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ELECTROMYOGRAPHY OF MUSCLES OF POSTURE: POSTERIOR VERTEBRAL MUSCLES IN MALES

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Previous investigations (Joseph, Nightingale & Williams, 1955; Joseph & Williams, 1957) have shown that a standardized posture such as the standing-at-ease position can be maintained as far as the lower limbs are concerned by the calf muscles and the ligaments of the knee and hip joints. Consideration of the relation of the line of weight to these joints, i.e. the perpendicular through the centre of gravity of the body, and the structure of the joints themselves can explain the mechanism for maintaining this posture. The vertebral column, however, with its curves, segmental structure and many muscles presents a much more complicated arrangement of joints, and it seemed possible that there would be differences in the activity of the muscles at various levels of the back. It was decided to investigate the posterior vertebral muscles at twelve levels between the upper part of the sacrum and the spine of the fourth cervical vertebra.

METHODS

The double-channel amplifier used was similar to that described previously (Joseph & Williams, 1957). It had a low noise level of 2 μV, so that the minimum detectable potentials were of the order of 3 μV peak-to-peak and had constant gain between 20 and 200 c/s, the response being reduced to one half at 4 and 700 c/s. The apparatus and subject were inside a screening cage in order to reduce interference. Surface electrodes retained in position by suction were used, and the electrode sites were rubbed with Cambridge electrode jelly.

The subjects were 20 males aged 18–46 years, of varied height and weight, with medical histories which suggested no abnormality of their locomotor system. They wore shoes and bathing trunks during the investigation. The position of the spine of every alternate vertebra from the fourth cervical to the second sacral was marked on the skin and the subject was asked to take up the standard posture (standing-at-ease position) which was used throughout the experiment. The electrodes were placed horizontally over the vertebral muscles at the level of the marked spines, one pair on either side about 2 cm from the mid line, with an interval of about 1 cm between the two electrodes of a pair. Frequently the electrodes were left in the same place for as long as 4–5 min and the oscilloscope was observed during the whole of this period. Typical recordings of what was seen on the screen were

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made at all twelve levels. In addition, the pairs of electrodes were often placed at two different levels of the same side and recordings were made.

The recordings were then examined and an assessment made of the amount of electrical activity shown: less than 5 μV peak-to-peak were graded as 'no activity', 5–25 μV 'slight activity', 25–70 μV 'moderate activity' and more than 70 μV 'marked activity'. Figure 1 shows some typical examples of the differences in activity at various levels of the vertebral column.

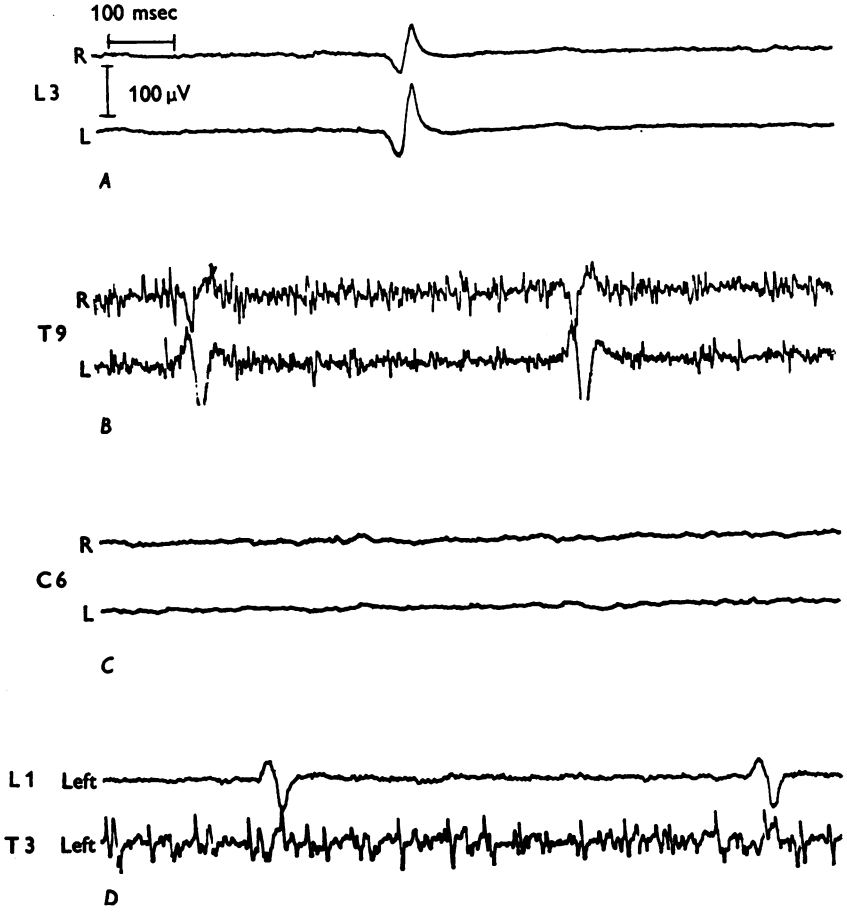

Fig. 1. Recordings from *A*, region of L3; *B*, region of T9; *C*, region of C6; *D*, (above) region of L1, (below) region of T3 of same side to show marked difference in activity at two levels.

RESULTS

Table 1 gives the details of the results (where there was asymmetry in the amount of activity, the greater has been recorded). It can be seen that there is considerable variation between different subjects at any one level. If however the activity in each subject is studied vertically a pattern

emerges in 15 out of the 20 subjects. In the lumbar region, usually at the level of the spine of the third lumbar vertebra, there is little or no detectable electrical activity as compared with the lower thoracic region (the spine of the ninth or eleventh thoracic vertebra). Higher up the detectable activity decreases and no, or only slight, electrical activity is found in the lower cervical region (the spine of the fourth or sixth cervical vertebra).

TABLE 1. Electrical activity* in the posterior vertebral muscles at 12 levels of the vertebral column in 20 subjects while standing at ease

Vertebral level	Subject 1	2	3	4	5	6	7	8	9	10
C4	+	+	++	+	−	++	+	+	−	+
C6	+	++	++	−	+	+++	++	+	++	+
T1	+	++	+++	++	++	+++	++	+	++	++
T3	+	+	+++	++	++	++	++	+	++	++
T5	++	+	−	+++	−	++	++	+	+	+
T7	+++	+++	−	++	−	++	++	++	++	++
T9	+++	+++	−	++	+	++	++	++	++	−
T11	++	+++	+	++	++	++	++	++	++	−
L1	++	+++	+	++	++	++	+	++	−	−
L3	+	+	+	+	−	+	−	+	−	−
L5	+	+	+++	++	−	++	−	+	−	++
S2	+	+++	++	−	+	+++	−	−	+	−

Vertebral level	11	12	13	14	15	16	17	18	19	20
C4	+	+	+	+	−	+	+	+	+	+
C6	+	+	+	+	+	+	+	+	+	+
T1	+	++	+	+	++	+	+	+	+	+
T3	+	++	+	+	−	+	+	+	+	+
T5	+	+	++	+	−	+	+	+	++	+
T7	+	++	++	+	−	++	+++	+	+++	−
T9	+++	++	+++	+++	+	++	+++	+++	+++	−
T11	+++	+	++	−	+	+	++	++	+++	+
L1	+++	+	+	−	+	−	+	++	++	+
L3	++	−	+	−	++	−	+	+	++	+
L5	+	−	+	−	++	+	+	++	+	+
S2	++	+	++	+	+++	+	+++	++	++	++

* − < 5 μV; + 5–25 μV; ++ 25–70 μV; +++ > 70 μV.

DISCUSSION

These results indicate that in the standing-at-ease position the activity of the posterior vertebral muscles varies at different levels. Other workers have usually studied only one region. Åkerblom (1948) found considerable variation between his subjects when he placed the electrodes over the middle of the lumbar region on one side. Floyd & Silver (1955) found little or no activity with the electrodes over 'the most prominent parts of the thoraco-lumbar and lumbar erectores spinae muscles' and Portnoy & Morin (1956) found that 12 out of 16 subjects showed activity in the lumbar region. They, however, placed one electrode at the level of the first lumbar vertebrae and the other at the level of the third. It is not surprising that

they detected some activity in many of their subjects, since the electrodes covered a comparatively wide area.

The differences in muscular activity at various levels may be due to the fact that the line of weight of that part of the body above the level studied lies in front of or behind the transverse axis of the joints between the vertebrae at which flexion or extension is taking place. Examination of a lateral X-ray of the vertebral column indicates that the line of weight of the segment of the body above the lumbar region passes *behind* the transverse axis of the joints between these vertebrae so that the trunk is extending in the lumbar region under the influence of gravity, and the extensors, i.e. the posterior vertebral muscles, are inactive. In the lower thoracic region the reverse is happening and the line of weight passes *in front of* the transverse axis of these vertebral joints. Consequently the posterior vertebral muscles of this region contract and resist flexion of the trunk.

It is more difficult to explain the absence or slight activity of the muscles of the cervical region, since a perpendicular through the centre of gravity of that segment of the body above the seventh cervical vertebra, as determined by Dempster (1955), passes in front of the vertebral bodies and therefore in front of what is probably the transverse axis of movement between adjacent cervical vertebrae. An attempt to find this axis by means of cineradiography and an analyser projector confirmed this. The likeliest explanation is that only slight muscular activity is required to supplement the passive structures (intervertebral disks, ligaments, etc.) which resist flexion of the neck in the standing-at-ease position.

The relatively small amount of activity detected in the posterior vertebral muscles in the lumbar and cervical regions while standing fits in with the observations of Hellebrandt, Brogdon & Teffer (1940) and Booyens & McCance (1957), who found that there was only a small increase in the basal metabolic rate of healthy men and women when standing as compared with the rate when lying down and that any muscular activity increased the rate very considerably.

SUMMARY

1. The activity of the posterior vertebral muscles at twelve levels in 20 males standing at ease has been studied by means of electromyography.

2. Although there is considerable variation in the detectable activity at one level, a pattern of activity in a vertical direction can be seen. There is little or no activity in the lumbar and cervical regions and moderate or marked activity in the lower thoracic.

3. The possible explanation of these observations is discussed.

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