Idiopathic Spinal Deformity And Electrical Stimulation References

Allington N.J. and Bowen J.R. (1996) Adolescent idiopathic scoliosis: treatment with the Wilmington brace. A comparison of full-time and part-time use. J. Bone Joint Surg. Am. 78, 1056-1062.

Abstract: We reviewed the clinical records and the radiographs of 188 patients who had adolescent idiopathic scoliosis. Our purpose was to determine whether part-time and full-time bracing had been equally effective in preventing progression of the curve. Full-time bracing had been used for ninety-eight patients; part-time bracing, for forty-nine; and electrical stimulation, for forty-one. Eighty-eight patients had had a curve of less than 30 degrees and 100 patients, a curve of 30 to 40 degrees. The treatment was considered a failure if the curve had increased 5 degrees or more. The curve progressed 5 degrees or more in thirteen (36 per cent) of the thirty-six patients who had had full-time bracing for a curve of less than 30 degrees, in thirteen (41 per cent) of the thirty-two who had had part-time bracing for such a curve, and in fourteen (70 per cent) of the twenty who had had electrical stimulation for such a curve. Compared with electrical stimulation, both full-time and part-time bracing prevented progression significantly more effectively ($p < 0.02$ and $p < 0.04$, respectively). With the numbers available, the difference in progression between the groups that had had full-time and parttime bracing was not significant ($p < 0.18$). The curve progressed 5 degrees or more in thirty-six (58 per cent) of the sixty-two patients who had had full-time bracing for a curve of 30 to 40 degrees, in ten of the seventeen who had had part- time bracing for such a curve, and in eighteen (86 per cent) of the twenty-one who had had electrical stimulation for such a curve. The difference in progression between each bracing program and electrical stimulation was significant ($p < 0.03$ for the full-time program and $p < 0.05$ for the part-time program). With the numbers available, the difference in progression between full-time and part-time bracing was not significant ($p < 1.14$)

Anciaux M., Lenaert A., Van Beneden M.L., Blonde W., and Vercauteren M. (1991) Transcutaneous electrical stimulation (TCES) for the treatment of adolescent idiopathic scoliosis: preliminary results. Acta Orthop. Belg. 57, 399-405.

Abstract: The authors report on the results of a preliminary study on the treatment of progressive idiopathic scoliosis by electrical surface stimulation. The study, involving 30 spinal curvatures, showed stabilization of the median primary curvature (30 degrees) in the course of treatment, the median duration of which was 12 months. Overall, 73.2% of the curvatures treated, responded favorably (stabilization or regression of the curve); however, 26.8% of the curvatures progressed in spite of the transcutaneous electrical stimulation treatment. The only complication noted was contact eczema in 20% of the cases. The authors feel that surface electrical stimulation treatment can be regarded as an acceptable alternative to a brace in the treatment of idiopathic scoliosis, and at this stage it deserves a place in the conservative therapeutic approach to idiopathic scoliosis

Andonian A.T. (1984) Detection of stimulated back muscle contractions by moire topography. J. Biomech. 17, 653-661.

Abstract: The ability to treat scoliosis via surface stimulated trunk muscle contractions is now being evaluated at several treatment centers. In order to make biomechanical analysis of the procedure, so that the technique can be used optimally, data are needed to quantify the muscle contractions and structural changes by different electrode locations. This paper presents the use of a modified

shadow moire technique to quantify geometric changes resulting from electrical stimulation applied to the surface of the back in a healthy subject

Axelgaard J., Brown J.C. (1983) Lateral electrical surface stimulation for the treatment of progressive idiopathic scoliosis. *Spine* 8:242-260.

Axelgaard J., Nordwall A., Brown J.C. (1983) Correction of spinal curvatures by transcutaneous electrical muscle stimulation. *Spine* 8, 463-481.

Bertrand S.L., Drvaric D.M., Lange N., Lucas P.R., Deutsch S.D., Herndon J.H., and Roberts J.M. (1992) Electrical stimulation for idiopathic scoliosis. Clin. Orthop. 176-181.
Abstract: To evaluate the effectiveness of lateral electrical spinal stimulation for idiopathic scoliosis, 87 patients treated with this modality were reviewed retrospectively. All patients had no prior treatment, had a documented progression of more than 5 degrees, and were skeletally immature. Forty-seven patients were compliant and followed until skeletal maturity or institution of other treatment. Fifty percent of patients with a high probability of progression required surgery. For compliant patients, 51% progressed 5 degrees or more and 36% progressed 10 degrees or more or required a change to another treatment modality. Statistical analysis demonstrated no significant difference in the probability of progression between this group of treated patients and previously published groups of untreated patients

Bradford D.S., Tanguy A., and Vanselow J. (1983) Surface electrical stimulation in the treatment of idiopathic scoliosis: preliminary results in 30 patients. Spine 8, 757-764.
Abstract: From 1978 to 1981, 30 patients have been treated for idiopathic scoliosis with surface electrical stimulation using the E.S.O. (Electro Spinal Orthosis) Single Channel designed by Medtronics. The criteria for selection were: patients who were skeletally immature; single thoracic, thoracolumbar or lumbar curvatures between 30 degrees and 40 degrees; or the same curve pattern greater than 20 degrees with 5 degrees of documented progression in one year; patient and family reliability. Patients with previous treatment were excluded from the study. No one was more than 15 years of age. Curve amplitude was between 25 degrees and 35 degrees in 72% of the patients. Curve pattern was single thoracic in 28 patients, thoracolumbar in one, and lumbar in one. Five patients were excluded from the evaluation of the results of stimulation of the correction of the curve. Of the 25 patients remaining, one was improved, 14 were stable, two had mild acceptable progression (less than 10 degrees with no need for further treatment), and eight had an unacceptable progression greater than 10 degrees requiring some form of alternative treatment. The authors conclude that significant improvement in the curvatures under treatment was extremely unlikely, that progression may have been stopped in some curves, that the curvatures under 30 degrees had the best results, and that curvatures that do not respond to surface electrical stimulation are not likely to respond to a Milwaukee brace treatment

Brown J.C., Axelgaard J., Howson D.C. (1984) Multicenter trial of a noninvasive stimulation method for idiopathic scoliosis. *Spine* 9,382-387.

Bunnel W.P. (1986) The natural history of idiopathic scoliosis before skeletal maturity. *Spine* 11, 773-776.

Campbell J.M., Meadows P.M. (1992) Therapeutic FES: From Rehabilitation to Neural Prosthetics. *Assistive Technology* 4, 4-18.

Chen P.Q. (1990) Spinal deformities among children under 10 years old: a clinical analysis of 41 cases. J. Formos. Med. Assoc. 89, 772-776.
Abstract: In order to investigate the number, types, severity and the various treatments of spinal deformity among children under 10 years old, a retrospective survey of registered patients in the scoliosis clinic at the National Taiwan University Hospital was performed. Between August 1982 and December 1988, there were 41 children who had scoliosis with a Cobb angle larger than 10 degrees and the onset was before 10 years of age. This number accounted for 3.8% of all scoliotic patients during the same time period. Of these children, 19 had idiopathic scoliosis (46.3%), 7 with infantile and 12 with juvenile; the other 19 were due to congenital, and the remaining 3 were postradiation, a resection of Wilms' tumor in 2 and neuroblastoma in 1. In the congenital group, hemivertebra (13 patients) outnumbered other causes. Twenty three patients (56%) underwent surgical correction, the rest were either under regular observation (9 patients), bracing (7 patients) or electrical stimulation (2 patients). The average preoperative Cobb angle in the operated groups was much larger, being 67.6 degrees in the infantile; 52.4 degrees in the juvenile; 57 degrees in the congenital; and 62 degrees in the postradiation. For those without an operation, the angles were smaller than 30 degrees. The indications for surgery were that the curvature was in progression, which could not be controlled by conservative means, or that in some congenital cases, the curve had the potential tendency to exacerbate. From the present study, the percentage of scoliosis under 10 years of age was far less than the adolescent group in our clinic.(ABSTRACT TRUNCATED AT 250 WORDS)

Durham J.W., Moskowitz A., and Whitney J. (1990) Surface electrical stimulation versus brace in treatment of idiopathic scoliosis. Spine 15, 888-892.
Abstract: Surface electrical stimulation using the ScoliTron device was applied to 40 adolescent patients for treatment of idiopathic scoliosis. Adequate follow-up was available for 30 of these patients. The overall failure rate was 15 of 30 or 50%. Due to curve progression while using the ScoliTron, these patients either went on to a fusion (9 of 15) or were changed to a brace (6 of 15). The remaining 15 patients were considered successes with no curve progression (10 of 30 or 33%) or successful/failures with slight curve progression not requiring a change in treatment (5 of 30 or 17%). None of the various parameters analyzed were found to be useful indicators of successful treatment using the ScoliTron device. Electrical stimulation was found to be ineffective in preventing curve progression for idiopathic scoliosis

Fisher D.A., Rapp G.F., and Emkes M. (1987) Idiopathic scoliosis: transcutaneous muscle stimulation versus the Milwaukee brace. Spine 12, 987-991.
Abstract: This paper compared 3-year results of electrical stimulation with the Milwaukee brace for the treatment of idiopathic scoliosis. Fifty patients in each group were compared retrospectively and matched for age, sex, Risser sign, and curve morphology. Evaluations were performed at 6-month intervals with radiographs and examinations. Skin irritation was the most common complication with electrical stimulation. Using survivorship analysis methods, no significant differences were found in rates of curve progression or failure. Overall, 70% of the patients in each group were successfully maintained over a course of 3 years. Electrical stimulation is comparable to the Milwaukee brace in managing idiopathic scoliosis

Friedman H.G., Herbert M.A., and Bobechko W.P. (1982) Electrical stimulation for scoliosis. Am. Fam. Physician 25, 155-160.
Abstract: Scoliosis is detectable in 6 to 14 percent of school-age children. An estimated 0.1 percent of the curvatures are progressive and require treatment. The usual method of treatment consists of a restrictive brace worn most of the time. A successful and nonrestrictive technique utilizing electrical stimulation of the deep paraspinal muscles has been developed. Therapy involves night-time use of an implanted stimulator system. It places no restrictions on the child's activities, while producing results that are superior to bracing

Grimby G., Nordwall A., Hulten B., and Henriksson K.G. (1985) Changes in histochemical profile of muscle after long-term electrical stimulation in patients with idiopathic scoliosis. Scand. J. Rehabil. Med. 17, 191-196.
Abstract: Adolescent patients with idiopathic scoliosis were treated with long- term electrical stimulation (30 Hz) at the posterior axillary line on the convex side of the curvature in order to correct the spinal deformity. The patients were also followed with muscle biopsies from the latissimus dorsi of the stimulated side taken before, after 3 and 6 months of electrical stimulation. There was a tendency for an increase in the percentage of type I and especially the type II C (undifferentiated) fibers after stimulation. The mean muscle fiber area and the fiber areas of the various fiber types did not change significantly. Histopathological findings were generally rare before as well as after 3 months of electrical stimulation, the only noticeable finding being a somewhat increased frequency of atrophic fibers in groups after 6 months of stimulation. In all studied patients the enzymatic activity of citrate synthase increased after 3 months and further in three studied patients after 6 months of stimulation. The present study gives some evidence of an adaptive process caused by electrical stimulation towards a more fatigue-resistant muscle

Goldberg C., Dowling F.E., Fogarty E.E., Regan B.F., Blake N.S. (1988) Electro-spinal stimulation in children with adolescent and juvenile scoliosis. *Spine* 13, 482-484.

Herbert M.A. and Bobechko W.P. (1987) Paraspinal muscle stimulation for the treatment of idiopathic scoliosis in children. Orthopedics 10, 1125-1132.
Abstract: More than 12 years ago, we began to investigate the potential use of electrical stimulation of the paraspinal muscles to control scoliosis in children. Animal experimentation showed that unilateral stimulation of these muscles will cause the spine to grow toward the stimulated side. It was also shown that the stimulation need only be carried on for part of the day. We have developed a treatment for scoliosis based on night-time use of stimulation either with an implantable or surface system. Both single and dual channel systems are available for the treatment of single or double scoliotic curves. Treatment is carried on at night while the child is asleep, and there are no exercises or brace programs associated with it. Approximately 75% of the curves are either improved significantly, or maintained at their starting value. Only about 15% of the curves fail to respond and require a spinal fusion to stabilize them. Patient acceptance and compliance has been excellent

Herndon W.A. (1984) Spinal deformities in children. The improving picture. Postgrad. Med. 76, 67-76.
Abstract: Significant advances have been made in knowledge of the natural history and treatment of spinal deformities. Early diagnosis remains the key to successful treatment. Newer techniques of bracing, electrical stimulation, and surgery have led

to a satisfactory outcome in the majority of patients. Smaller scoliotic curves (less than 20 degrees) may be treated by observation, but for more significant curves prompt referral is best

Hopf C., Sandt E., and Heine J. (1989) [The progression of untreated idiopathic scoliosis in the x-ray image]. Rofo Fortschr. Geb. Rontgenstr. Neuen Bildgeb. Verfahr. 151, 311-316.
Abstract: The natural history of scoliosis, or lateral curvature of the spine, was followed up in 135 patients (111 girls, 24 boys) for a total average period of 52.4 months. We observed patients with a curvature of between 5 degrees and 30 degrees none of whom had been treated specifically as orthotics or with electrical stimulation or by surgery. Two groups of patients with progressive curvature were differentiated: 1) in 62.2% of the patients the curvature progressed by more than 5 degrees during the entire observation period; 2) in 36% of the patients we found an increase in curvature by more than 5 degrees within one year. Another result of our study was that idiopathic scoliosis is particularly dangerous in young patients with a "0" Risser sign. Thoracic curvatures and double major curvatures were more liable to progress than lumbar and thoracolumbar curvatures. Even a small angle of curvature in young patients must be taken seriously

Hsu J.D., Slager U.T., Swank S.M., and Robinson M.H. (1988) Idiopathic scoliosis: a clinical, morphometric, and histopathological correlation. J. Pediatr. Orthop. 8, 147-152.
Abstract: At the time of spinal fusion, muscle biopsies were taken from both the convex and concave side at the apex of the curve from 27 patients with idiopathic scoliosis. Histochemical and morphometric studies showed generally small and atrophic type 1 muscle fibers on both sides, with preservation of the normal type 1 predominance. The most striking abnormality was a type 2A predominance over type 2B fibers, the reverse of normal in the paraspinous muscle. These changes showed no correlation with sex, age, or electrical stimulation but showed a significantly greater severity with the duration and severity of the curve. We conclude that these changes are a secondary muscle adaptation to the curve and not its primary etiology

Kahanovitz N., Snow B., and Pinter I. (1984) The comparative results of psychologic testing in scoliosis patients treated with electrical stimulation or bracing. Spine 9, 442-444.
Abstract: Proponents of the surface stimulation treatment of idiopathic scoliosis have reported approximately 75-85% success rates in arresting progressive curvatures. Although encouraging, these results do not appear to be better than those of the more traditional brace programs. Now recognizing electrical stimulation as a viable alternative to bracing, supporters have advocated the psychologic and physical freedom with electrical stimulation as a major advantage over brace treatment. However, to date, there have been no objective psychologic studies to substantiate these claims. This prospective study was devised to detect any significant differences between a group of patients treated in a TLSO or Milwaukee brace and a group of patients treated with lateral electrical surface stimulation (LESS) (ScoliTron). The study consisted of 40 female private patients with idiopathic scoliosis treated for a minimum of 3 months. Each patient was given a set of seven standardized psychologic tests and an observer rating by the treating physician or physical therapist working with the patient. Results of the Psychological Epidemiology Research Interview (PERI) revealed that the LESS group had

significantly higher self esteem than the brace group. The brace patients demonstrated a much greater perception of directed hostility than the LESS group. The coping response inventory showed the brace group to manifest a more primitive coping mechanism than the LESS group. The brace group attempted to avoid problems associated with their disease, rather than cope with them as the LESS group was better able to do. The brace group focused more on their emotions than the realistic problems of their disease.(ABSTRACT TRUNCATED AT 250 WORDS)

Kahanovitz N. and Weiser S. (1986) Lateral electrical surface stimulation (LESS) compliance in adolescent female scoliosis patients. Spine 11, 753-755.
Abstract: This retrospective study of lateral electrical surface stimulation (LESS) treatment for patients with progressive idiopathic scoliosis was performed to document patient compliance in the standard electrical stimulation program and to gain objective data to perform a relative comparison of electrical stimulation and bracing compliance. Forty mothers of adolescent female patients participating in the electrical stimulation program of one of the authors (NK) were interviewed confidentially by an independent observer (SW). Patients whose compliance was rated good or total were thought to have acceptable compliance rates. Overall, 50% showed good or total compliance, 10% fair, 5% poor, and 35% failures. It appeared that the failures tended to exaggerate their symptoms and use "skin irritation" as an excuse to discontinue treatment. The longer patients used the LESS (scolitron) device, the more compliant they became (P less than 0.0). This is opposite to the findings about brace compliance. Confidence of the mother in the device showed a positive correlation (P less than 0.008) with compliance, and a mother's concern of how others would react to her child's scoliosis had a negative correlation (P less than 0.003). From the results of this study, overall compliance appears to be somewhat better for electrical stimulation programs than for bracing programs. However, the high failure rate was both disappointing and surprising

Keller R.B. (1989) Nonoperative treatment of adolescent idiopathic scoliosis. Instr. Course Lect. 38, 129-135.
Abstract: Nonoperative treatment of spinal deformity will continue to change. In recent years, many long-held tenets regarding the natural history and response to various treatment methods have been challenged, and we do not yet have answers to many of the questions that have been raised. New orthotic devices and electrical stimulation have multiplied treatment approaches. From this array of options, the clinician must decide whom to treat and what method to use. On the basis of the current consensus, patients who have significant, progressive deformity and an immature spine should be treated by one of the nonoperative techniques. The various TLSOs are most favored, although the Milwaukee brace still has a definite role in certain curve patterns and remains the standard of braces. The role of electrical spinal stimulation is uncertain at present, and further research is necessary. We have learned that only appropriate orthotic treatment of scoliosis produces long-term stabilization of deformity. Impressive initial curve correction does not signify the end result, and patients who have curves that are unacceptable when the patient is first seen should be considered for surgical treatment. Thus, while questions remain, the guidelines for treatment outlined in this chapter are appropriate for the present

Lonstein J.E., Carlson J.M. (1984) The prediction of curve progression in untreated idiopathic scoliosis during growth. *J Bone Joint Surg* 66A, 1061-1071.

Lonstein J.E. (1988) Natural history and school screening for scoliosis. Orthop. Clin. North Am. 19, 227-237.
Abstract: In light of the questions and controversy regarding school screening for spinal deformities, should the programs be dropped? The natural history is not completely known and the results of nonoperative treatment questioned. The costs are high due to over-referral and numerous physician visits and radiographs. Would it not be best to wait until the epidemiologic questions are answered? The best approach is one in the middle ground. The program needs to be organized and strengthened. With the education of screeners, over-referral can be reduced. The treating physician must confirm the physical finding, take appropriate radiographs, and plan appropriate follow-up. In this way, the costs will be reduced. In addition, with knowledge regarding natural history, only larger curves or progressive curves will be treated. Nonoperative treatment of idiopathic scoliosis is effective. It can control progression and even result in correction of some curves. The overall effectiveness of braces and electrical stimulation needs to be constantly reviewed. How do these forms of nonoperative treatment affect the progressive curve, and do they reduce the need for surgery in idiopathic scoliosis? Only after we have more studies on natural history and on the results of nonoperative treatment can screening for scoliosis be reassessed to determine its role in the overall treatment program of spinal deformities

Macek C. (1982) Electrical stimulation of muscles replaces braces for scoliosis. JAMA 247, 1097-1098.

McCollough N.C., III (1985) Electrical stimulation in management of idiopathic scoliosis. Instr. Course Lect. 34, 119-126.

McCollough N.C., III (1986) Nonoperative treatment of idiopathic scoliosis using surface electrical stimulation. Spine 11, 802-804.

Nachemson A.L. and 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, 815-822.
Abstract: In a prospective study by the Scoliosis Research Society, 286 girls who had adolescent idiopathic scoliosis, a thoracic or thoracolumbar curve of 25 to 35 degrees, and a mean age of twelve years and seven months (range, ten to fifteen years) were followed to determine the effect of treatment with observation only (129 patients), an underarm plastic brace (111 patients), and nighttime surface electrical stimulation (forty-six patients). Thirty-nine patients were lost to follow-up, leaving 247 (86 per cent) who were followed until maturity or who were dropped from the study because of failure of the assigned treatment. The end point of failure of treatment was defined as an increase in the curve of at least 6 degrees, from the time of the first roentgenogram, on two consecutive roentgenograms. As determined with use of this end point, treatment with a brace failed in seventeen of the 111 patients; observation only, in fifty-eight of the 129 patients; and electrical stimulation, in twenty-two of the forty-six patients. According to survivorship analysis, treatment with a brace was associated with a success rate of 74 per cent (95 per cent confidence interval, 52 to 84) at four years; observation only, with a success rate of 34 per cent (95 per cent confidence interval, 16 to 49); and electrical stimulation, with a success

rate of 33 per cent (95 per cent confidence interval, 12 to 60).(ABSTRACT TRUNCATED AT 250 WORDS)

O'Donnell C.S., Bunnell W.P., Betz R.R., Bowen J.R., and Tipping C.R. (1988) Electrical stimulation in the treatment of idiopathic scoliosis. Clin. Orthop. 107-113.
Abstract: Sixty-two fully compliant patients (with 94 curves) met protocol criteria of 20 degree-39 degree curves, Risser iliac crest signs of 0, 1, or 2, and no prior treatment. Both clinical and roentgenographic examinations were performed before, during, and after treatment. The follow-up periods averaged 2.3 years, with a 3.2-year average follow-up period for patients who completed, rather than failed, Electro Spinal Orthosis (ESO) treatment. Seventy-one percent of the 20 degree-29 degree curves and 66% of the 30 degree-39 degree curves had progressed 5 degrees or more at follow-up evaluation. Fifty percent of the patients had a follow-up curve of at least 40 degrees or were treated by posterior spinal fusion and were considered treatment failures. The curve progression paralleled that found in natural history studies, and the rate of failure exceeded that found in orthotic treatment studies

O'Malley T.J. (1992) A review of the functional electrical stimulation equipment market. Assist. Technol. 4, 40-45.
Abstract: The market for functional electrical stimulation (FES) equipment for use in rehabilitation is growing as increasingly sophisticated products enter the market each year. Factors that impact the availability of FES equipment include technological limitations, government regulation, reimbursement status, and clinician training. New products have become available in the last decade with many innovative applications available under investigational status. The current availability of FES equipment for selected applications such as therapeutic muscle stimulation, cardiovascular exercise, restoration of function in the lower and upper extremities, respiratory assist, restoration of bladder function, electroejaculation, and scoliosis correction is reviewed. A review of FES equipment for nonneuromuscular applications such as control of epilepsy, cochlear implants, electrotactile stimulation, and systems to enhance wound healing and bone growth is also included. Key manufacturers are identified

Peterson L.E. and Nachemson A.L. (1995) Prediction of progression of the curve in girls who have adolescent idiopathic scoliosis of moderate severity. Logistic regression analysis based on data from The Brace Study of the Scoliosis Research Society. J. Bone Joint Surg. Am. 77, 823-827.
Abstract: In a study conducted by the Scoliosis Research Society, 159 girls with a mean age of thirteen years (range, ten to fifteen years) who had adolescent idiopathic scoliosis were followed prospectively until skeletal maturity or until the curve had increased 6 degrees or more. All patients had had an initial curve of 25 to 35 degrees and an apical level between the eighth thoracic and first lumbar vertebrae, inclusive. Of the 159 patients, 120 were observed without treatment and thirty-nine were managed with lateral electrical surface stimulation. The curve progressed at least 6 degrees in eighty patients. There was no apparent difference in the outcome between the patients who were managed with observation only and those who were given electrical stimulation. Logistic regression analysis was performed to determine which of eleven factors were predictive of progression of the scoliotic curve. A Risser sign of 0 or 1, an apical level cephalad to the twelfth thoracic vertebra, and an imbalance of ten millimeters or less were found to be independently prognostic of progression of more than 6 degrees. A prognostic model that included

these three factors and chronological age allowed correct classification of the curve as either progressive or non-progressive in 81 per cent of these patients who had a thoracic or thoracolumbar adolescent idiopathic scoliosis. The positive predictive value was 82 per cent, the negative predictive value was 80 per cent, and the sensitivity and specificity were each 81 per cent

Rab G.T. (1979) Muscle forces in the posterior thoracic spine. Clin. Orthop. 28-32.
Abstract: Using a three-dimensional model, the theoretical maximal forces that can be generated by electrical stimulation of several posterior thoracic muscles have been analyzed to investigate the kinesiology of scoliosis. None provides a pure lateral bending moment, and most exaggerate lordosis. None satisfactorily generates a rotary force for correction of scoliotic deformity. Although maximum muscle contraction can ideally produce lateral bending moments of the same magnitude as the Milwaukee brace, current techniques do not cause continuous, complete muscle contraction. The best muscle studied for electrospinal intrumentation is the lateral erector spinae. Multiple sites of stimulating electrodes are probably necessary. None of the individual muscles studied is ideal. Further investigation should be directed to the stimulation of anterior thoracic muscles

Ray C.D. (1978) Electrical stimulation: new methods for therapy and rehabilitation. Scand. J. Rehabil. Med. 10, 65-74.
Abstract: Electrical stimulation is emerging as a new therapeutic and rehabilitative agent. Reviewed are pain control, restoration of lost functions and alteration of abnormal movement and other functions using electrical stimulation. Reported for acute and chronic pain control use are transcutaneous, dorsal column, spinal cord, peripheral nerve, and direct brain stimulation methods and results. Overall success ranges up to 50% for chronic pain problems and up to 80% for acute pain; e.g., postoperative incisional pain, sports medicine, and trauma. Restoration of lost function has broad implications for the future. These include phrenic nerve pacing for respiration, foot drop control, restoration of bladder function, and grasp control in the spinal cord-injured patient. Amelioration of abnormal function includes stimulation for epilepsy and cerebral palsy, certain symptoms of multiple sclerosis and scoliosis. The effects of electrostimulation are completely reversible and nondestructive. Technical details of devices and stimulus waveforms are also briefly considered

Rogala E.J., Drummond D.S., Gurr J. (1978) Scoliosis: incidence and natural history. A prospective epidemiological study. *J Bone Joint Surg* 60A, 173.

Schutt R.C., Jr., Brown C.W., Tiefel L.C., Odom J.A., and Donaldson D.H. (1982) Surface electrical stimulation for the treatment of scoliosis. Biomed. Sci. Instrum. 18, 83-85.

Swank S.M., Brown J.C., Jennings M.V., Conradi C. (1989) Lateral electrical surface stimulation in idiopathic scoliosis. Experience in two private practices. *Spine* 14, 1293-1295.

Velazquez R.J. (1986) Histological and histochemical characteristics of skeletal muscle after long-term intermittent electrical stimulation in scoliosis. *Orthop Trans* 10, 613.

Wright J., Herbert M.A., Velazquez R., and Bobechko W.P. (1992) Morphologic and histochemical characteristics of skeletal muscle after long-term intramuscular

electrical stimulation. Spine 17, 767-770.
Abstract: The purpose of this investigation was to examine the morphologic and histochemical characteristics of paraspinal muscles in patients with scoliosis after long-term electrical stimulation. Thirty-six children with idiopathic scoliosis, who had been treated with implantable muscle stimulators, had paraspinal muscle biopsies at the time of implantable muscle stimulator removal. Group A patients whose curve did not progress, had 2.9 years of stimulation stopped at skeletal maturity, with a further 1.5 years of nonstimulation before implant removal and biopsy. In group B patients, who had an average of 2.3 years of stimulation, the curve progressed and stimulation was continued until fusion and biopsy. Neither group showed any increase in the frequency of pathologic changes of paraspinal muscles contrasted with values reported in the literature for scoliotic muscle. In group A patients there was an increased proportion of type 1 fibers on the convex side of the curve compared to the concavity. Despite this finding the curves did not require fusion, suggesting that the increased percentage of type 1 fibers was not the cause of the scoliosis. In group B patients there was an even higher type 1 concentration on the convex side contrasted to the convex side of group A patients