Review Paper

Evaluating the Efficiency of Milwaukee Brace on Scoliosis Deformity: A Systematic Review of Literature

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ABSTRACT

Objectives: Scoliosis is a three-dimensional deformity of the spine that can be treated using various treatment approaches. The use of braces is one of the most commonly used treatment methods for controlling curve progression. This study aimed to evaluate the effectiveness of the Milwaukee brace (MB) in controlling scoliosis curve progression, based on available literature.

Methods: This study was conducted using several databases, including ISI Web of Science, PubMed, Google Scholar, Ebsco, and Scopus. Some keywords, such as MB, were used in combination with Milwaukee orthosis and scoliosis. Down and Black tool evaluated the quality of the studies.

Results: Based on the keywords, 18 papers were selected, including 11 on the efficiency of MB, three on psychological issues and quality of life (QoL), one on the combination of exercise and brace, and three on the comparison between braces. The quality of the studies ranged from 6 to 18. Various studies have shown that MB controls the progression of the curve in scoliosis deformity and influences the natural history of scoliosis.

Discussion: The results of various studies confirmed that although MB controls the progression of scoliosis curve, it is not comparable with other available braces, which may be due to the mechanism of action. It is recommended that, due to the advantages of MB, a combination of transverse and traction forces be used to control and decrease scoliosis deformity.

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Highlights

- The MB helps control scoliosis progression.
- Although the MB controls the progression of the scoliosis curve, it is not comparable to other available braces.
- A combination of transverse and vertical forces should be used in designing the MB.

Plain Language Summary

Various conservative treatment approaches have been used to control the progression of scoliosis deformity, with the use of braces being an effective method. The Milwaukee brace (MB) has been utilized to control and correct scoliosis deformities. The results of this review indicate that the quality of most available studies on the MB is acceptable due to the large number of participants involved in these studies. The MB can control the progression of curves in scoliosis deformities. A combination of transverse and vertical forces is recommended for the design of MB.

Introduction

Scoliosis is defined as a three-dimensional deformity of the spine, characterized by the misalignment of the spine in the sagittal and coronal planes, associated with abnormal rotation of the spine [1]. It can be divided into two types: Structural and non-structural. The incidence of this deformity ranges from 2% to 13.6% in various countries [1, 2]. Although the primary cause of scoliosis is not well understood, several factors, such as genetics, growth, hormonal dysfunction, changes in bone mineral density, abnormalities in tissue, central nervous system abnormalities, and biomechanical factors, contribute to the incidence of this disease [3].

The treatment methods selected for scoliosis patients vary and depend on several factors, such as age, severity of the curvature, rate of progression, and location of the curve [3, 4]. Most clinicians attempt to decrease the incidence of curve progression using conservative approaches. One of the most commonly selected conservative approaches for individuals with scoliosis is the use of braces. Various types of braces have been designed for individuals with scoliosis, including the Milwaukee brace (MB), Boston brace, Cheneau braces (Rigo Cheneau, Cheneau light, Gensingen, Cheneau Toulouse Munster), Triac, C-brace, scoliosis Lycra, SpineCor, Charleston bending brace, long lever scoliosis brace, Providence, Sferzesco, Lapadula, Sibilla, Dynamic derotational brace, progressive action short brace, Spinealite soft brace, asymmetrical rigid torsion (ART) brace, Lyon, and Wilmington braces [5-10].

MB is the first modern brace designed for individuals with scoliosis. Blount and Schmidt developed the brace for postoperative treatment of post-polio scoliosis [11, 12]. The design of this brace is based on the concept that lumbar lordosis should be flattened to correct scoliosis deformity (scoliosis may be due to hypokyphosis). Scoliosis correction may be achieved through the enhancement of two active and passive mechanisms. Based on a passive mechanism, scoliosis correction can be achieved using pads or a brace's traction [13]. However, due to the pressure applied to the body through the pads, the participants attempted to move their bodies away from the pads by actively contracting their trunk musculature.

The primary objective of using an orthosis for individuals with scoliosis is to control curve progression and subsequently decrease the scoliotic curve [3, 4]. An early report on MB efficiency supported the potential of this brace to alter the natural history of adolescent idiopathic scoliosis (AIS) and prevent curve progression. However, following up with patients over a long period showed that although some corrections could be achieved at the end of bracing, the curve tended to continually increase toward the pretreatment angle [13].

Two designs are available for MB. In the first design of the brace, correction of the curve was achieved through the use of external transverse loads applied on the apex of the curve by the use of transverse pads and vertical traction through external pressure on the mandible and the iliac crest [12-15]. Due to the side effects of traction (including alternation in facial development and vertical growth in the anterior portion of the face) in the new design, correction is achieved through the use of only transverse loads [14, 16].

The amount of MB efficiency required to control the progression of the scoliosis curve and alter the natural history of scoliosis has not been well determined. Moreover, it is crucial

to determine which design of MB is more effective and has fewer side effects. The output of this review may be used to improve the design of braces for individuals with scoliosis. Therefore, this study aimed to determine the efficiency of MB in managing curve progression and curve control in patients with scoliosis based on the available literature.

Materials and Methods

This study was conducted using several databases, including Google Scholar, ISI Web of Science, PubMed, Ebsco, Embase, and Scopus, over a period between 1960 and 2024. Some keywords, such as Milwaukee orthosis and Milwaukee brace, were used in combination with scoliosis. The first selection of papers was based on the keywords above. The second selection of papers was based on their titles and abstracts, as well as whether the papers were published in English. The methodology of papers was evaluated to include the population, intervention, comparison, and outcomes. Moreover, the quality of the papers was evaluated using the Downs and Black tool. The validity and reliability of this tool were evaluated in various studies [17].

Results

Based on the keywords above, 35 studies were identified. After screening based on titles and abstracts, 21 papers were selected for the final analysis. The available studies were categorized based on the following criteria.

1) Papers on the efficiency of MB [10]; 2) Psychological and quality of life (QoL) of the subjects treated with MB [5]; 3) Comparison between the efficiency of Milwaukee and other orthoses [2]; 4) Combination of exercise and brace [1]. The quality of the studies varied from 6 to 18. Tables 1, 2, 3, 4 and 5 summarize the methods used in these studies and the results of the quality assessment.

Discussion

Various conservative treatment approaches have been used for patients with scoliosis deformity. The use of various orthotic designs has been recommended for this group of patients, with the MB being one of the most commonly used braces. This review aimed to collect and evaluate the evidence regarding the efficiency of MB on scoliosis. The available papers on MB can be further divided into those on

Table 1. The studies focused on the efficiency of MB on scoliotic curve correction, and progression control

Ref.	Subjects	Method	Results and Discussion
Mellencamp et al. 1977 [16]	Forty-seven subjects with scoliosis	All subjects used the MB. They were followed up for more than 5 years after MB use.	No correlation was observed between correction of scoliosis and age, initial curve size or curve pattern. 1/3 of the subjects had a correction of 5 or less. In contrast, in 2/3 of the subjects, the scoliotic curve increased by 1 or 2 °C per year. The flexible curves were better stabilized but lost correction.
Noonan et al. 1996 [20]	A total of 102 patients with IPS.	The scoliotic subjects were followed up for 6 years and 4 months after brace prescription.	The average progression of the curve was 4 °C. Curve progression was 5 °C after brace removal. A total of 42% of the participants underwent surgery. The patients in whom the curve did not progress or did not need surgery had an average correction of 20%. The results of this study confirmed that it is controversial whether use of brace influences the natural history of scoliosis or not.
Paul, 1968 [22]	A total of 135 scoliotic subjects, including 102 IPS, 14 juvenile scoliosis, 4 paralytic and 15 hypnotic.	MB was prescript for all subjects.	33% of the patients got correction better than 20 °C. 56% improved in brace or were stabilized. 11% had undergone surgery.
Cochran & Nachemson 1985 [31]	Ninety-five subjects with scoliosis	Subjects were followed for an average of 7.5 years. 90% of the subjects were followed regularly.	The successful treatment was considered to have achieved a curve with the same magnitude as the pre-brace condition. The use of a brace did not influence marriage, childbearing, sport activities, and job performance. They have the same level of back pain. The results showed that MB users were the same as the control group in terms of social and functional aspects.
Edmonsson & Morris 1977 [14]	Fifty-two patients with IPS included six high thoracic, 42 thoracic, three lumbar and one thoracolumbar	The subjects were regularly followed up. The average time was 22 months after the cessation of brace wearing.	The percentage of curve progression was 1% for high thoracic curves, 18% for thoracic curves, and 16% for lumbar curves. The correction achieved with the MB was not comparable that achieved with surgery. Occasionally, improvement in deformity and curve reduction is significant with the brace, but loss of improvement occurs to some degree after cessation of treatment. MB treatment is effective in skeletally immature subjects with small, flexible, and none-deformity curves. For those who focus on permanent correction surgery, it is recommended.

IPS: Idiopathic scoliosis.

Table 2. The studies focus on the efficiency of MB on scoliotic curve correction, and progression control

Ref.	Subjects	Method	Results and Discussion
Keiser & Shufflebarger 1976 [15]	A total of 123 patients with scoliotic were recruited for this study.	No information	MB can control the curves with mild-to-moderate severity. However its efficiency depends on dorsal location, age at the onset of treatment, flexibility of the curve, and cooperation from the subjects and their parents. The loss of correction after discontinuing the brace is negligible.
Carr et al. 1980 [12]	A total of 133 scoliotic subjects (127 girls and six boys) were included. Age=8.5-16.2 years. A total of 119 right thoracic curves, 39 high lumbar, 12 thoracolumbar, 22 high left thoracic.	All subjects were prescribed MB. A total of 74 subjects were followed up for 5 years.	The mean value of curve correction was 2 ˚C for the thoracic curve, 4 ˚C for the thoracolumbar and lumbar curves. Bracing was more effective for curves <40 ˚C. In contrast, 1/3 of the patients with a curve <40 ˚C require surgery. No correlation was observed between curve correction using brace and age, curve pattern, and iliac crest status. The best item to determine curve correction using MB is curve correction during the first year of treatment. If the curve is reduced to 50% of the initial curve, there is a good chance of achieving permanent correction.
Lonstein & Winter 1994 [13]	A total of 1020 scoliotic subjects were selected for this study. Age=13.5 years	All of the subjects were treated with MB. Treatment failure was determined if the progression of the curve was >5 ˚C.	Operative intervention was performed in 22% of patients, especially those with a curve >30 ˚C. Among them, 791 had curve corrections between 1 and 4. However, the progression of the curve depends on the pattern and magnitude of the curve, age of the patients, riser sign, and girl monarchal status. It is recommended to start treatment with a brace for participants with a curve of more than 25 ˚C and a riser sign of 0.
Wong & Evans 1998 [32]	Three subjects with scoliosis. Age=10-14 years, Risser sign=4 or less, and Cobb angle=25 to 40.	The force of the strap and pad was measured using an embedded transducer.	A significant correlation was observed between the tension of the strap and the pressure between the skin and the thoracic pad. Therefore, the position of the strap influences the pressure of the pad.
Babaee et al. 2020 [23]	Forty-two females with scoliosis. Age=4 to 10 years Cobb angle >20 degrees Follow up=2 years	The curve size was evaluated before and after follow-up.	Brace treatment failed in 36% of the subjects. It may be an effective strategy to control scoliotic curve progression. However, its efficiency depends on the curve magnitude, the type of curve, and the degree of brace correction.
Tolo & Gillespie 1978 [24]	Fifty-nine subjects had juvenile idiopathic scoliosis. Follow-up duration: 18 months.	The scoliotic subjects were divided into two groups. No treatment group (18 participants). Forty-one used MB. Rib vertebra angle difference (RVAD) was evaluated in this study.	Thirty subjects were managed with part-time brace wear. A total of 30% of the patients in the first group showed no progression of the curve. 13% correction of scoliotic curves occurred in group 2. The results showed that part-time bracing controlled many curvatures.

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the efficiency of the brace, those on comparisons with other braces, those on psychological aspects and QoL, review articles on MB, and those on the combination of MB with other therapeutic methods.

The first questions posted here are: Is MB effective in controlling curve progression and reducing curves, and which parameters influence the efficiency of MB? There were 11 studies on the efficiency of MB in scoliosis curves. The quality of most of the studies was acceptable based on the Down and Black tool. Regarding the efficiency of MB on scoliosis curves, some points should be acknowledged.

How can the efficiency of an orthosis be determined? The efficiency of MB is determined based on the progression of the curve or the number of patients who underwent surgery [12-14, 18, 19]. Moreover, treatment failure was determined if the progression of the curve exceeded 5 degrees. Edmonsson and Morris showed that braces are effective in skeletally immature patients with a small, flexible curve [14]. Moreover, Keiser and Shufflebarger confirmed that MB is effective in controlling and correcting mild to moderate idiopathic scoliosis [15]. The loss of correction after discontinuing the brace is negligible. In contrast, Lonstein and Winter showed that 22% of the subjects underwent operative intervention, especially for those with a curve greater than 30 ˚C [13]. Noonan et al. have shown that the use of MB is controver-

Table 3. The studies on comparison between MB and other braces and exercise

Ref.	Subjects	Method	Results and Discussion
Ganjavian et al. 2011 [33]	A total of 215 patients with IPS were included, comprising 182 females and 33 males. Age=13.2±1.8; severity of the curve=24-50 degrees. The wearing time was 23 hours per day, and the curves were as follows: Double major curve (51%), single main thoracic curve (19.5%), and single major thoracolumbar (14.4%).	The subjects were divided into groups using the MB and the Boston braces. The evaluation results were classified as follows: Successful, correction of more than 5 ˚C; failure, progression of the curve of more than 8 ˚C; and the same result, progression of approximately 5 ˚C.	The scoliosis curve decreased in 21.3% of the subjects did not change in 42.2% and increased in 36.5% of the subjects. Of the participants, 23.2% had undergone surgery. Those with a Boston brace achieved more correction of the lumbar and main thoracic curves.
Howard et al. 1998 [18]	A total of 170 scoliotic subjects, 45 used TLSO, 95 used Charleston bending orthosis, and 35 used MB.	The three groups were matched based on age, riser sign, severity of curve, and time of bracing and observation. Some parameters, such as the increase in curve, percentage of the curve increased beyond 6 °C, and 10 ˚C threshold, and the number of subjects undergoing surgery, were examined in this study.	Curve progression included TLSO=1.1%, Charleston=6.5 %, MB=6.3 %. Curve progression of more than 10 included TLSO=14%, Charleston=28%, MB=43%. Surgery was performed in: TLSO=18%, Charleston=31%, and MB=23%. TLSO brace controls the progression of the curve more than other braces.
Montgomery & Willner 1989 [19]	A total of 244 girls with scoliosis were selected from 2 378 patients. The subjects used Boston and MB.	The scoliotic subjects were followed for 2 years after brace removal. Indications for brace usage were children aged less than 16 years, riser sign below 4, and progression >5 ˚C. Failure of treatment was noted if the curve exceeded 45 ˚C.	The risk of progression above 45 ˚C was more than 300 times that of the risk between 25 ˚C and 35 ˚C. Curve pattern, skeletal age, monarchal status, and brace type did not influence curve progression. The failure rate of the MB was five times higher than that of the Boston brace. Maturity may correlate with the incidence of curve progression, but not with the failure rate.
Carman et al. 1985 [30]	A total of 24 scoliotic girls with primary right thoracic curve participated in this study.	Two groups participated in this study: Those who used MB with exercise, and those without exercise (just used MB).	Age at onset, initial curve degree, skeletal maturity, and total time in brace did not differ between the groups. No significant difference was observed between the curve improvements of the two groups. It was concluded that MB alone is an effective method to control curve progression.
Gratz & Papalia-Finlay 1984 [25]	A total of 16 scoliotic subjects and their parents participated in this study. The mean age was 16 years. They wore their braces for 12 hours.	The points of view of the scoliotic subjects and their parents were obtained on various aspects of scoliosis, including wearing the brace, its influence on school performance, their personal attitude, and experiences.	The majority of the participants experienced stress when a brace was recommended. However, they adjusted their lives and enjoyed an active and fulfilling lifestyle. The participants confirmed the positive aspects of brace-wearing, such as improved posture and a straighter back. The negative aspects were buying clothing, limited movement, and rudeness shown toward them by others.
Clayson et al. 1987 [26]	A total of 46 females with a history of scoliosis, aged 21-34.	The subjects included those treated with a brace (A) and those treated with surgery (B). Some parameters, such as self-esteem, capacity for intimacy, sexual satisfaction, and body image were selected in this study.	Both groups of scoliotic subjects had sexual satisfaction more than normal. Group B showed a higher level of sexual adjustment, self-esteem and body image than group A.
Matsunaga et al. 1997 [34]	Fifty female patients with IPS and fifty parents of matched normal subjects were recruited for this study.	The Maudsley personality inventory test was used to evaluate personality in terms of emotional response to stress achieved through the use of orthosis.	The shift from normal to abnormal was greater in the brace therapy group than in the control group. Bracing use places a high psychological stress on young adults.
Misterska et al. 2018 [27]	A total of 42 females with scoliosis deformity. Follow up: 23 years	The influence of the MB brace on the QoL was evaluated.	MB does not negatively affect everyday activities, pain level, child's behavior, and mental health. Psychological problems were more significant in patients with larger curve sizes.
Babaee et al. 2014 [28]	Sixty subjects with scoliosis with a curve between 20-45 degrees. Thirty used TLSO, and thirty used MB for at least six months.	QoL was evaluated in this study.	Both braces negatively affect QoL. No statistically significant difference was observed in QoL between MB and TLSO.

Ref.	Subjects	Method	Results and Discussion
Climent & Sánchez 1999 [29]	A total of 68 subjects with scoliosis were recruited for this study. Of these, 25 used the MB, 30 the Boston brace, 13 the TLSO, and 34 the Charleston bending brace.	QoL was evaluated in this study.	The QoL of the participants using MB was more than that of those using other braces. However the Risser sign, duration of brace treatment and degree of correction influenced QoL.
Gratz & Papalia-Finlay 1984 [25]	A total of 16 scoliotic subjects and their parents participated in this study. The mean age was 16 years. They wore their braces for 12 hours.	The points of view of the scoliotic subjects and their parents were obtained on various aspects of scoliosis, including wearing the brace, its influence on school performance, their personal attitude, and experiences.	The majority of the participants experienced stress when a brace was recommended. However, they adjusted their lives and enjoyed an active and fulfilling lifestyle. The participants confirmed the positive aspects of brace-wearing, such as improved posture and a straighter back. The negative aspects were buying clothing, limited movement, and rudeness shown toward them by others.
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TLSO: Thoraco-Lumbo-Sacral orthosis; IPS: Idiopathic scoliosis.

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sial regarding its influence on the natural history of scoliosis [20]. It should be emphasized that there are two designs for MB. In the first design, a combination of transverse load and vertical traction was used [11, 12]. However, due to its effect on the tempomandibular joint, only transverse loads were applied in the new design [21]. Therefore, the high efficiency of MB, as mentioned by some researchers, may be related to the first design approach [14, 16, 22]. However, a new MB design was used in other studies [20]. In a study conducted by Babaee et al., 75 individuals with scoliosis were followed for 2 years. A total of 36% of participants underwent surgery. MB was used to control the curve progression in the other subjects. The results of this study showed that MB is effective in controlling the progression of scoliotic curves. However, its efficiency depends on the curve magnitude, the type of the curve, and the degree of brace correction [23]. Tolo et al. also showed that part-time bracing (MB) can control scoliotic curve progression, depending on the severity of the curve [24]. Therefore, MB could control curve progression in scoliotic subjects depending on the type of design and may also influence the natural history of scoliosis.

Based on the available literature, the efficiency of MB on scoliosis curves depends on the location of the curve, the age of the subjects, the flexibility of the curve, and the cooperation of the subjects and their parents. Lonstein showed that progression of scoliotic curve depends on the pattern and magnitude of the curve, age of the patients, riser sign, and in girls' monocular status [13]. Babaee et al. also showed that MB is an effective strategy to control scoliotic curve progression; however, its efficiency depends on the curve magnitude, curve type, and degree of brace correction [23]. In contrast, Carr et al. showed no correlation between age, curve pattern, and iliac crest status [12]. Montgomery and Willner also ob-

Table 4. The Studies on the Effects of Milwaukee Brace (MB) on Psychological Health of the Subjects With Scoliosis

Ref.	Subjects	Method	Results and Discussion
Gratz & Papalia-Finlay 1984 [25]	A total of 16 scoliotic subjects and their parents participated in this study. The mean age was 16 years. They wore their braces for 12 hours.	The points of view of the scoliotic subjects and their parents were obtained on various aspects of scoliosis, including wearing the brace, its influence on school performance, their personal attitude, and experiences.	The majority of the participants experienced stress when a brace was recommended. However, they adjusted their lives and enjoyed an active and fulfilling lifestyle. The participants confirmed the positive aspects of brace-wearing, such as improved posture and a straighter back. The negative aspects were buying clothing, limited movement, and rudeness shown toward them by others.
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Babaee et al. 2014 [28]	Sixty subjects with scoliosis with a curve between 20-45 degrees. Thirty used TLSO, and thirty used MB for at least six months.	QoL was evaluated in this study.	Both braces negatively affect QoL. No statistically significant difference was observed in QoL between MB and TLSO.
Climent & Sánchez 1999 [29]	A total of 68 subjects with scoliosis were recruited for this study. Of these, 25 used the MB, 30 the Boston brace, 13 the TLSO, and 34 the Charleston bending brace.	QoL was evaluated in this study.	The QoL of the participants using MB was more than that of those using other braces. However the Risser sign, duration of brace treatment and degree of correction influenced QoL.

QOL, Quality of Life; TLSO, Thoraco-Lumbo-Sacral Orthosis.

tained the same finding, namely that there should be no correlation between correction and age, initial curve size, or curve pattern [19]. However, it should be noted that a more flexible curve can be better stabilized but loses correction [15]. Based on the studies mentioned above, the efficiency of MB may depend on factors such as, age, location, curve flexibility, and maturation status of the subjects. Therefore, MB could influence curve progression in scoliotic subjects. Although the efficiency of MB depends on the age of the subjects, the type of the curve, the riser sign, and the magnitude of the curve, the difference between the outputs of treatment with MB also depends on its design.

Based on the above-mentioned studies, MB could influence curve progression. The other crucial question is: What are the effects of MB on psychological health and QoL? The quality ratings of the six studies on this topic ranged from 9 to 16. In a study conducted by Gratz and Papalia-Finlay, 16 MB users and their parents were interviewed regarding their braces and various aspects of scoliosis, as well as the influence of the braces on school performance. They confirmed that although they were initially depressed with their brace, they could adjust their performance during daily activities [26]. In another study conducted by Clayson et al., the body image, self-esteem, and sexual satisfaction of two groups of scoliotic subjects treated with MB and surgery were compared with those of normal subjects [26]. The results showed that both groups of subjects had a higher level of sexual satisfaction than normal; however, those who underwent surgery showed a higher level of sexual adjustment and self-esteem [26]. Gratz also showed that although the participants had received a shock after wearing the brace, they confirmed that wearing the brace improved their posture and straightened their back [25]. The perception of trunk disfiguration, self-image, men-

Table 5. The results of quality assessment based on down and black tool of the studies selected in this research

Reference	Reporting	External Validity	Internal Validity (Bias)	Internal Validity (Confounding)	Total Score (26)
Mellencamp et al. 1977 [16]	2.1	0.3	3.7	1.6	6
Noonan et al. 1996 [20]	7.1	1.3	4.7	3.6	15
Paul, 1968 [22]	4.1	1.3	3.7	2.6	10
Cochran & Nachemson 1985 [31]	5.1	2.3	3.7	3.6	13
Edmonsson & Morris 1977 [14]	4.1	1.3	3.7	1.6	9
Keiser & Shufflebarger 1976 [15]	4.1	2.3	4.7	3.6	13
Carr et al. 1980 [12]	7.1	3.3	4.7	4.6	18
Lonstein & Winter 1994 [13]	10.7	3.3	4.7	4.6	18
Wong & Evans 1998 [32]	4.1	3.3	5.7	3.6	15
Ganjavian et al. 2011 [33]	6.1	1.3	2.7	1.6	10
Howard et al. 1998 [18]	6.1	2.3	5.7	4.6	17
Montgomery & Willner 1989 [19]	6.1	3.3	5.7	3.6	17
Carman et al. 1985 [30]	5.1	2.3	5.7	3.6	15
Gratz & Papalia-Finlay 1984 [25]	4.1	3.3	4.7	3.6	14
Clayson et al. 1987 [26]	6.1	2.3	5.7	3.6	16
Matsunaga et al. 1997 [34]	3.1	1.3	4.7	1.6	9
Misterska et al. 2018 [27]	5.1	1.3	5.7	4.6	15
Babaee et al. 2014 [28]	5.1	2.3	5.7	4.6	16
Climent & Sánchez 1999 [29]	6.1	2.3	5.7	4.6	17
Babaee et al. 2020 [23]	7.1	2.3	5.7	4.6	18
Tolo & Gillespie 1978 [24]	6.1	2.3	5.7	4.6	17

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tal health, pain level, and activities of daily living were evaluated in 42 women after 23 years of MB use. The results of this study showed that scoliosis treated conservatively did not have a negative influence on everyday activities, pain levels, the child's behavior and mental health [27]. In a study conducted by Babaee et al., a group of individuals treated with MB and Thoraco-Lumbo-sacral orthosis (TLSO) were followed for at least 6 months. They showed that although both braces negatively affect QoL, no significant difference was observed between the QoL of scoliotic individuals treated with MB and TLSO [28]. Clinment et al. studied the effects of MB, Boston brace, TLSO, and Charleston bending brace on the QoL of scoliotic patients. The results of this study showed that QoL score of the subjects was higher with MB. However, the Risser sign, duration of brace use, and degree of correction influence QoL [29].

Therefore, based on the aforementioned studies, MB does not have a significant effect on the psychological health of scoliotic subjects and their parents. Furthermore, it did not influence their daily activities or self-image.

The other question posted here is whether there is any difference between the treatment outputs achieved with MB compared to those with other braces. The quality ratings of the three studies on this topic ranged from 10 to 17. The quality of these studies was high due to the big large number of participants. In a study conducted by Howard on 170 scoliotic subjects, 45 used a TLSO, 95 used a Charleston bending orthosis, and 35 used an MB [18]. The treatment output was scored based on the progression of the curve and the number of participants who underwent surgery. The results confirmed that MB had a five-times greater risk of failure than the Boston

brace [18]. The risk of failure of brace treatment for a curve more than 45 ˚C was 300 times greater than that for an initial curve between 25 ˚C and 35 ˚C. Moreover, they confirmed that the vital parameter to predict the failure of the brace is the initial curve magnitude [18]. Carman et al. checked the combination of exercise and use of MB on the scoliosis curve. They confirmed that the use of MB is enough to decrease the progression of the scoliosis curve [30]. From the above-mentioned studies and due to quality of the studies, it can be concluded that Boston brace which is a total contact brace may be more effective for scoliotic subjects. However, it should be noted that it can only be used for curves below T8. The primary feature of the Boston brace design is its total contact structure, which applies a transverse force and traction along the curve. Another point that should be emphasized is that the new MB design was used for the participants in these studies.

However, there are some limitations to the available studies. The main limitation associated with the available studies was limited information regarding the type of MB used. Moreover, in most studies, the efficiency of the brace was determined after a follow-up period. No information was available regarding in-brace correction. Finally, the follow-up duration varied significantly among the studies.

Based on the above-mentioned studies, MB could decrease scoliosis curve progression. The efficiency of the MB depends on the type of curve, location of the curve, flexibility, age of the subjects, and riser sign. The effectiveness of other orthoses seems to be better than MB, possibly due to their designs, which allow for total contact and the simultaneous application of transverse and traction forces. It should be emphasized that the efficiency of MB differs between the new and old designs. Although the efficiency of the old design is better than the new design, it has some side effects. Therefore, it is recommended that, due to the adjustability of the MB and its wide usage for all scoliotic curves, a new type of this brace be developed to use both transverse and traction load configurations.

Conclusion

Available studies on MB were compiled using a systematic approach. The results of the quality assessment showed that most studies had a high degree of quality due to the large number of subjects, and long follow-up duration. The results of these studies showed that MB decreased the progression of scoliotic curve. The efficiency of the older design of the MB and other TLSO orthoses is greater than that of the new design of the MB. It is recommended that, due to the adjustability of MB and its advantages, a new type of MB be developed to incorporate both transverse and traction to straighten the scoliotic curve.

Ethical Considerations

Compliance with ethical guidelines

There were no ethical considerations to be considered in this research.

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Authors' contributions

Investigation: Majid Ansari; Quality assessment: Majid Ansari and Morteza Faghih Jouibari; Writing the original draft: Morteza Faghih Jouibari; Supervision, review and editing: Mohammad Taghi Karimi.

Conflict of interest

The authors declared no conflict of interest.

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