiopathic scoliosis are in line with several studies conducted by several researchers, including Weinstein (2013) which stated that the use of scoliosis brace can reduce the degree of scoliosis in adolescents with idiopathic scoliosis. This is because the use of a scoliosis brace can correct the peak of the curve and also prevent the increase in the degree of scoliosis.

Another study that has been conducted by Lee et al. (2012) that the use of the Charleston brace can reduce the degree of scoliosis in adolescents with idiopathic scoliosis. Patients with a high peak curve had a success rate of 67.6%, and those with a low peak curve had a success rate of 83.0%.

The results of the study are in line with those conducted by Zhu et al. (2017) who stated that the effectiveness of using a brace can significantly be applied to adolescent patients with idiopathic scoliosis on a curve between 40 to 50 degrees to reduce the degree of scoliosis in these patients. Even though most of these patients will definitely undergo an intervention in the form of surgery, thus using a brace before getting a surgical intervention can minimize the increase in the scoliosis degree curve.

Another similar study was conducted by Xu et al. (2019) which stated that the use of a brace resulted in a decrease in the degree of scoliosis in adolescents with idiopathic scoliosis on a curve between 40 to 45 degrees, but when using a brace it is necessary to pay attention to how to use it and also the

duration of use of the brace, because there is a probability of failure in using the brace.

According to Palazzo et al. (2017) adolescent patients with idiopathic scoliosis can reduce the degree of scoliosis by using a scoliosis brace, in addition to reducing the degree of scoliosis using a brace can also function to slow the rate of increase of the scoliosis curve, but still must pay attention to further treatment so that the progress of the scoliosis curve is always monitored.

This study is in accordance with research conducted by Aulisa et al. (2019) with the results of the study, namely the use of a scoliosis brace can be used in patients with a curve of 20 degrees and a Riseser sign or bone maturity level ranging from 0 to 2, but treatment using this scoliosis brace cannot be used in patients with a curve above 40 degrees who refuse surgery because if the scoliosis brace is used in these patients it does not progress too much in reducing the degree of scoliosis.

AUTHORS CONTRIBUTION

Etanaulia Marsim is the main researcher who selects topics, searches for and collects research data and analyzes data. Hanung Prasetya and Bhisma Murti reviewed the research documents and provided input and suggestions for conducting the research.

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CONFLICT OF INTEREST

There is no conflict of interest in this research.

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