The role of paraspinal muscles in the pathogenesis of idiopathic scoliosis: A preliminary EMG study

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The paraspinal muscles of ten patients with adolescent idiopathic scoliosis (AIS) and four normal healthy controls were investigated electromyographically during standing and locomotion. None of the controls and only three of the scoliotics showed EMG activity while standing. During locomotion, six patients showed a predominance of myoelectric activity on the convexity of the curve. This data suggests that bilateral muscle imbalances in patients with scoliosis are more readily distinguished by electromyography during locomotion than while standing. Furthermore, this study confirms previous reports that show a predominance of muscle activity on the convexity of the curvature in idiopathic scoliosis. (JCCA 1987; 31(4): 179–184)

KEY WORDS: scoliosis, muscle, electromyography, chiropractic, manipulation.

Les muscles para-vertébraux chez dix patients souffrant de scoliose idiopathique de l'adolescence (SIA) et de quatre contrôles de santé normale ont été étudiés à l'électromyographie en position debout et en locomotion. Aucun des contrôles et seulement trois des patients scoliotiques on démontré une activité EMG à la station debout. Durant la locomotion, six patients ont démontré une prédominance d'activité muoélectrique sur la convexité de la courbe. Ces données suggèrent que les déséquilibres des muscles bilatéraux chez les patients souffrant de scoliose sont plus facilement décelés par l'électromyographie à la marche qu'à la station debout. En sus, cette étude confirme les rapports précédents qui démontrent une prédominance de l'activité musculaire sur la convexité de la déviation dans la scoliose idiopathique. (JCCA 1987; 31(4): 179–184)

MOTS CLÉS: scoliose, muscle, électromyographie, chiropractique, manipulation.

Introduction

Adolescent idiopathic scoliosis (AIS) remains a clinically difficult problem for all physicians. Since the cause or causes of AIS remain unknown, treatment must be directed towards early recognition and prevention of curve progression. Some chiropractors claim to be able to correct spinal deformities such as AIS with various exercise and manipulative techniques. However, these claims have not been documented by clinical controlled studies; hence, it is difficult to decide on a reasonable course of chiropractic treatment. The situation is further complicated by the fact that the majority of curves under 20 degrees do not progress and many spontaneously improve without treatment. It is, therefore, questionable if treatment alters the natural history of curves under 20 degrees.[1]

In progressive curves over 20 degrees, only two treatments have shown to be effective in halting progression. The Milwaukee brace is used predominantly to halt progression of curves between 20 and 45 degrees. Beyond 45 degrees, the brace is not effective and surgical intervention is indicated. Electrical muscle stimulation has been advocated in curves less than 40 degrees, but its effectiveness has not yet been established.

It is not ethical to apply an unproven therapy in lieu of a proven therapy such as bracing. Hence, chiropractors need to be very careful in defining their goals in the treatment of these patients. There are two reasons why most AIS patients present themselves to chiropractic clinics. In the adolescent, deformity is of prime concern; once the curve has stabilized in adult life, mechanical back pain is the main reason for chiropractic consultation. In our experience, mechanical back pain in adults with AIS can be managed effectively by chiropractors in a majority of cases.[1,2] However, it is not yet known what role chiropractors can play in curve management. Until this role is better defined, we recommend that the chiropractor work closely with orthopaedic specialists.

A common denominator in many chiropractic approaches to AIS is muscle balancing and/or stretching techniques involving the paraspinal muscles. The purpose of this paper is to review the role of the paraspinal muscles in the pathogenesis of AIS and to present the results of a preliminary EMG study on the paraspinal muscles of 10 AIS patients and four asymptomatic controls.

Pathogenesis

Information about the pathogenesis of scoliosis is confusing, fragmented, and incomplete. Studies focusing on muscle pathology, connective tissue disorders, altered proprioceptive input, and disorders of skeletal growth are all weighted to lend credence to a particular school of thought. However, most experts would agree that AIS is a multi-factorial disease involving mostly genetic and growth factors, and that most of the connective tissue, muscle, and proprioceptive changes are secondary to the curve. This concept is reasonable when one considers the strong familial tendency of AIS,[3–7] as well as the changes which develop in the vertebrae and ribs from growth disturbances and changes in the internal architecture of bone.[8,9] Structural changes in bone, expressed in physiologic principles by the Heuter-Volkman Rule and the Julius Wolffe Law, help to explain the irreversibility of AIS by conservative treatments.

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The role of muscle in the pathogenesis of AIS is controversial. There are those who strongly believe that muscular imbalance is a primary cause of AIS. In fact, muscle imbalance is a known cause of several scolioses that can accompany various diseases (eg: poliomyelitis, cerebral palsy, and muscular dystrophy). Animal experiments have shown that unilateral denervation or resection of spinal muscles can produce spinal curvatures.[10–12]

Histochemical studies of the paraspinal muscles in scoliotics have been done. Initial studies showed a predominance of type 1 (tonic-postural) fibres on the convexity of the curve.[13] More recent controlled studies have shown a predominance of type 1 fibres in all paraspinal muscles in a normal population.[14] It is more likely that the apparent increase of type 1 fibres on the convex side of a curve is due to a real decrease of type 1 fibres on the concavity of the curve.[15] It is not known if these changes are a cause or an effect of spinal curvature.

Over the past four decades, there have been several extensive EMG studies of paraspinal muscle activity in scoliosis. The vast majority of these studies have been performed while the subject assumed various static postures such as standing, sitting, or lying prone.[16–23] There are no studies observing paraspinal muscle acticity in scoliotics during locomotion.

Riddle and Roaf did EMG examinations on 20 cases with paralytic thoracic scoliosis and 19 cases with idiopathic thoracic scoliosis.[16] Recordings were made during inspiration, expiration, head raising, and lateral flexion of the spine. In 15 of the 20 paralytic curves and 16 of the 19 idiopathic curves, the paraspinal muscles at the apex of the curve were significantly more active on the convex side. They concluded that the main deforming factor in all scolioses is the unopposed action of the deep rotating muscles on the convexity of the curve.

Zuk recorded EMG activity of the erector spinae in 112 scoliotic patients in the prone and upright positions.[22] The vast majority showed more acitivity on the convexity of the curve. The largest EMG activity occurred in patients whose curves progressed. Zuk interpreted this data to mean that the muscles on the convex side of the curve were weaker and that this was why the scoliosis progressed. He also suggested that the increased myoelectric activity in the muscles on the convex side was secondary to scoliosis and represented the body's attempt to correct the curvature.

Alexander and Season along with Donovan et al. disputed the finding that larger convex side myoelectric activity indicated curve progression.[20,23] They found their patients had EMG silence or bilaterally symmetric activity in the prone position and felt that previously observed prone position asymmetries in myoelectric activity were due to improper positioning of patients.

Reuber et al. found that EMG activity in patients whose curves progressed were not significantly different from activities in patients who did not progress.[24] They performed their analysis in a quantitative, controlled fashion with their patients performing 15 isometric exercises while standing and concluded that patients with curves of 25 degrees had significantly larger convex EMG activity. The authors felt that asymmetries in EMG activity were secondary to the curve and that scoliosis progression was not caused by asymmetry in muscle contractions.

EMG studies of the back muscles of scoliotics during gait have not been performed. Previous studies of the back muscles of normal controls during gait have shown that there are two periods of activity.[25,26] These occur at intervals of half a stride when the limb is fully flexed and fully extended at the hip at the beginning and end of the supporting phase, or at heel strike and toe off. There is no consistent difference in this biphasic activity from one side of the spinal column to the other. Both paravertebral muscle masses fire together and remain constant in their relationship to parts of the walking cycle.[27]

The purpose of the study was to perform a preliminary electromyographic study of the back muscles in patients with AIS during locomotion.

Materials and methods

Electromyographic potentials were recorded from the paraspinal muscles of 4 healthy controls and 10 patients with AIS. Of the 10 patients, 8 were female and 2 were male with ages ranging from 10 to 16 years (mean 13 years). The 4 controls were all females aged 12 to 13 years (mean 12.5 years). All the patients were recruited from a scoliosis clinic at the University Hospital.

The 10 patients had a total of 13 curves with Cobb angles ranging from 8 to 36 degrees (mean 20.6 degrees). Of these patients, 9 were untreated at the time of testing, while 1 had worn a Milwaukee brace for several months. Three more were subsequently treated for progressive scoliosis with a Milwaukee brace. Three patients had thoracic curves, 3 had double primary curves, 3 had thoracolumbar curves, and there was 1 lumbar curve.

Four pairs of surface electrodes were placed on the right and left sides of the thoracic and lumbar region, 3 cm lateral to the spinous processes. (Figure 1) Electrode level was determined by curve location so that electrodes were oriented 3 cm above and 3 cm below the apex of the curve on each side. For patients with a single curve, the second pair of electrodes were placed below the curve in the lumbar region and for the controls they were oriented above and below T6 and L3.

The EMG recording apparatus is shown in Figures 2 and 3. Recordings were made while the subjects stood at ease and walked on a treadmill at a natural cadence which varied from 2.5 to 3 miles/hour. The EMG was monitored in both raw and integrated forms on a storage oscilloscope and permanently recorded with a polaroid camera. The floor contacts of both feet were monitored on two separate channels by means of foot switches taped to the undersides of the shoes. Recordings were made at a standard sensitivity of 50 mv/unit at sweep speeds of 0.5, 0.2 and 0.1 sec/unit. The amount of EMG activity was estimated from the polaroids and graded on a scale from zero to 3+.

Figure 1 Electrode placement on a patient with AIS.

Figure 3 Illustration of patient, treadmill, and electrode placement.

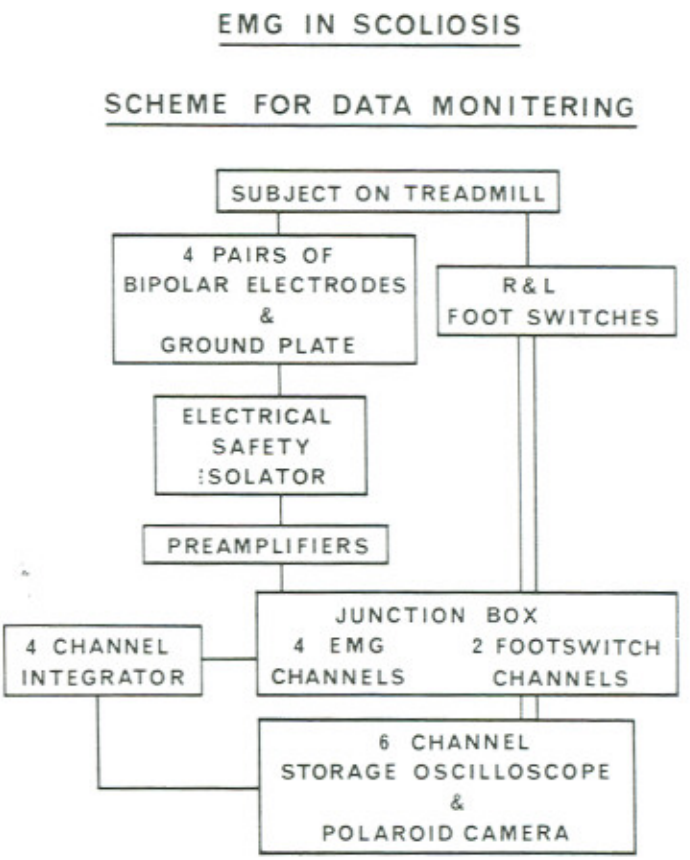

Figure 2 EMG in scoliosis – scheme for data monitoring.

Results

Controls

EMG recordings were made from four healthy adolescent females to provide experimental control. None of the control subjects showed myoelectric activity while standing. Recordings done during locomotion confirmed previous reports of equal, biphasic activity occurring bilaterally in the paraspinal muscles during each stride.

Scoliotics

The results of recordings made from the 10 patients with AIS are summarized in Table 1.

Three subjects showed EMG activity while standing at ease. Two of these 3 subjects, 1 with a lumbar curve and the other a thoracic curve, showed convex muscle activity; the third, with a double primary curvature, had concave muscle activity in the upper curve. This subject had a very progressive curve and subsequently required a brace. (Figure 4)

During locomotion, six patients showed a predominance of myoelectric activity on the convexity of the curve. The six included the one lumbar curve (Figure 5), all three thoracic

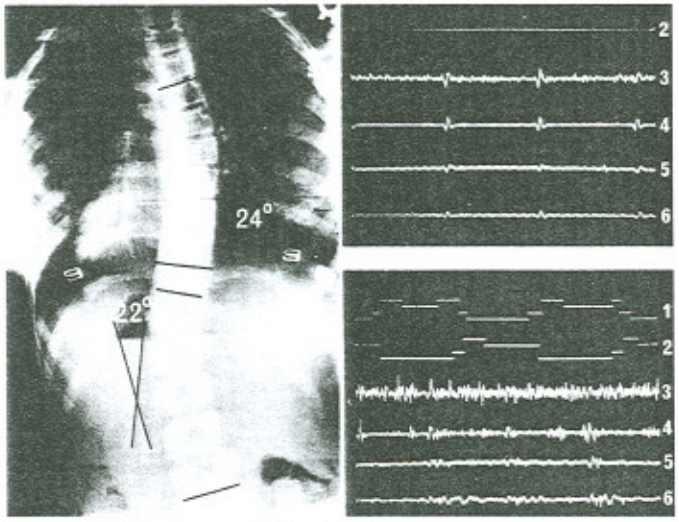

Figure 4 This 12-year-old female with a double primary curve of 24 and 22 degrees respectively showed concave myoelectric activity on channel three in the upper recording while standing at ease. In the lower locomotion recording, there was marked activity on the concavity of the upper curve on the concavity (channel 6). This patient's scoliosis proved to be very progressive.

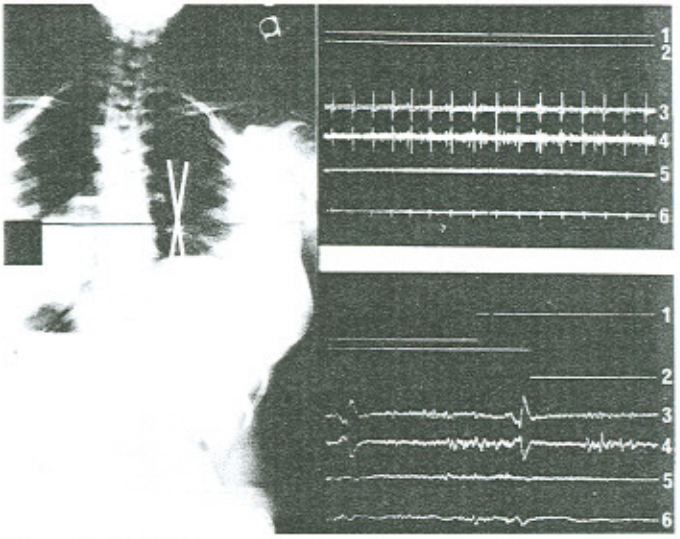

Figure 6 This 28 degree right thoracic curve in a 14-year-old female showed convex myoelectric activity while standing at ease, as seen on the upper recording on channel 4. In the lower recording, there is more activity on channel 4 again, indicating a predominance of convex activity during locomotion.

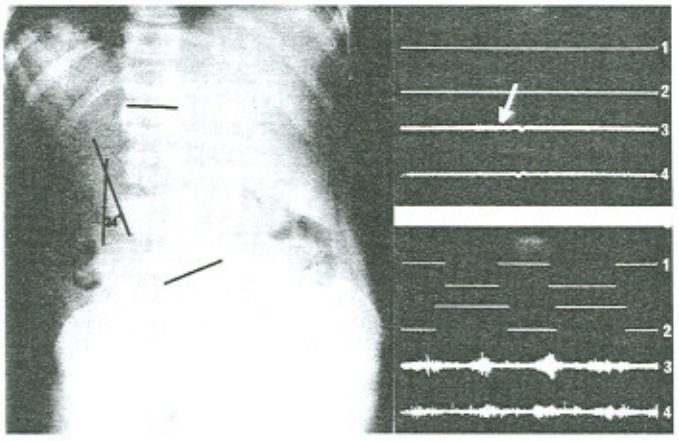

Figure 5 This 13-year-old male with a 24 degree convex left lumbar scoliosis showed periodic bursts of myoelectric activity in the convex paraspinal muscles while standing. This can be seen to the left of the heart artifact, at the arrow, on channel 3 in the upper recording. During locomotion his convex musculature is more active, as seen in the lower recording on channel 3 again. His scoliosis was progressive and he was eventually prescribed a modified Milwaukee brace.

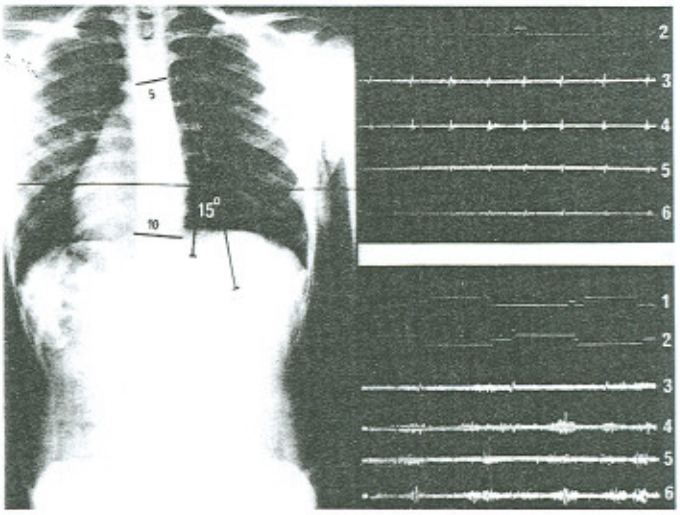

Figure 7 This 12-year-old female with a 15 degree right convex thoracic scoliosis showed an absence of myoelectric activity while standing and only heart artifact is visible in the upper recording. The lower recording, done during locomotion, shows a predominance of activity on the convexity of the curve (channel 4) compared to the concavity (channel 3).

Table 1 Estimated EMG activity in the paraspinal muscles of 10 patients with adolescent idiopathic scoliosis (activity graded from 0 to 3+)

Curves Subject Number	EMG Activity Standing		EMG Activity Walking	
	Concave	Convex	Concave	Convex
Lumbar				
– subject 1	0	+	++	+++
Thoracic				
– subject 1	0	0	+	++
– subject 2	0	0	+	++
– subject 3	0	+	+	++
Thoracolumbar				
– subject 1	0	0	++	++
– subject 2	0	0	++	++
– subject 3	0	0	+	++
Double Primary				
– subject 1 – upper curve	0	0	+++	++
– lower curve	0	0	++	+++
– subject 2 – upper curve	+	0	+++	++
– lower curve	0	0	+++	++
– subject 3 – upper curve	0	0	+	++
– lower curve	0	0	+	++

curves (Figures 6, 7), subject three of the thoracolumbar curves, and subject three of the double primary curves. Subject one and two of the thoracolumbar curves had equal biphasic activity. Both these curves were not of a very large magnitude (10 degrees, 8 degrees respectively). Subject one of the double primary category showed a predominance of activity on the concave side of the upper curve and the convex side of the lower curve. Subject two of the double primary category showed a predominance of activity on the concavities of both the upper and lower curves. This subject's curve was progressive (Figure 4).

Discussion

This preliminary report confirms previous reports that show there is a predominance of myoelectric activity on the convexity of the scoliotic curve in the majority of cases. However, 4 of the 6 patients with predominantly convex activity during locomotion were myoelectrically silent while standing at ease. It would appear that muscle imbalances are more readily distinguished during locomotion.

At the time of recording, only one progressive scoliosis was studied. (Figure 4) Both curves in this double primary scoliosis showed predominantly concave activity, leading us to wonder if this abnormal myoelectric finding was associated with curve progression. However, subsequent follow-up revealed progression involving brace treatment in another three of our patients; hence we cannot conclude that EMG is useful in delineating progressive from non-progressive AIS. However, this certainly warrants further investigation.

This study, as well as past evidence, indicates that the paraspinal muscles are predominantly active on the convexity of the curve. It remains unresolved if this phenomenon is a cause of an effect of the deformity; however, the weight of scientific evidence seems to favor muscle imbalance as a secondary change to other causes.

The early success of electrical stimulation is promising, but not proven; however, this treatment does indicate that the paraspinal muscles may be used to try to correct AIS, at least below 40 degrees. Most treatment regimens with electric stimulation are long and involved (similar to brace wearing) before results are seen. It is also interesting to note that exercise programs have been shown to be virtually useless in correcting the curvature of AIS.[28]

To our knowledge, no chiropractic technique involving balancing of the paraspinal muscles in AIS has ever been scientifically studied.

Conclusions

On the basis of these preliminary data, it appear that:

1 Bilateral muscle imbalances are more readily distinguished during locomotion than while standing.
2 In most instances, muscle activity tends to predominate on the convexity of the curves.
3 It seems reasonable, in view of current evidence about the pathogenesis of AIS, that muscle changes tend to be secondary to other causative factors.

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