MUSCLE IMBALANCE IN THE AETIOLOGY OF SCOLIOSIS
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At the apex of an idiopathic scoliotic curve there is a greater proportion of “slow twitch” muscle fibres in multifidus on the convex as compared to the concave side. To determine whether this represents a primary muscular imbalance relevant to the aetiology of idiopathic scoliosis or merely a secondary change, the lengths of multifidus on opposite sides of the curve were measured. Multifidus is shorter on the convex side. This is consistent with the theory of primary muscular imbalance, in which the more tonically acting muscle with its higher proportion of “slow twitch” fibres contracts and shortens as the deformity is produced. The paradox of multifidus being shorter on the convex rather than on the concave side is explained by consideration of its action.

Muscle imbalance has long been recognised as a possible aetiological factor in idiopathic scoliosis. Historical examination has revealed no differences between the muscles on opposite sides of a scoliotic spine (James, Lloyd-Roberts and Pilcher 1959). Histological studies, however, have demonstrated a consistently greater proportion of “slow twitch” as compared to “fast twitch” muscle fibres in multifidus on the convex side at the apex of the idiopathic scoliosis curve (Fidler, Jowett and Troup 1974). Whether this difference in muscle fibre distribution is a primary aetiological factor in scoliosis or is merely secondary to the development of the scoliosis must be determined. In either event, the muscles on one side of the curve will be of different length from those on the other side. If muscle imbalance is to produce a growth deformity in the spine it seems reasonable to assume that those muscles producing the deformity should shorten as the deformity develops. To determine the relationship between the difference in muscle fibre distribution and muscle length, the lengths of multifidus on opposite sides of the idiopathic scoliotic spine were measured.

MATERIAL AND METHOD

One cadaveric spine and the spines of two patients during spinal fusion, all with idiopathic scoliosis, were examined.

The lengths of multifidus were determined by measuring the distances between their bony origins and insertions. The tips of the thoracic transverse processes and the tip of the spinous process of the next but one cephalad vertebra were used as reference points.

On the cadaveric spine measurements were taken over the whole length of the curve. At operation, measurements were made only at the apex to avoid unnecessary delay, though it was obvious that the lengths of multifidus became progressively more equal from the apex to the extremities of the curve.

RESULTS

The cadaveric spine
An idiopathic scoliosis extended from the third to the twelfth thoracic vertebrae with the apex at the level of the eighth thoracic vertebral body; the convexity of the curve was to the right. The amount by which multifidus was shorter on the convex side at each level is shown in Figure 1.

\[ \text{FIG. 1} \]
Scoliosis in a cadaver. Histogram showing the amounts by which the multifidus muscle was shorter at each vertebral level on the convex as compared to the concave side of an idiopathic scoliosis curve which extended from the third to the twelfth thoracic vertebrae. The apex was level with the eighth thoracic vertebra.

Operation cases
Case 1—in this girl a juvenile idiopathic scoliosis extended from the fifth thoracic to the first lumbar vertebrae with the apex at the level of the ninth thoracic segment; the convexity of the curve was to the right; the maximum precorrection angle was 62 degrees; the angle at the time of operation was 25 degrees. The amount by which the multifidus was shorter on the convex side at the apex is shown in Table 1.

Case 2—in this boy an adolescent idiopathic scoliosis extended from the sixth thoracic to the second lumbar vertebrae with the apex at the level of the tenth thoracic

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vertebra; the convexity of the curve was to the right; the maximum precorrection angle was 106 degrees; the angle at the time of operation was 87 degrees. The amount by which the multifidus was shorter on the convex side at the apex is shown in Table I.

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<thead>
<tr>
<th>Case</th>
<th>Length of multifidus</th>
<th>Convex side multifidus shorter by</th>
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<tbody>
<tr>
<td></td>
<td>Convex side</td>
<td>Concave side</td>
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<tr>
<td>1</td>
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<td>3.8 centimetres</td>
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<tr>
<td>2</td>
<td>3.9 centimetres</td>
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**DISCUSSION**

The multifidus muscle is shorter on the convex than on the concave side of the idiopathic scoliotic curve. The difference is greatest at the apex and progressively decreases towards the extremities of the curve as shown in Figure 1. Even after partial correction of the curve this relative shortening of the convex side multifidus was easily measurable in the operation cases.

Although the major part of erector spinae is longer on the convexity, multifidus is shorter because the spinous processes are deviated to the convexity (Fig. 2) and the laminae and transverse processes lie more posteriorly on the convex side. The familiar appearance of the spinous processes lying in the concavity of the curve is a result of the rotation inherent in idiopathic scoliosis.

"Slow twitch" muscle fibres fatigue slowly and are used during sustained tonic activity, whereas "fast twitch" muscle fibres fatigue rapidly and are used for short-term phasic activity. The predominance of "slow twitch" muscle fibres in multifidus on the convexity at the apex of the curve suggests a tonic rather than a phasic function of this muscle. This is consistent with the greater electromyographic activity on the convexity found by Riddle and Roaf (1955) and Žuk (1962), though they interpreted their findings differently as to whether the muscles on the convexity were stronger or weaker. Although the actual relative strengths of the muscles on opposite sides of the spine are not known, it seems reasonable to assume that the muscles which contain a greater proportion of "slow twitch" fibres, and which may therefore be expected to exert a more sustained tonic action, should shorten whilst their more phasically acting opponents are stretched. The shortening of convex multifidus with its higher proportion of "slow twitch" fibres is consistent with muscle imbalance producing the deformity in which the more tonically active muscle contracts, and becomes shorter, as the deformity is produced.

Furthermore, while multifidus would be shorter on the convex side if the scoliosis was produced by some other mechanism, in such an event, the muscle, being passively shortened, should undergo the changes associated with this, namely, atrophy of "slow twitch" fibres (Engel, Brooke and Nelson 1966). The observed changes in the convex multifidus of shortening associated with an increased proportion of "slow twitch" fibres are unlikely therefore to be secondary to the development of the scoliosis.

Multifidus is only one of the muscles affecting spinal posture and before the role of muscular imbalance in the aetiology of idiopathic scoliosis is settled the other postural muscles need to be similarly examined. However, on the basis of the present study it is suggested that increased tonic activity of the deep medial paraspinal muscles, such as multifidus, on one side of the spine and a consequent effect on vertebral growth could be of importance in the aetiology of idiopathic scoliosis.

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**REFERENCES**


