

# Evidence-Based of Nonoperative Treatment in Adolescent Idiopathic Scoliosis

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Until now because there are many published journals with a variety of opinions so I will stratify these articles by giving weighted value on grade evaluation which depend on each institution (written author and co-authors) and external evaluate status (SCI, SCIE, impact factor) rather than the outcomes provided by each article. Consequently, before evaluating publicized papers, study quality assessment of each interesting paper should be performed by mean of gauging the quality of evidence. Reviewing these articles, a grade of medical literature was divided into the following 5 levels as level I (randomized controlled study), level II (non-randomized controlled study), level III (case-control study), level IV (case series), and level V (expert opinions). However, in present article I concluded only involved medical literatures with weighted value of level I and II evidence.

**Keywords:** Scoliosis; Exercise; Orthotic devices; Braces

## Introduction

Regarding to an agreeable opinion provided by orthopedic surgeon society associated with classic medical team and scoliosis research society (SRS), treatment of adolescent idiopathic scoliosis (AIS) can be addressed in three ways as 1) observation with regular follow-up 2) brace orthotic and 3) surgery while other unmentionables are ineffective [1-3].

However, in reality as present practice there are other doctors rather than orthopaedists who get involved in this condition. These groups of doctors do not use only observation with regular follow-up or brace orthotic but also provide some specific methods for management such as heel pad, exercise therapy specified for AIS, chiropractics, manual therapy, electrical stimulation, acupuncture or even specific therapies as Pilates and Yoga [4]. Interest-

ingly, at present even ordination prayer and psychic therapy can also be found as one of therapies in some areas.

Due to there are several published papers from the field of oriental medicine, rehabilitation medicine, chiropractor and sport-related practitioners that demonstrated the effectiveness of conservative treatment including many supportive evidence provided by expert opinions rather than evidence-based literatures, so the systematic literature reviews have to play a role in assuring patients and guardians who do not have any specialized medical knowledge as well as orthopaedic surgeons who take major responsibilities in management of AIS leading to proper answers for several questions associated with. As such, we, orthopaedic surgeons specialized in AIS are in a necessary position to review published medical articles about conservative treatment besides operative management and expect to organize these information in a

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**Table 1.** List of articles analyzing nonoperative treatment in adolescent idiopathic scoliosis as level I or II evidence

Type of therapy	Study	Authors
Scoliosis specific exercise	Level II	Negrini et al. [5], 2003
	Level II	Negrini et al. [6], 2008
Yoga	None	-
Pilates	None	-
Brace	Level II	Danielsson et al. [7], 2007
	Level II	Nachemson et al. [8], 1995
	Level II	Wong et al. [9], 2008
	Level I	Weinstein et al. [10], 2013
Foot orthosis, wedge insoles	None	-
Electrical stimulation	Level II	Nachemson et al. [8], 1995
Acupuncture	None	-

proper way which is my purpose in this article.

Until now because there are many published journals with a variety of opinions so I will stratify these articles by giving weighted value on grade evaluation which depend on each institution (written author and co-authors) and external evaluate status (SCI, SCIE, impact factor) rather than the outcomes provided by each article. Consequently, before evaluating publicized papers, study quality assessment of each interesting paper should be performed by mean of gauging the quality of evidence. Reviewing these articles, a grade of medical literature was divided into the following 5 levels as level I (randomized controlled study), level II (non-randomized controlled study), level III (case-control study), level IV (case series), and level V (expert opinions). However, in present article I concluded only involved medical literatures with weighted value of level I and II evidence (Table 1) [5-10].

## Exercise, Manual and Physiotherapy

Despite there are varieties of treatments related to exercise and manual therapy in AIS, after analysis they can be classified in 2 categories as 1) exercise and manipulation therapy specified for the curve characteristic pattern in AIS (scoliosis specific exercise, SSE), and 2) general exercise therapy (Pilates, Yoga, physiotherapy, swimming, and etc.). There are many published papers with level I and II evidence existed regarding to SSE or the other name called Dubowitz which is belonged to a developer due to SSE or SEAS (scientific exercises approach to scoliosis, version 2002) is the method advocated by reha-

bilitation doctors and chiropractors [5,6,11-13]. On the contrary, the published papers associated with general exercise therapy (Pilates, Yoga, etc.) are far less studied and reported, so I will take more attention in this article.

### 1. Scoliosis specific exercise

Although there was no definite description about exercise therapy in the past, in year 2002 specified exercise treatment program named SSE or SEAS (scientific exercises approach to scoliosis, version 2002) [14] was introduced by Italian Scientific Spine Institute (ISICO). They claimed that this specific exercise yielded to reduce scoliotic angle significantly especially in the two well-controlled group studies when using combined with undefined physiotherapy. However, despite these interesting and attractive findings are based on scientific article grading as Oxford evidence-based level II, there are considerable issues concerned by orthopaedic surgeon's point of view. First, it is unclear to determine whether this restoration was an effect of the exercise itself or was improved with adjunctive bracing because most of patients were rarely prescribed only exercise therapy without bracing and furthermore multi-modality approach was also involved in most of the cases [1]. Second, according to the fact that Cobb's angle was reduced only by 1 degree which is generally too small for 3 to 5 degrees of error measurement accepted by orthopaedic surgeons. And third, considerable doubt can be spread over these articles about grading as level II because there was a flaw as the researcher and the evaluator was the same person.

Furthermore, despite the systematic review literatures

have been demonstrated strong evidence as level II [5,6], it is debated that whether this is enough rational or not on account of the same reason stated previously and the article was written by one author named S. Negrini as such it can cause question of reproducibility for academic contents. In spite of these drawbacks, the Cochrane review journal still accepted two prospective randomized controlled articles and stated their results for specific exercise therapy of AIS as a treatment method with a very low quality of evidence [15,16]. Therefore, orthopaedic surgeon should be an optimism to search more accurate and objective researches for this kind of treatment rather than reject that this therapy is ineffective. Likewise, I have a great expectation for Weinstein research team who are making a progress now. Noticeably, when both exercise and bracing therapy are prescribed to the patient with small curve, no harm in medical aspects existed but patient's discomfort and cost which are the fact needed to be considered by orthopaedic surgeons who emphasize only traditional ways.

While SSE has been conceived and developed mostly in Europe as well as chiropractic and manipulation therapy have been propagated and used widespread in USA. This term of manipulation therapy has not been, however, arranged in English yet so it has no clearly definition.

The online Pubmed search engine was used by searching terms as followings: manipulation; mobilization; manual therapy; massage; osteopathy and therapeutic manipulation. The results returned from MEDLINE database query demonstrated that only 3 articles were met criteria among total of 73 relevant articles including the review by Romano and Negrini [17]. In addition, there is one paper required further study due to a small sample size [17] and the other reported that manipulation therapy was ineffective [18]. Lastly the other article written by Morningstar et al. [19] in year 2004 revealed an interesting outcome that manipulation therapy can reduce 17 degrees in Cobb's angle when prescribed for 4 to 6 weeks [15]. Unfortunately, one flaw rendered this article dubiously due to the corrected Cobb's angle was measured immediately after finishing the therapy.

Interestingly, there is a remarkable case report about 65-year-old woman obtained 27 degree correction of Cobb's angle in 4 weeks. And also one article written by Hales et al. [20] used similar methods, but provided different results [21]. They reported their outcome in spine orthopedic surgery journal that the curve of their pa-

tients can be reduced by the device called LTX3000 [22]. Although the curve returned to the original state after one month, they claimed in a rehabilitation journal that the efficacious of this device was excellent.

In conclusion, nowadays quality assessment of many published papers in a proper way is necessary needed to qualify the existed evidence which made orthopaedic surgeons specialized in scoliosis accept these treatment methods.

## 2. General exercise therapy, Yoga, Pilates

Yoga is one of the ways about religious and spiritual asceticism associated with Hinduism. As in Sanskrit, Yoga can mean as control, union, means (instruments), or means (methods). In Hinduism, Yoga is defined as seeking thoroughness for practical life philosophy. Historically, as appearance in the second verse of major scripture, Yoga Sutra, in Yoga school where is the one of six orthodox philosophical schools in Hinduism, it was defined Yoga as the extinction (Nirodha) of the action of the heart (Citta-Vritti). As such Yoga is a part of belief and asceticism among various religions arisen in India. Outside India, Yoga is commonly known as Asana (a posture) of Hatha Yoga or basically a form of exercise. Recently, Yoga fad hit in USA as along with the opinion stated that Yoga is effective in AIS. Consequently, Yoga has become a popular treatment method in private clinic including health care providers other than orthopaedic surgeons. Unfortunately, it is lack of official reported papers. Yoga was, however, presented twice as it was an effective treatment for nonoperative treatment of scoliosis in medical conference [23,24]. In 2012, Cochrane reviews stated that they cannot evaluate Yoga because there is no randomized control or controlled prospective study or as equivalent for it [15,16]. I also assumed that Yoga does not have efficacy, but it is difficult to evaluate correctly without data.

Pilates was created by a German, Joseph H. Pilates, who worked in the hospital for internment camp located in Lancaster Castle in UK during World War I during early 20th century. Pilates, which propagated to mainly New York, is a muscle strengthening exercise using simple tools such as a bed or a mattress for relaxing exercise, rehabilitation and mental training of prisoners. While Yoga is focused on a variety of stretching, breathing and meditation, Pilates is the method that combine with the

theories of Yoga included weight training, sports and ballet. Furthermore, Yoga is usually consisted of a mattress exercise, while Pilates is used a variety of equipment, mattresses and props. Basically Yoga is the way of training to stretch their body and stop it for a while. In contrary, Pilates is the way to work out the same movement repeatedly matching for anatomical exercise. Although both Yoga and Pilates considered breathing is important, there is a difference in fundamental. Whereas Yoga traditionally adopts the way of breathing based on experience of practitioners, Pilates performs based on the scientific breathing technique associated with modern anatomy, sports science created by Joseph H. Pilates. In addition, Pilates uses many kinds of equipment such as a mattress, a Trapeze table, a Cadillac, a reformer, a ladder barrel, a chair and a steo barrel. Of those are invented by Joseph H. Pilates and developed by his disciples later.

Many people, especially medical assistants or non-surgical physicians, insist that Pilates is very effective for idiopathic scoliosis. There are, however, very limited academic reports about Pilates as same as Yoga. The academic paper that I could find was written by Alves de Araujo et al. [25] in 2012. They revealed that Cobb's angle and pain were improved from the result by follow up on 31 women; 20 patients were provided Pilates therapy and 11 patients were control group. As mentioned previously, Cochrane reviews stated that they cannot evaluate Yoga because there is no randomized control study or controlled prospective study or as equivalent [15,16].

## Brace

Bracing for AIS has been commonly prescribed since Blount et al. [26] let the patient wear Milwaukee brace after scoliosis surgery in 1945 [22]. From 1960 to the early 1970, Milwaukee brace was adopted for the purpose of nonoperative treatment. The principle of Milwaukee brace is as followings: 1) active stimulation of trunk muscles induced automatically by a longitudinal distraction to escape the pressure applied to the neck by a neck ring, 2) a passive longitudinal distraction induced by the pad at head and neck when the patient faces forward, 3) a decrease in lumbar lordosis by a pelvic girdle known as improving curvature of lumbar and thoracic region, 4) a passive transverse corrective force by using 3-point pressure principle.

Since Milwaukee brace has been conducted, several

types of this brace were produced and tried out, but unfortunately patients usually gave up using as difficulty to wear. Subsequently, Boston brace was a representative brace to overcome compliant problem. Boston brace is a typical thoraco-lumbosacral brace (TLSO) established by Hall and Miller in 1971 [27]. Initially, it was made as a part of pelvic girdle in a process of making Milwaukee brace, but later they realized that the upper part as a neck part of Milwaukee brace was not necessary for lumbar curve or thoraco-lumbar curve and can be used alone. The principle of Boston brace is as followings: 1) lumbar flexion or hyperlordosis, 2) a pad by using 3-point pressure principle, 3) passive corrective force by adhering to a body of a brace, 4) active muscle controlled by effort to reduce the pressure by moving body in the opposite direction of the pressure.

The principle of most braces which were developed after Boston brace is using the force to resist the opposite direction force of the curvature. In Korea, the same type of Boston brace using distraction force was produced and revealed that it was effective. About 200 articles are published in the world and 90% of those were proved that these braces are efficacious [28].

Even though there are several articles to support the beneficial effect, there are a few of approved evidence-based articles with level I or level II study. In 2010, Cochrane reviews [7,29] accepted only three papers among hundreds of articles as a randomized control study or controlled prospective study and suggested specialized bracing in accordance with vertebra curvature angle, location and curve size (severity of the curve) as one of treatment methods with a very low quality of evidence. Of these three accepted articles, two articles were written by Nachemson and Peterson [8]. The first article was published initially in 1995 and then after 16 years of follow-up the second article was released in 2007.

According to the article reported by Danielsson et al. [7] in 2007, the study was conducted by enrolling patients with AIS from two different places. Their age and degree of vertebra curvature angle were similar. 41 patients were treated with underarm braces (Boston braces), while 65 patients were assigned to observation only. The patients in bracing group showed primary outcome to decrease 6 degrees at 16 years of follow-up. Although the curve size returned to the same original level after removing a brace, nobody underwent surgery. However, of 65 patients in observation group as the intention to treat, 20% of these

were braced during adolescence due to progression and another 10% underwent surgery. In conclusion, at the 16 years of follow-up the only observation group increased by 6 degrees and revealed that the brace treatment was effective. Also, by the same authors [8], he carried out the study in 1995 including 286 patients with AIS who have 25 to 35 degrees vertebra curvature angle. 129 of them were observed only, 111 of them were applied underarm plastic braces and 46 of them were used nighttime electric stimulation. At four years, it was success in 74% of the brace group, 34% of the observation group and 33% of the electric stimulation group. From these results, the authors determined the observation and electric stimulation treatments were ineffective. Another well-designed and systematic paper which is acknowledged in Cochrane reviews was published by Wong et al. [9] in 2008. This paper compared the effectiveness between a rigid and a soft elastic brace. In this comparison, 45 months of follow-up was conducted in 22 patients with soft braces named SpineCor and 21 patients with rigid orthosis. As a result, it was demonstrated that 95% of the patients with soft brace and 68% of the patients with rigid brace deteriorated their curve progression and as consequently, the authors revealed that an optimal brace in patients with AIS should be rigid.

According to the studies of brace in AIS, Cochrane reviews demonstrated that the randomized control study is absent and there are only controlled prospective studies or as equivalent until 2010 [26,27]. Thus, they concluded that although three papers mentioned previously were accepted, the treatment effectiveness of brace is still weak for AIS. However in order to verify the effectiveness of brace treatment by reducing uncertainty, Weinstein, who is reputable for treatment of scoliosis through his life, studied about the effectiveness of a TLSO by separating 242 patients to randomized control cohort and preference control cohort [10]. In this study, the primary outcomes as regarded as failure were curve progression to 50 degrees or more. As a result, it demonstrated that 72% of both cohorts with brace treatment were success and they did not need surgical treatment. In the observation cohort, 48% of them had less than 50 degrees of curve size and they did not need surgical treatment. However, the randomized control was stopped in middle of the study because the effectiveness of the brace was very significant ( $p < 0.001$ ). This is an example of well-designed study which showed the beneficial effectiveness of brace. And

of note, this study was published on The New England Journal of Medicine which has the impact factor higher than 40 in 2013.

In conclusion, considering all the issues above, there might be no doubt that we can conclude brace is an alternative effective treatment for AIS.

### Foot Orthosis, Wedge Insoles

Foot orthosis is the one of treatment methods based on a theory that incongruity of pelvis, especially sacroiliac joints, can induce deformation of lower extremities that causes scoliosis. This method was studied in orthopedics domain in the 1990's, but finally it was abandoned because of the ineffectiveness [30].

In 2002, D'Amico et al. [31,32] made a study for investigating the effectiveness and claimed that this method is effective. However, due to only two papers existed; it was difficult to support their evidence. Furthermore since I could not find the original paper that they provided treatment especially associated with scoliosis and could not qualify in detail for the concrete methodology of medical articles [32], it is arduous to evaluate accurately. Or even if I could find case series on websites of some hospitals, it was impossible to objectively verify the actual effectiveness because those were just a few of cases.

### Electric Stimulation

Electric stimulation was used in orthopedics around 1980 but there are many papers which claimed it was ineffective [33]. For this reason, it seems to be used limitedly only in chiropractic and rehabilitation domain. However, there is a report that this method was effective when combined with other exercises and braces. Since paper of Nachemson and Peterson [8] has been evaluated as well designed comparatively among Cochrane reviews, it was reported that there was no significant difference with general observation. It is also known that this kind of treatment is no academic sense. Finally, in 2010, Cochrane reviews concluded that it is impossible to judge studies of electric stimulation because of lack of randomized control study [29]. Although the concept of correcting scoliosis by stimulating to muscles seems to be almost disappeared, this treatment method for scoliosis to carry out vertebral growth modulation for promoting one side of concave growth and disturbing another side growth by



using the electric stimuli are being tested on animals [34].

## Acupuncture

Acupuncture is the technique of healing diseases and curing vital energy by giving stimulus to a certain part of the body by sharp and sensitive needles (or similar tools). The letter chim (鍼) of chimsul (acupuncture) is originated from pyeom-seok (砭石) to jam-seok (箴石) and jam-seok to chim (鍼). This acupuncture has been often used for back pain, and it is also used a lot for treatment of scoliosis in Chinese medicine clinics or elsewhere nowadays.

If we search on Pubmed using the search words 'acupuncture and scoliosis' to look for general medical information, two papers are found. One of those is an Italian paper published in 1980 [35] and so it is impossible to make an understand entire of the paper. However, according to the abstract, they used acupuncture for scoliosis. Although the skin temperature was changed, it is doubtful that how it related to actual treatment of scoliosis. The second paper was published by Weiss et al. [36] in 2008. This is an only practical medical paper. There were 21 patients (mean ages, 15.1 years) with scoliosis and 33 degrees of vertebra curvature angle. The technique of acupuncture therapy was addressed by snake venom. After this therapy, vertebra curvature angle was not deteriorated and maintained of 35 degrees in comparison with control group. However, this paper is difficult to be considered as an article graded in Oxford level I or II. Therefore, it can be regarded that the effectiveness of acupuncture has not proven yet on actual treatment of scoliosis.

## Conclusions

Besides the most common scoliosis treatment, such as observation with regular follow-up, bracing and surgery, being used in orthopedics nowadays, the various treatment methods of scoliosis as described above are alternative options for patients with AIS. Of these methods, many papers about bracing, SSE and chiropractic are published and on the way of debating their evidence-based individually.

However, according to validation results of the treatises so far, the nonoperative treatment for idiopathic scoliosis, only bracing is determined as quite an effective treatment

while SSE has a very low level of treatment effects based on scientific evidence and there is lack of paper about other treatment methods. Even if there is any paper, it tends to be deficient of academic quality and can be classified just an optional treatment (Table 1). As the nonoperative treatment methods have been increasing day by day, it is responsibility of doctors who are specialized in scoliosis should acquire and verify the basic knowledge about the effects of nonoperative treatment methods for scoliosis and should provide proper information for patients and their guardians.

## Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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