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PREVENTION AND REHABILITATION: REVIEW ARTICLE

Manual therapy treatment for adolescent idiopathic scoliosis

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ABSTRACT

Background: Adolescent idiopathic scoliosis (AIS) is a common orthopedic condition with a prevalence of 2%–3% in children aged 10–16 years. Conservative interventions remain controversial and are usually based on physical therapy exercises and treatments. Manual therapy techniques may also serve as adequate treatments for AIS due to their ability to improve range of motion and decrease muscle tone and pain.

Objective: To critically assess the current literature on the effectiveness of manual therapy methods used to treat AIS.

Methods: PubMed, PEDro, BioMed Central, and Google Scholar databases were searched from inception until December 2016 using keywords associated with scoliosis and manual therapy. Criteria for inclusion were studies investigating the effect of manual therapy methods on AIS treatment. We analyzed all published material with an emphasis on randomized controlled trials (RCT). Trials of any methodological quality written in English were included in the review.

Major findings: Fourteen papers were reviewed, all presenting manual therapy treatments such as manipulation, mobilization, and soft tissue techniques used to treat AIS. All case studies showed a significant improvement, post-treatment, in most measured parameters. Observational studies showed mixed results. Only one RCT concluded manual therapy techniques were ineffective in improving trunk morphology and spine flexibility in AIS patients.

Conclusion: Case reports and small-scale clinical trials of poor methodological quality presented in this review did not allow us to draw a clear conclusion about the effectiveness of manual therapy in the treatment of AIS. On the other hand, they provide us a basis to assume that manual therapy techniques such as myofascial release and spinal manipulative techniques may potentially be effective in treating AIS in conjunction with other conservative treatments. Further high-quality studies are essential to determine the effectiveness of the different manual therapy techniques.

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1. Introduction

Scoliosis is defined as a deviation from the normal vertical line of the spine consisting of a lateral curvature and rotation of the vertebra (Janicki and Alman, 2007; Rowe et al., 2006). There are several types of scoliosis, each with its own specific characteristics. Adolescent idiopathic scoliosis (AIS) comprises approximately 80% of diagnosed scoliosis cases. Other known types of scoliosis are congenital (10%) and neuromuscular (5%–7%) (Thomson and

Lehnert-Schroth, 1992). The majority of scoliosis cases, classified as AIS, affect ~2–3% of adolescent females (Rowe et al., 2006), and appears in 89% of patients >10 years old. Infantile idiopathic scoliosis affects only 0.5% of patients <3 years old and juvenile scoliosis affects 10.5% of patients between the ages of 4–10 (Riseborough and Wynne-Davies, 1973).

Asher & Burton considered AIS as a complex genetic trait disorder (Asher and Burton, 2006). Clinical observation and results of genetic studies support the genetic etiology of AIS (Machida, 1999). There is often a positive family history, but the pattern of inherited susceptibility is unclear (Hadley Miller, 2000). Most patients with AIS have a less functional limitation or pain in adulthood (Chen and Chiu, 2008). Wunk et al. (Wnuk et al., 2015) found limited rib mobility on the concave side of scoliosis leading to restrictive disturbances of pulmonary ventilation. The prognosis of scoliosis itself

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depends upon various factors, in particular, the age of onset of AIS and curvature angle magnitude (Lehnert-Schroth, 1992).

The basic physical evaluation includes a visual assessment of patient while bending forward (Janicki and Alman, 2007). In this position, the slightest dorsal asymmetry becomes evident. The greater the rib prominence, the greater the torsion of corresponding vertebrae as ribs and musculature move with the rotation and develop dorsal elevations (humping of ribs, lumbar hump, 'elevated shoulder') or depressions (concavities of the back). X-ray assessment of the spinal curvature to determine the extent of the curve and to eliminate other possible causes (e.g. tumors) is generally carried out on the first visit. The most accepted way of scoliosis evaluation is Cobb angle measurement performed on frontal plane x-ray.

Treatment options for AIS usually include observation, bracing and surgery. The general goal is to prevent the progression of scoliosis and keep the Cobb angle (Cobb, 1948) curves $<50^\circ$. In general, observation is recommended for patients with curves less than 25° . Orthotic management such as bracing is recommended for patients with progressive curves between 25° and 50° . Bracing, however, does not improve or correct the curve but attempts to prevent it from worsening. Surgical correction of AIS is considered when curves are $>45^\circ$ in immature patients and when curves are $>50^\circ$ in mature patients. The goals of surgical treatment are to prevent progression and improve spinal alignment (Dickson et al., 1995; Nachemson and Peterson, 1995).

Most of the conservative physical therapy treatments for AIS are based on exercises such as the Schroth, Dobosiewicz and side-shift methods (Kalichman et al., 2016). Manual therapy is a less common treatment. However, the ability of manual therapy to improve range of motion (ROM) and decrease muscle tone and pain may be useful in treating AIS. According to the International Federation of Orthopaedic Manipulative Physical Therapists (IFOMPT) (Physiopedia contributors), the definition of manual therapy is "Skilled hand movements intended to produce any or all of the following effects: improve tissue extensibility; increase range of motion of the joint complex; mobilize or manipulate soft tissues and joints; induce relaxation; change muscle function; modulate pain; and reduce soft tissue swelling, inflammation or movement restriction".

The aim of this review was to assess the current literature for the effectiveness of manual therapy methods, such as spinal mobilization and manipulation and soft tissue techniques (i.e. massage, etc.) in the treatment of AIS.

2. Methods

This study was a critical narrative review. PubMed, PEDro, BioMed Central and Google Scholar databases were searched from inception until December 2016 using predefined search strategies. The databases were searched for the following keywords: "massage", "manual therapy", "scoliosis", "idiopathic scoliosis", "adolescent idiopathic scoliosis", "conservative treatment" "soft tissue mobilization", "myofascial release", "spinal manipulation", "mobilization treatment", "chiropractic techniques". The search results were pooled and duplicates removed. The titles and abstracts of all articles were reviewed. The reference lists of all articles retrieved in full were also searched.

Criteria for inclusion in the review were studies investigating the effect of manual therapy methods in AIS treatment. Excluded were articles reporting on spinal surgery, exercises or pharmacological interventions for scoliosis. Study protocol articles and articles without available full text were also excluded.

We analyzed all published material with an emphasis on randomized controlled trials (RCTs). Trials of any methodological

quality written in English were included in the review.

3. Results

3.1. Single case studies

Numerous case studies described the effect of manual therapy on AIS. LeBauer et al. (2008) presented an 18-year-old female who had undergone six weeks of myofascial release treatment consisting of two sessions each week for 60 min. The effect of treatment on pain (using the visual analog scale (VAS)), pulmonary function and quality of life were measured. In addition, six goniometric measurements of lumbar/thoracic flexion, extension, and rotation were taken showing an improvement in most measures especially in pain and thoracic and lumbar rotation. Before treatment, the VAS level was 4.8 and after, the level decreased to 1.8. The ROM of thoracic rotation pre-treatment was 45° and post-treatment 60° . No direct measurements of scoliosis angles were performed.

In another case study, Chen et al. (Chen and Chiu, 2008) presented a 15-year-old girl diagnosed with right thoracic scoliosis with a Cobb angle (Cobb, 1948) of 46° . The patient began a treatment course of two visits per week for six weeks, followed by once-weekly visits for six weeks. Each visit began with a brief session of deep tissue massage, followed by anterior thoracic manipulation and lumbopelvic adjustments delivered bilaterally. After three months of treatment, a post-intervention radiograph revealed a 34° right thoracic scoliosis. After 18 months of treatment and an additional radiograph, the angle was reduced to 30° . In total, the Cobb angle decreased by 16° (from 46° to 30°) as a result of spinal manipulation therapy (Chen and Chiu, 2008).

In a case study by Morningstar (Morningstar et al., 2004a), a 23-year-old female diagnosed with left thoracic-right lumbar scoliosis underwent intervention treatment for 12 weeks followed by 10 months of home care rehabilitation. A specific treatment routine was followed at each visit and included spinal warm-up therapy, a brief session of deep tissue massage and manipulative intervention according to Pettibon's technique (Pettibon, 2011–2015). Immediately following the manipulative intervention, a spinal rehabilitative method was performed wearing a Pettibon head weight on the front of her head for 10 min. The patient ended each of these visits with supine positional traction for seven minutes. After 12 weeks of treatment, the patient was reevaluated by spinal radiography. Before treatment, standing radiography showed a 37° left thoracic and 26° right lumbar scolioses. After treatment, left thoracic scoliosis shown on supine x-ray was 21° ; right lumbar scoliosis was 15° . It is possible that changes in the scoliosis angle can be explained, at least partially, due to photographing from different positions. The patient then continued a 10-month home care treatment and subsequently, the Cobb angles continued to decrease.

Aspegren and Cox (1987) presented is a case report of chiropractic manipulative therapy and transcutaneous neuromuscular stimulation utilized in the treatment of progressive AIS. The curvature was shown to be progressing at the rate of 1° /month for the 9 previous months. The patient's curvature was successfully stopped at 27° and reversed to 17° in the first 3 months of care.

Tarola (1994) reported two cases of AIS treated by chiropractic manipulative therapy. Both had scoliosis that had progressed after skeletal maturity. Diversified type chiropractic manipulative therapy was used only for back pain relief in one case, and routinely 1–2 times per month in the other case. Vertebral levels manipulated were identified as fixated/dysfunctional segments based on static and/or motion palpation. No attempt was made to "straighten the curve" by thrusting into the convex side. Trusting vertebral manipulations, gentle intersegmental mobilization, stretching, and

muscle massage techniques were applied. The case treated only for pain had curve progression consistent with the literature over an 8-yr period. The case treated routinely did not. The procedure was effective in both cases for the subjective relief of back pain.

A case report by [Khauv and Dickholtz \(2010\)](#) described the treatment of a 15-year-old with a 44° AIS that decreased to 32° after 5 months of upper cervical manipulation. The patient was managed for more than 4 years, but a long-term effect was not reported.

[Jaszewski and Sorbara \(2010\)](#) reported on the treatment of a 7-year-old patient with juvenile idiopathic scoliosis. Pierce technique manipulations were performed during 1 month of treatment (4 visits). Scoliosis curve, measured on the radiograph, decreased from 13° to 5°.

[Chung and Salminen \(2011\)](#) reported on a case of a 10-year-old girl with a 35° thoracolumbar AIS. She was treated with chiropractic manipulations for 25 weeks. Follow-up radiograph showed a reduction in Cobb angle of 10°.

3.2. Case series and pre-post design studies

[Byun and Han \(2016\)](#) performed a case series study examining whether chiropractic techniques would reduce the curvature of patients with AIS. The subjects were five healthy elementary school students with a Cobb angle > 10°. Chiropractic spinal manipulations were performed at the spinal levels “that does not maintain correct alignment”, followed by a brief soft tissue massage. Duration of treatment was 30 min per session, three times a week for eight weeks. The average Cobb angle before the intervention was 11.2°. After four weeks of treatment, the Cobb angle decreased to an average of $2.4 \pm 3.4^\circ$. After 8 weeks of intervention, an additional decrease occurred demonstrating an average Cobb angle of $1.0 \pm 2.2^\circ$.

In a retrospective case series by Morningstar and colleagues ([Morningstar et al., 2004b](#)), 19 patients (aged 15–64) received a combination of chiropractic manipulations, spinal traction, and corrective exercises. After 4–6 weeks of treatment, the average Cobb angle decreased by 17° (range 8–33). None of the patients' Cobb angles increased.

Lantz and Chen ([Lantz and Chen \(2001\)](#) in cohort time-series trial of 42 subjects with AIS (age between 6 and 12 found that chiropractic manipulations and heel lifts were not effective in reducing the severity of scoliotic curves.

A pilot pre-post designed clinical study by [Wnuk et al. \(2015\)](#) evaluated the effectiveness of passive and active derotation techniques of manual therapy according to Kaltenborn-Evlenhth ([Kaltenborn, 1993](#)) relating to the angle reduction of trunk rotation in patients with AIS. This prospective double-blind clinical study enrolled 33 female patients diagnosed with AIS and treated with DoboMed physiotherapy in combination with the Cheneau brace. The patients were divided into two groups according to the curves location. Group A consisted of 17 women (14 ± 2.4 years) with single curve scoliosis in the thoracolumbar segment; group B consisted of 16 women (15 ± 2.24 years) with double curve scoliosis in the thoracic and lumbar segments. Three treatment sessions with a 24 h interval between sessions were performed. On the first and second day of treatment, passive and active derotation techniques were used. On the third day, a lateral bending of the spine technique was performed, which stretches the shortened muscles on the concave side of the curve and rotates in the opposite direction of the patient's curve. The results of the study showed a statistically significant decrease in the trunk rotation angle at the level of the derotated curve. In group A, the value of the trunk angle inclination decreased on average by $2.2^\circ \pm 1.61^\circ$. After a session of active derotation in the group with lumbar scoliosis, the trunk rotation angle decreased on average by $4.5^\circ \pm 1.14^\circ$. However, the

treatment effect did not last long. After 24 h, the study parameters regained their baseline as before the therapy. The authors concluded that derotational mobilizations have a positive impact on the correction of rotational parameters. These techniques should be used as a groundwork preparation for exercises crucial in treating AIS and not as a standalone treatment ([Wnuk et al., 2015](#)).

3.3. Randomized controlled trials

[Rowe et al. \(2006\)](#) presented a pilot small-scale RCT exploring the effectiveness of chiropractic manipulation patients with AIS. Six patients, aged 10–16, diagnosed with AIS and suffering from a spinal curvature between 20° and 40° were tested. In this six-month study, three patients were treated with standard medical care (observation or brace treatment), two with standard medical care plus chiropractic manipulation ([McKenney et al., 2013](#)), and one was treated with standard medical care plus sham manipulation. Results of this study showed that patients who were treated with chiropractic techniques succeeded in decreasing the Cobb angle by 6–10°. In comparison, in the standard medical group plus sham manipulation, there was no improvement of the Cobb angle. The patients treated with chiropractic techniques also reported an improvement in self-esteem, back pain, physical activity, and mood.

[Hasler et al. \(2010\)](#) tested the effect of the osteopathic manual intervention on trunk morphology and spine flexibility in a pilot RCT of 20 post-pubertal young women (Cobb angle 20°–40°) randomly allocated to observation or osteopathic treatment. The treatment group received three sessions of osteopathic manual intervention over five weeks. No intervention was performed on the observation group. The intervention protocol included osteopathic testing and osteopathic visceral and parietal manipulations. Parietal interventions act directly on the locomotor system (muscles, joints, ligaments, tendons). Visceral osteopathic treatments are presumed to work on the inner organs via the connective tissues which interact with the locomotor system. The authors reported no significant differences between groups in trunk morphology ($p = .44$) and spinal flexibility ($p = .43$). No evidence was found to support osteopathic manual intervention as a treatment for mild AIS.

4. Discussion

This critical narrative review evaluated the efficiency of manual therapy treatment in patients with AIS. The manual therapy techniques used were the Kaltenborn derotational mobilization techniques ([Wnuk et al., 2015](#)), spinal manipulation ([Aspegren and Cox, 1987](#); [Chen and Chiu, 2008](#); [Chung and Salminen, 2011](#); [Jaszewski and Sorbara, 2010](#); [Khauv and Dickholtz, 2010](#); [Morningstar et al., 2004a, 2004b](#); [Rowe et al., 2006](#); [Tarola, 1994](#)), osteopathic treatment ([Hasler et al., 2010](#)), and myofascial release ([LeBauer et al., 2008](#)). Six of the studies ([Byun and Han, 2016](#); [Chen and Chiu, 2008](#); [LeBauer et al., 2008](#); [Morningstar et al., 2004b](#); [Rowe et al., 2006](#); [Wnuk et al., 2015](#)) using various manual therapy techniques, showed a significant improvement in most measured parameters, post-treatment. According to the reviewed data, manual therapy such as myofascial release and spinal manipulations may reduce the Cobb angle, prevent the progress of a scoliotic curve, improve thorax and spine ROM and relieve back pain. However, all aforementioned studies were of low scientific quality, i.e. case reports, case series or pilot clinical trials with a small number of subjects and no control intervention. The only reviewed RCT ([Hasler et al., 2010](#)), also not of high quality, found that use of osteopathic treatment was ineffective in improving trunk morphology and spine flexibility in AIS patients.

It is commonly accepted that the most appropriate AIS treatment for each patient should be individually chosen and based on parameters such as the Cobb angle, age at diagnosis, the potential for spinal growth (by clinical and radiological markers of growth and maturity), motivation and patient compliance to treatment (Kalichman et al., 2016). Bracing, regardless of its type, is probably the most effective conservative treatment of AIS, although additional high-quality studies are needed to solidify this conclusion (Lenssinck et al., 2005; Negrini et al., 2010; Rowe et al., 1997). Exercise-based physical therapy is also an appropriate intervention for patients with AIS. There is initial evidence that exercises may be effective in reducing the progression rate (mainly in early puberty) and/or improving the Cobb angles (near the end of growth) (Mordecai and Dabke, 2012; Negrini et al., 2008). Because manual therapy (spinal manipulation and soft-tissue therapy) decreases thoracic pain (Lehtola et al., 2010), increases joint mobility and decreases muscle hypertonicity (Bialosky et al., 2009), applying these interventions to the patient's spine and rib cage may reduce spinal and chest wall rigidity, thereby improving breathing mechanics (Masarsky and Weber, 1988). Corrective exercises performed with less effort and pain may improve adherence to exercise-based therapy.

This review of the literature revealed many shortcomings and gaps in the scientific knowledge and evidence concerning the efficiency of different manual therapy treatments. We found no high-quality RCT's comparing different manual therapy treatments and their influence on AIS. No literature was found comparing manual therapy as a standalone treatment to exercise treatment methods. Further high-quality studies are essential to determine the potential benefits of manual therapy in AIS treatment. Recent review on non-specific manual therapy in the treatment of AIS (Czaprowski, 2016) reached the similar conclusions: at present, the efficacy of non-specific manual therapy in the treatment of patients with AIS cannot be reliably evaluated; And it is necessary to conduct further research based on appropriate methods (prospective, RCTs) in order to reliably assess the usefulness of manual therapy in the treatment of AIS.

5. Conclusions

Case reports and small-scale clinical trials of poor methodological quality presented in this review did not allow us to draw a clear conclusion about the effectiveness of manual therapy in the treatment of AIS. On the other hand, they provide us a basis to assume that manual therapy techniques such as myofascial release and spinal manipulative techniques may potentially be effective in treating AIS in conjunction with other conservative treatments. Further high-quality studies are essential to determine the effectiveness of the different manual therapy techniques.

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Conflicts of interest

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References

Asher, M.A., Burton, D.C., 2006. Adolescent idiopathic scoliosis: natural history and long term treatment effects. *Scoliosis* 1 (1), 2.
 Aspegren, D.D., Cox, J.M., 1987. Correction of progressive idiopathic scoliosis utilizing neuromuscular stimulation and manipulation: a case report. *J. Manip. Physiol. Ther.* 10 (4), 147–156.
 Bialosky, J.E., Bishop, M.D., Price, D.D., Robinson, M.E., George, S.Z., 2009. The

mechanisms of manual therapy in the treatment of musculoskeletal pain: a comprehensive model. *Man. Ther.* 14 (5), 531–538.
 Byun, S., Han, D., 2016. The effect of chiropractic techniques on the Cobb angle in idiopathic scoliosis arising in adolescence. *J. Phys. Ther. Sci.* 28 (4), 1106–1110.
 Chen, K.C., Chiu, E.H., 2008. Adolescent idiopathic scoliosis treated by spinal manipulation: a case study. *J. Alternative Compl. Med.* 14 (6), 749–751.
 Chung, J., Salminen, B., 2011. Reduction in scoliosis in a 10 year-old female undergoing upper cervical chiropractic care: a case report. *J. Pediatr. Matern Fam Health Chiropr* 2011 (1), 23–30.
 Cobb, J.R., 1948. Outline for the study of scoliosis. In: Edwards, J.W. (Ed.), *Instructional Course Lectures*. American Academy of Orthopaedic Surgeons, Ann Arbor, MI, pp. 261–275.
 Czaprowski, D., 2016. Manual therapy in the treatment of idiopathic scoliosis. Analysis of current knowledge. *Ortop. Traumatol. Rehabil.* 18 (5), 409–424.
 Dickson, J.H., Mirkovic, S., Noble, P.C., Nalty, T., Erwin, W.D., 1995. Results of operative treatment of idiopathic scoliosis in adults. *J. Bone Joint Surg. Am.* 77 (4), 513–523.
 Hadley Miller, N., 2000. Spine update: genetics of familial idiopathic scoliosis. *Spine (Phila Pa 1976)* 25 (18), 2416–2418.
 Hasler, C., Schmid, C., Enggist, A., Neuhaus, C., Erb, T., 2010. No effect of osteopathic treatment on trunk morphology and spine flexibility in young women with adolescent idiopathic scoliosis. *J. children's orthopaedic.* 4 (3), 219–226.
 Janicki, J.A., Alman, B., 2007. Scoliosis: review of diagnosis and treatment. *Paediatr. Child Health* 12 (9), 771–776.
 Jaszewski, E., Sorbara, A., 2010. Improvement in a child with scoliosis, migraines, attention deficit disorder and vertebral subluxations utilizing the Pierce chiropractic technique. *J. Pediatr. Matern. Fam. Health. Chiropr.* 2010 (1), 30–34.
 Kalichman, L., Kendelker, L., Bezalel, T., 2016. Bracing and exercise-based treatment for idiopathic scoliosis. *J. Bodyw. Mov. Ther.* 20 (1), 56–64.
 Kaltenborn, F.M., 1993. *The Spine: Basic Evaluation and Mobilization Techniques*. Norli, 1993, third ed.
 Khau, K.B., Dickholtz, M., 2010. Improvement in adolescent idiopathic scoliosis in a patient undergoing upper cervical chiropractic care: a case report. *J. Pediatr. Matern. Fam. Health Chiropr.* 2010 (4), 136–142.
 Lantz, C.A., Chen, J., 2001. Effect of chiropractic intervention on small scoliotic curves in younger subjects: a time-series cohort design. *J. Manip. Physiol. Ther.* 24 (6), 385–393.
 LeBauer, A., Brtali, R., Stowe, K., 2008. The effect of myofascial release (MFR) on an adult with idiopathic scoliosis. *J. Bodyw. Mov. Ther.* 12 (4), 356–363.
 Lehnert-Schroth, C., 1992. Introduction to the three-dimensional scoliosis treatment according to Schroth. *Physiotherapy* 78 (11), 810–815.
 Lehtola, V., Korhonen, I., Airaksinen, O., 2010. A randomised, placebo-controlled, clinical trial for the short-term effectiveness of manipulative therapy and acupuncture on pain caused by mechanical thoracic spine dysfunction. *Int. Musculoskel. Med.* 32 (1), 25–32.
 Lenssinck, M.L., Frijlink, A.C., Berger, M.Y., Bierman-Zeinstra, S.M., Verkerk, K., V. A.P., 2005. Effect of bracing and other conservative interventions in the treatment of idiopathic scoliosis in adolescents: a systematic review of clinical trials. *Phys. Ther.* 85 (12), 1329–1339.
 Machida, M., 1999. Cause of idiopathic scoliosis. *Spine* 24 (24), 2576–2583.
 Masarsky, C.S., Weber, M., 1988. Chiropractic management of chronic obstructive pulmonary disease. *J. Manip. Physiol. Ther.* 11 (6), 505–510.
 McKenney, K., Elder, A.S., Elder, C., Hutchins, A., 2013. Myofascial release as a treatment for orthopaedic conditions: a systematic review. *J. Athl. Train.* 48 (4), 522–527.
 Mordecai, S.C., Dabke, H.V., 2012. Efficacy of exercise therapy for the treatment of adolescent idiopathic scoliosis: a review of the literature. *Eur. Spine J.: official publication of the European Spine Society, the European Spinal Deformity Society, and the European Section of the Cervical Spine Research Society* 21 (3), 382–389.
 Morningstar, M.W., Strauchman, M.N., Gilmour, G., 2004a. Adolescent idiopathic scoliosis treatment using Pettibon corrective procedures: a case report. *J. Chiropractic Med.* 3 (3), 96–103.
 Morningstar, M.W., Woggon, D., Lawrence, G., 2004b. Scoliosis treatment using a combination of manipulative and rehabilitative therapy: a retrospective case series. *BMC Musculoskel. Disord.* 5, 32.
 Nachemson, A.L., Peterson, L.E., 1995. Effectiveness of treatment with a brace in girls who have adolescent idiopathic scoliosis. A prospective, controlled study based on data from the Brace Study of the Scoliosis Research Society. *J. Bone Joint Surg. Am.* 77 (6), 815–822.
 Negrini, S., Fusco, C., Minozzi, S., Atanasio, S., Zaina, F., Romano, M., 2008. Exercises reduce the progression rate of adolescent idiopathic scoliosis: results of a comprehensive systematic review of the literature. *Disabil. Rehabil.* 30 (10), 772–785.
 Negrini, S., Minozzi, S., Bettany-Saltikov, J., Zaina, F., Chockalingam, N., Grivas, T.B., Kotwicki, T., Maruyama, T., Romano, M., Vasiliadis, E.S., 2010. Braces for idiopathic scoliosis in adolescents. *Spine (Phila Pa 1976)* 35 (13), 1285–1293.
 Pettibon, B., 2011–2015. *The Pettibon System*. © The Pettibon System.
 Physiopedia contributors. *Manual therapy*. Physiopedia. https://www.physio-pedia.com/index.php?title=Manual_Therapy&oldid=174818 (Accessed December 17, 2017).
 Riseborough, E.J., Wynne-Davies, R., 1973. A genetic survey of idiopathic scoliosis in Boston, Massachusetts. *J. Bone Joint Surg. Am.* 55 (5), 974–982.
 Rowe, D.E., Bernstein, S.M., Riddick, M.F., Adler, F., Emans, J.B., Gardner-Bonneau, D., 1997. A meta-analysis of the efficacy of non-operative treatments for idiopathic

- scoliosis. *J Bone Joint Surg. Am.* 79 (5), 664–674.
- Rowe, D.E., Feise, R.J., Crowther, E.R., Grod, J.P., Menke, J.M., Goldsmith, C.H., Stoline, M.R., Souza, T.A., Kambach, B., 2006. Chiropractic manipulation in adolescent idiopathic scoliosis: a pilot study. *Chiropr. Osteopathy* 14, 15.
- Tarola, G.A., 1994. Manipulation for the control of back pain and curve progression in patients with skeletally mature idiopathic scoliosis: two cases. *J. Manip. Physiol. Ther.* 17 (4), 253–257.
- Thomson, B., Lehnert-Schroth, C., 1992. Introduction to the three-dimensional scoliosis treatment according to Schroth introduction. *Physiotherapy* 78, 810–815.
- Wnuk, B., Blicharska, I., Blaszcak, E., Durmala, J., 2015. The impact of the derotational mobilization of manual therapy according to Kaltenborn-Evjenth on the angle of trunk rotation in patients with adolescent idiopathic scoliosis—pilot study, direct observation. *Ortop. Traumatol. Rehabil.* 17 (4), 343–350.