

# THE SCOLIOSIS RESEARCH SOCIETY BRACE MANUAL

## INTRODUCTION

**Dale E. Rowe, M.D.**  
**Kalamazoo, Michigan**

Idiopathic scoliosis has been divided into Infantile (IIS), Juvenile (JIS), and Adolescent (AIS) forms<sup>67</sup>. Recent researches into the early onset types of scoliosis (IIS and JIS) have pointed out that about twenty percent of these patients have neuro-axis anomalies which may contribute to the development of a curved spine<sup>19</sup>. These types of curves in all patients under ten years of age may not actually be "idiopathic" in nature. For this reason, the natural history of these patients is different from the behavior of late onset scoliosis (AIS)<sup>8</sup>. Long term outcome studies of untreated patients with AIS have demonstrated that these curves will worsen when they are 50 degrees and more at maturity<sup>56</sup>. Thoracic curves more than 80 degrees are associated with shortness of breath and risks of cor pulmonale and death. Patients with this degree of scoliosis will have more concern about their cosmetic appearance. Many patients with AIS have more pain but do not exhibit more disability than the general population. Depression does not seem to be more of a problem than in the general population<sup>79</sup>. Patients with curves less than 45 degrees have lives with quality and length equal to those of control subjects. Both non-operative and operative treatments, therefore, aim toward keeping patients' curves under the important threshold of 50 degrees at maturity.

Non-operative treatment of scoliosis has been depicted as early as Hippocrates, in art and literature, using traction and lateral localizer straps. Modern bracing is said to have started with Blount and Schmidt in 1946<sup>5</sup>, when they started using a brace developed for post-operative immobilization for non-operative treatment. This "Milwaukee Brace" used metal uprights to give a distraction effect to a sub-mandibular molded pad. Lateral straps and pads were placed over the apex of sclerotic curves to add lateral bending moments to the treatment, along with distraction. The brace was intended to stimulate the patient to pull away from the contact points thus using muscle power to correct the curve. Close observation indicated that those patients treated with the Milwaukee brace did not progress as often as those untreated. The standard treatment protocol became full-time wear for the duration of growth for all patients found to have scoliotic curves from around 20 degrees to 45 degrees. Physicians found that bracing did not generally change the natural history of scoliosis if the curves were greater than 45 degrees.

Patients apparently followed Dr. Blount's instructions well, but others found the constraints of a rigid brace from the chin or throat to the pelvis uncomfortable and unsightly. Hall and Miller<sup>22,76</sup> developed a more total contact brace that works as a sleeve while applying lateral pressure over the apices of curves. This low profile brace offered less conspicuous brace wear under clothing with the hope it would be more acceptable to

the patients and improve compliance. The outcome of the Boston Brace on the scoliosis progression was the same as the Milwaukee Brace.

Green<sup>18,33</sup> found that adolescents often did not wear their braces as long during each day as was prescribed. He suggested that it was possible to have the children wear their braces part-time and achieve the same control of curve progression. Variations of the treatment protocols for the Boston Brace were developed. The Charleston Bending Brace, Providence, and others, which were specifically built for nighttime wear.<sup>6,14,23</sup> These braces bent patients out of their curves. Other mechanisms of treatment used electrical stimulation of trunk muscles to bend patient out of the curves<sup>2</sup>. They suggested that a treatment period of nighttime or eight hours was adequate to keep scoliosis from progressing.

Manipulation and exercise therapies have been tried largely based on theory or anecdotal experience. There are no studies which prove or refute chiropractic treatment<sup>24</sup>.

## **INDICATIONS FOR TREATMENT**

Since adolescent idiopathic scoliosis progresses most often in patients who are growing and have curves which are above 20 degrees, this is the time to use a brace modality. Studies have shown that curves greater than 40 degrees are unlikely to respond to bracing. Treatment protocols may vary but closely resemble that shown in Fig. I<sup>63</sup>

**Figure 1**  
**Indications for Treatment**

<b>RISSER</b>	<b>CURVE</b>	<b>ACTION</b>
<b>0 - 1</b>	<b>0 - 20 degrees</b>	<b>Observe</b>
<b>0 - 1</b>	<b>20 - 40 degrees</b>	<b>Brace</b>
<b>2 - 3</b>	<b>0 - 30 degrees</b>	<b>Observe</b>
<b>2 - 3</b>	<b>30 - 40 degrees</b>	<b>Brace</b>
<b>0 - 3</b>	<b>40 - 50 degrees</b>	<b>Gray</b>
<b>0 - 4</b>	<b>50 degrees and higher</b>	<b>Surgery</b>

## **ARE BRACES REALLY A VIABLE TREATMENT OPTION?**

In 1993 Goldberg reviewed patients in Dublin who did not wear braces<sup>31</sup>. She discovered that their clinic had the same number of surgeries for scoliosis when patients did not wear braces as they had while the authors were using the brace regimens. About the same time, series of patients treated with external electrical stimulators seemed to indicate that these patients had the same progression as might be expected from the natural history studies indicated<sup>9,20,29,62</sup>. To answer these challenges, the Scoliosis Research Society commissioned a prospective, non-randomized, multi-center study to evaluate the effect of bracing and electrical stimulation on the natural history of

scoliosis<sup>57</sup>. Researchers were given freedom to treat patients as they felt appropriate; that is to say they braced with their favorite brace or treated their patients with observation if they did not believe that bracing was effective. The overall results indicated that bracing did keep curves from getting larger compared to no treatment or treatment with lateral trunk electrical stimulation.

In 1995, the SRS Natural History and Prevalence Committee carried out a meta-analysis in order to determine from the English literature whether braces did keep idiopathic scoliosis from progressing<sup>64</sup>. The committee also wanted to try to determine whether part-time bracing had the same effect as full-time bracing. A total of twenty studies were included in the meta-analysis studying 1,910 patients who had completed treatment. 1,459 had been braced, while 322 were treated with lateral electric stimulation (LESS) and 129 were treated by observation only<sup>1-4, 7-13, 18, 20-23, 25, 26, 28, 29, 30, 32, 33-39, 40, 43, 44, 46, 47, 49-54, 57-60, 68-72, 74-78, 79, 80-82</sup>.

The untreated patients did not progress (successful treatment) in forty-nine percent of the cases. Those treated with the LESS were successful thirty nine percent and braced patients did not progress in ninety-two per cent of the cases. The braced patients responded favorably significantly more than other forms of treatments reviewed.

The very young patients, especially juveniles, did not respond as well as adolescents and, of course, more mature patients who had little growth remaining. The reason for this is not clear from the meta-analysis, however literature since its publication has added precautions to the treatment of juvenile patients and boys. Karol<sup>40</sup> has shown that boys only respond in twenty-five percent of the cases treated. Goldberg, et al,<sup>32</sup> and Dobbs, et al,<sup>19</sup> have shown that boys with scoliosis have a higher incidence of neuro-axis defects than the girls with adolescent idiopathic scoliosis. All children under the age of ten have been found to have an increased incidence of neuro-axis deformities. These findings may explain why braces are less effective in girls that are in the adolescent period.

Especially interesting, was the finding that there seemed to be a “dose response curve” related to the amount of time the braces were worn each day. While there was a trend that the patients prescribed part-time brace wear preformed better than observation, full-time bracing was significantly better ( $p=0.001$ ). Furthermore, the Charleston brace which is worn eight hours was not statistically different then the TLSO’s worn for twelve hours, and both were not as successful as those braces worn full-time. The TLSO type of brace was not statistically different from the Milwaukee brace if both were worn full-time. These data were based on the length of time braces were prescribed to be worn. No timed data was available to confirm that patients were compliant with their prescriptions.

Literature since the meta-analysis has confirmed these findings.<sup>6,27,48,73,81</sup> Katz and Durrani<sup>42</sup> have also shown that a dose response curve exists for the length of time braces are worn daily and the control of curve progression. They did demonstrate that this time effect was more important for curves greater than 35 degrees. This makes treatment of smaller curves with part-time braces seem possible, further refining the treatment modalities the physician can offer patients and their families.

## **LONG TERM RESULTS OF BRACING**

Danielsson and Nachemson<sup>15,16,17</sup> have demonstrated in a long-term follow-up review of Swedish patients that the curve controlled by bracing seemed to keep the natural history of smaller untreated curves. That is to say curves kept under 45 degrees did not progress over a lifetime to a size likely to cause excessive concern about the cosmetic deformity, nor pulmonary functional loss. The average lifetime progression of curves that had been braced was 7.9 degrees compared to 23 degrees in the untreated population. They did show that there was a subgroup that progressed more than 10 degrees. This group could not be distinguished by demographic markers. Katz and Duranni<sup>42</sup> also showed a group of braced patients that needed surgery after bracing in 36% of the cases. These sub-groups need further study.

## **CONCLUSION**

The literature supports that bracing for Adolescent Idiopathic Scoliosis is effective in controlling curve progression. The physician must be careful to evaluate all patients under ten years of age and all males before recommending this treatment. Boys do not respond well to brace treatment.

Part-time bracing may be effective for scoliosis with curves under 35 degrees. For curves greater than 35 degrees, full time bracing offers more predictable control of curve progression. Correction of scoliosis is unlikely using brace treatment. Bracing of curves over 40 degrees is not likely to effectively change the natural history.

Long-term studies show that the effects of bracing remain over a lifetime. Therefore, curves that are kept under 50 degrees at maturity are unlikely to progress over time to curves of 80 degrees or more, preventing pulmonary effects or shortened life expectancy. Patient body image satisfaction will likely be more positive with curves in the mild to moderate ranges.

It is our hope that the information in this manual will help physicians, patients and their families understand what bracing can do for their health and match their preferences and expectations to the treatments available.

All information in this manual represents the views of the authors and does not express the views of nor is it endorsed by *THE SCOLIOSIS RESEARCH SOCIETY*.

## References

1. **Apter, A.; Morein, G.; Munitz, H.; Tyano, S.; Maoz, B.; and Wijzenbeek, H.:** The psychosocial sequelae of the Milwaukee brace in adolescent girls. *Clin. Orthop*, 131:156-159, 1978.
2. **Axelgaard, J.; and Brown, J. C.:** Lateral electrical surface stimulation for the treatment of progressive idiopathic scoliosis. *Spine*, 8:242-260, 1983.
3. **Bassett, G.S.; and Bunnell, W.P.:** Effect of a thoracolumbosacral orthosis on lateral trunk shift in idiopathic scoliosis. *J. Pediat. Orthop.*, 6:182-185, 1986.
4. **Beekman, C. E.; and Hall, V.:** Variability of scoliosis measurement from spinal roentgenograms. *Phys. Ther.*, 59:764-765, 1979.
5. **Blount, W. P.; Moe, J. H.:** *The Milwaukee Brace*. Baltimore, Williams & Wilkins, 1973.
6. **Bowen, J. R.; Keeler, K. A.; Pelegie, S.:** Adolescent idiopathic scoliosis managed by a nighttime bending brace. *Orthop*, 24(10): 967-970, 2001.
7. **Bradford, D.S.; Tanguy, A.; and Vaneslow, J.:** Surface electrical stimulation in the treatment of idiopathic scoliosis: preliminary results in 30 patients. *Spine* 8:757-764, 1983.
8. **Bunnell, W. P.:** The natural history of idiopathic scoliosis before skeletal maturity. *Spine*, 11:773-776, 1986.
9. **Bylund, P.; Aaro, S.; Gottfries, B.; and Jansson, E.:** Is lateral electric surface stimulation an effective treatment for scoliosis? *J. Pediat. Orthop.*, 7:298-300, 1987
10. **Chang, L.:** A power analysis of the test of homogeneity in effect-size meta-analysis. *Doctoral dissertation, Department of Counseling, Educational Psychology, and Special Education*, Michigan State University, East Lansing, Michigan, 1992.
11. **Clayson, D.; Luz-Alterman, S.; Cataletto, M. M.; and Levine, D. B.:** Long-term psychological sequelae of surgically versus nonsurgically treated scoliosis. *Spine*, 12:983-986, 1987.
12. **Cobb, J. R.:** Outline for the study of scoliosis, In *Instructional Course Lectures, The American Academy of Orthopaedic Surgeons*, Vol. 5, pp. 261-275. Ann Arbor, J.W. Edwards, 1948.
13. **Cook, D. J.; Guyatt, G.H.; Ryan, G.; Clifton, J.; Buckingham, L.; William, A.; McIlroy, W.; and Oxman, A.D.:** Should unpublished data be included in meta-analyses? Current convictions and controversies. *J. Am. Med. Assn.*, 269: 2749-2753, 1993.
14. **D'Amato, C. R.; Griggs, S.; McCoy, B.:** Nighttime bracing with the Providence brace in adolescent girls with idiopathic scoliosis. *Spine*, 26(18):2006-2012, 2001.
15. **Danielsson, A. J.; Nachemson, A. L.:** Childbearing, curve progression, and sexual function in women 22 years after treatment for adolescent idiopathic scoliosis: a case-control study. *Spine*, 26(13): 1449-1456, 2001.
16. **Danielsson, A. J.; Nachemson, A. L.:** Radiologic findings and curve progression twenty-two years after treatment for adolescent idiopathic scoliosis: comparison of brace and surgical treatment with matching control group of straight individuals. *Spine*, 26(5): 516-525, 2001.
17. **Danielsson, A. J.; Wilklund, I.; Pehrsson, K.; Nachemson, A. L.:** Health-related quality of life in patients with adolescent idiopathic scoliosis: a matched follow-up at least 20 years after treatment with brace surgery. *Eur Spine J*, 10(4):278-288, 2001.
18. **DiRaimondo, C.V.; and Greene, N.E.:** Brace-wear compliance in patients with adolescent idiopathic scoliosis. *J. Pediat. Orthop.*, 8:143-146, 1988.
19. **Dobbs, M.B.; Lenke, L. G.; Morcuende, J.; Weinstein, S. L; Bridwell, K. H.; and Sponseller, P. D.:** Incidence of neural axis abnormalities in infantile patients diagnosed with idiopathic scoliosis: Is a screening MRI necessary? *Scoliosis Research Society*, Paper #10, presented at the 36<sup>th</sup> Annual Scoliosis Research Society Meeting, Cleveland, Ohio, Sept. 19-22, 2001.

20. **Durham, J. W.; Moskowitz, A.; and Whitney, J.:** Surface electrical stimulation versus brace in treatment of idiopathic scoliosis. *Spine*, 15: 888-892, 1990.
21. **Edmonson, A. S.; and Morris, J. T.:** Follow-up study of Milwaukee brace treatment in patients with idiopathic scoliosis. *Clin. Orthop.*, 126: 58-61, 1977.
22. **Emans, J. B.; Kaelin, A.; Bancel, P.; Hall, J. E.; and Miller, M.E.:** The Boston bracing system for idiopathic scoliosis. Follow-up results in 295 patients. *Spine*, 11:792-801, 1986.
23. **Federico, D. J.; and Renshaw, T. S.:** Results of treatment of idiopathic scoliosis with the Charleston bending orthosis. *Spine*, 15: 886-887, 1990.
24. **Feise, R. J.; Rowe, D. E.; Crowther, E. R.:** Developing an effective design for a multi-disciplinary, collaborative, multi-site trial of chiropractic manipulation as a treatment for adolescent idiopathic scoliosis. (Scoliosis Research Society Grant Proposal.)
25. **Focarile, F. A.; Giarolo, M. A.; Ferrari, U.; Zilioli, E.; and Ottaviani, C.:** Effectiveness of nonsurgical treatment for idiopathic scoliosis. Overview of available evidence. *Spine*, 16, 395-401, 1991.
26. **Freeman, B. L.:** Non-operative management of idiopathic scoliosis. In *Campbell's Operative Pediatric Orthopedics*, edited by S. T. Canale and J. H. Beaty. Ed 2, pp. 640-642. St. Louis,. Mosby-Year Book, 1995.
27. **Gepstein, R.; Leitner, Y.; Zohar, E.; Angel, I.; Shabat, S.; et al:** Effectiveness of the Charleston bending brace in the treatment of single-curve idiopathic scoliosis. *J Pediatr Orthop*, 22(1):84-87, 2002.
28. **Goldberg, C. J.; Dowling, F. E.; Fogarty, E. E.; and Moore, D.:** School scoliosis screening and the U.S. Preventive Services Task Force. An examination of long-term results. *Orthop. Trans.*, 19:590-591, 1995-1996
29. **Goldberg, C. J.; Dowling, F. E.; Fogarty, E. E.; Regan, B. F.; and Blake, N. S.:** Electro-spinal stimulation in children with adolescent and juvenile scoliosis. *Spine*, 13: 482-484, 1988.
30. **Goldberg, C. J.; Dowling, F. E.; Hall, J. E.; and Emans, J. B.:** A statistical comparison between natural history of idiopathic scoliosis and brace treatment in skeletally immature adolescent girls. *Spine*, 18: 902-908, 1993.
31. **Goldberg, C. J.; Moore, D. P.; Fogarty, E. E.; Dowling, F. E.:** Adolescent idiopathic scoliosis: the effect of brace treatment on the incidence of surgery. *Spine*, 26(1):42-47, 2001.
32. **Goldberg, C. J.; Moore, D. P.; Fogarty E. E.; Dowling, F. E.:** Left thoracic curve patterns and their association with disease. *Spine*, 24(12): 1228-1233, June 15, 1999.
33. **Green, N. E.:** Part-time bracing of adolescent idiopathic scoliosis. *J. Bone and Joint Surg.*, 68-A: 738-742, June 1986.
34. **Gross, C.; Gross, M.; and Kuschner, S.:** Error analysis of scoliosis curvature measurement. *Bull. Hosp. Joint Dis.*, 43, 171-177, 1983.
35. **Hanks, G. A.; Zimmer, B.; and Nogi, J.:** TLSO treatment of idiopathic scoliosis. An analysis of the Wilmington jacket. *Spine*, 13: 626-629, 1988
36. **Hassan, I.; and Bjerkreim, I.:** Progression in idiopathic scoliosis after conservative treatment. *Acta Orthop. Scandinavica*, 54:88-90, 1983.
37. **Hedges, L. V.:** Fixed effects models. In *The Handbook of Research Synthesis*, pp. 285-299. Edited by H. Cooper and L. V. Hedges. New York, Russell Sage Foundations, 1994.
38. **Jonasson-Rajala, E.; Josefsson, E.; Lundberg, B.; and Nilsson, H.:** Boston thoracic brace in the treatment of idiopathic scoliosis. Initial correction. *Clin. Orthop.*, 183: 37-41, 1984.
39. **Kahanovitz, N.; Levine, D. B.; and Lardone, J.:** The part-time Milwaukee brace treatment of juvenile idiopathic scoliosis. Long-term follow-up. *Clin. Orhtop.*, 167: 145-1512, 1982.
40. **Karol, L. A.:** Effectiveness of bracing in male patients with idiopathic scoliosis. *Spine*, 26(18): 2001-2005, 2001.

41. **Karol, L. A.; Johnston, C. E., II; Browne, R. H.; and Madison, M.:** Progression of the curve in boys who have idiopathic scoliosis. *J. Bone and Joint Surg.*, 75-A: 1804-1810, Dec. 1993.
42. **Katz, D. E.; Durrani, A. A.:** Factors that influence outcome in bracing large curves in patients with adolescent idiopathic scoliosis. *Spine*, 26(21):2354-2361, 2001.
43. **Keiser, R. P.; and Shufflebarger, H. L.:** The Milwaukee brace in idiopathic scoliosis. Evaluation of 123 completed cases. *Clin. Orthop.*, 118:19-24, 1976.
44. **Kitteson, A. C.; and Lim, L. W.:** Measurement of scoliosis. *Am. J. Roentgenol.*, 108-775-777, 1970
45. **Korovessis, P.; Kyrkos, C.; Piperos, G.; Soucacos, P.N.:** Effects of thoracolumbosacral orthosis on spinal deformities, trunk asymmetry, and frontal lower rib cage in adolescent idiopathic scoliosis. *Spine*, 25(16):2064-2071, 2000.
46. **Laurnen, E. L.; Tupper, J.W.; and Mullen, M. P.:** The Boston brace in thoracic scoliosis. A preliminary report. *Spine*, 87:388-395, 1983.
47. **Lonstein, J. B.; and Carlson, J. M.:** The prediction of curve progression in untreated idiopathic scoliosis during growth. *J. Bone and Joint Surg.*, 66-A: 1061-1071, Sept. 1984.
48. **Masso, P. D.; Meeropol, E.; Lennon, E.:** Juvenile-Onset scoliosis followed up to adulthood: orthopaedic and functional outcomes. *J. Pediatr Orthop.*, 22(3):279-84, 2002
49. **McAlister, W. H.; and Shakelford, G.D.:** Measurement of spinal curvatures. *Radiol. Clin. North America*, 13:113-121, 1975.
50. **McCollough, N. C., III; Schultz, M.; Javech, N.; and Latta, L.:** Miami TLSO in the management of scoliosis: preliminary results in 100 cases. *J. Pediat. Orthop.*, 1: 141-152, 1981.
51. **McLean, W. E., Jr.; Green, N. E.; Pierre, C. B.; and Ray, D.C.:** Stress and coping with scoliosis: psychological effects on adolescents and their families. *J. Pediat. Orthop.*, 9: 257-261, 1989.
52. **Mellencamp, D. D.; Blount, W. P.; and Anderson, A. J.:** Milwaukee brace treatment of idiopathic scoliosis. Late results. *Clin. Orthop.*, 126: 47-57m 1977.
53. **Miller, J. A.; Nachemson, A. L.; and Schultz, A. B.:** Effectiveness of braces in mild idiopathic scoliosis. *Spine*, 9:632-635, 1984.
54. **Montgomery, F.; and Willner, S.:** Prognosis of brace-treated scoliosis. Comparison of the Boston and Milwaukee methods in 244 girls. *Acta Orthop. Scandinavica*, 60: 383-385, 1989.
55. **Montgomery, F.; Williner, S.; and Appelgren, G.:** Long-term follow-up of patients with adolescent idiopathic scoliosis treated conservatively: an analysis of the clinical value of progression. *J. Pediat. Orthop.*, 10:48-52, 1990.
56. **Nachemson, A.; Lonstein, J. E.; and Weinstein, S. L.:** Prevalence and Natural History Committee report. Read at the Annual Meeting of the Scoliosis Research Society, Denver, Colorado, Sept. 25, 1982.
57. **Nachemson, A.; Peterson, L. E.; and members of the Brace Study Group of the Scoliosis Research Society:** 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 and Joint Surg.*, 77-A: 815-822, June 1995.
58. **Park, J.; Houtkin, S.; Grossman, J.; and Levine, D. B.:** A modified brace (Prenyl) for scoliosis. *Clin Orthop.*, 126: 67-73m 1977.
59. **Piazza, M. R.; and Bassett, G. S.:** Curve progression after treatment with the Wilmington brace for idiopathic scoliosis. *J. Pediat. Orthop.*, 10: 39-43, 1990.
60. **Price, C. T.; Scott, D. S.; Reed, F. E. Jr.; and Riddick, M.F.:** Nighttime bracing for adolescent idiopathic scoliosis with the Charleston bending brace. Preliminary report. *Spine*, 15:1294-1299, 1990.

61. **Risser, J. C.:** The iliac apophysis: an invaluable sign in the management of scoliosis. *Clin. Orthop.*, 11:111-119, 1958.
62. **Rowe, D. E.:** Comparison of patient acceptance of Scolitron and brace treatment of idiopathic scoliosis. *Presentation to Scoliosis Research Society, page 100*, Bermuda, 1986.
63. **Rowe, D. E.:** Non-operative treatment for idiopathic scoliosis. *Scoliosis Research Society CME Course: Fundamentals of Spinal Deformity II*, September 18, 2002, Seattle, WA, 2002.
64. **Rowe, D. E.; Bernstein, S.M.; Riddick, M. F.; Adler, F.; Emans, J. B.; Gardner-Bonneau, D.:** A meta-analysis of the efficacy of non-operative treatments for idiopathic scoliosis. *JBJS*, 79A-5:664-674, 1997.
65. **Rudicel, S., and Renshaw, T. S.:** The effect of the Milwaukee brace on spinal decompression in idiopathic scoliosis. *Spine*, 8:385-387, 1983.
66. **Sacks, H. S.; Berrier, J.; Reitman, D.; Ancona-Berk, V. A.; and Chalmers, T. C.:** Meta-analyses of randomized controlled trials. *New England J. Med.*, 316: 45-455, 1987.
67. **Scoliosis Research Society Terminology Committee:** A glossary of scoliosis terms. *Spine*, 1:57-58, 1976.
68. **Shadish, W. R.; and Haddock, C. K.:** Combining estimates of effect size. *The Handbook of Research Synthesis*, pp. 261-281. Edited by H. Cooper and L. V. Hedges, New York, Russell Sage Foundation, 1994.
69. **Spectors, P.E.; and Levine, E. L.:** Meta-analysis for integrating study outcomes: a Monte Carlo study of its susceptibility to type I and type II errors. *J. Appl. Psychol.*, 72: 3-9, 1987.
70. **Styblo, K.:** Conservative treatment of juvenile and adolescent idiopathic scoliosis. Unpublished doctoral thesis. Rijksuniversiteit te Leiden, The Netherlands, 1991.
71. **Sullivan, J. A.; Davidson, R.; Renshaw, T. S.; Emans, J. B.; Johnston, C.; and Sussman, M.:** Further evaluation of the Scolitron treatment of idiopathic adolescent scoliosis. *Spine*, 11: 903:906. 1986.
72. **Swank, S. M.; Brown, J. C.; Jennings, M. V.; and Conradi, C.:** Lateral electrical surface stimulation, in idiopathic scoliosis. Experience in two private practices, *Spine*, 14: 1293-1295, 1989.
73. **Trivedi, J. M.; Thomson, J. D.:** Results of Charleston bracing in skeletally immature patients with idiopathic scoliosis. *J Pediatr Orthop*, 21(3):277-280, 2001.
74. **UdJn, A.; and Willner, S.:** The effect of lumbar flexion and Boston thoracic brace on the curves in idiopathic scoliosis. *Spine*, 8: 846-850, 1983.
75. **United States Preventive Services Task Force:** Screening for adolescent idiopathic scoliosis. Review article. *J. Am. Med. Assn.*, 269:2667-2672, 1993.
76. **Watts, H. G.; Hall, J. E.; and Stanish, W.:** The Boston brace system for the treatment of low thoracic and lumbar scoliosis by the use of girdle without superstructure. *Clin. Orthop.*, 126L 87-92, 1977.
77. **Weinstein, S. L.:** Editorial Advances in the diagnosis and management of adolescent idiopathic scoliosis. *J. Pediatr. Orthop.* 14:561-563, 1994.
78. **Weinstein, S. L.; Zavala, D. C.; and Ponseti, I. V.:** Idiopathic scoliosis. Long-term follow-up and prognosis in untreated patients. *J. Bone and Joint Surg.*, 63-A:702-712, June 1981.
79. **Weinstein, S. L.; Zlan, L. A.; Spratt, K. F.; Peterson, K. M.; Spoonamore, M. J.; Ponseti, I.V.:** Health and function of patients with untreated idiopathic scoliosis: A 50-year natural history study. *JAMA*, 289:559-567, 2003.
80. **Wickers, F. B.; Bunch, W. H.; and Barnett, P. M.:** Psychological factors in failure to wear the Milwaukee brace for treatment of idiopathic scoliosis. *Clin Orthop.*, 126:62-66, 1977.
81. **Wiley, J. W.; Thompson, J. D.; and Mitchell, T. M.:** Effectiveness of the Boston brace in treatment of large curves in adolescent idiopathic scoliosis. *Spine*, 25(18):2326-2332, 2000.
82. **Willers, U.; Normelli, H.; Aaro, S.; Svenson, O.; and Hendlund, R.:** Long-term results of Boston brace treatment on vertebral rotation in idiopathic scoliosis. *Spine*, 18:432-435, 1993.



- 83. Wilson, M. S.; Stockwell, J.; and Leedy, M.G.:** Measurement of scoliosis by orthopedic surgeons and radio logists. *Aviat. Space and Environ. Med.*, 54: 69-71, 1983.
- 84. Ylikoski, M.; Peltonen, J.; and Poussa, M.:** Biological factors and predictability of bracing in adolescent idiopathic scoliosis. *J. Pediat. Orthop.*, 9:680-683, 1989.