EMG and near-segmental kinematic analysis during lateral bending in the preoperative evaluation of patients with adolescent idiopathic scoliosis

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Introduction

In adolescent idiopathic scoliosis (AIS), surgical planning relies presently on spinal flexibility as evaluated from radiographs obtained when the subjects perform a lateral bending (Kleinman et al., 1982, Vaughan et al., 1996, Cheung et al., 1997, Mason et al., 1998, Beauséjour et al., 1999, Vedantam et al., 2000). This approach has several limitations: use of only static planar images, administration of ionising radiations, poor reliability and reproducibility of classification systems (Aronsson et al., 1996, Lenke et al., 1998) and difficulty with instrumentation planning. In this context, our aim was to propose a non-invasive and dynamic test. It consists of investigating near-segmental trunk kinematics and back muscle activity during a dynamic lateral bending before surgical correction. It is hypothesised that such evaluation can provide useful and additional information to those obtained presently.

Methods

During repetitive trunk lateral bending, erector spinae (18 sites) and abdominal (4 sites) muscle activity (EMG) was sampled with surface electrodes (Nutab, Ag/AgCl, 10 mm diameter) placed parallel to main muscle fibre direction (20 mm centre-to-centre). Electrode locations are shown in figure 1. A 24-channel system (20 MΩ input impedance, CMRR = 30000:1 at 90 dB, gain = 1000) was used with a 16-bit data acquisition board (A/D = 2000 Hz). EMG signals were band-passed filtered (Butterworth 10 to 350 Hz) motion artefacts were removed and root-mean squared (rms) values obtained from consecutive 50 ms intervals. Simultaneously, the spatial displacements of 14 photo-diodes located over the spinous processes of T1, L5, apical and limit vertebrae, the acromions, rib hump and pelvis (figure 1) was tracked at 50 Hz with 3 cameras. For EMG signals, the ratios between left and right rms values at each site and activation period were considered. For kinematics, total lateral bending and Cobb angle (angle between the lines perpendicular to the spinal curve at the end vertebrae) and Fergusson angle (angle between the two lines joining the end and apical vertebrae) evolution. This protocol was assessed in 10 AIS patients and in 10 healthy controls. An ethical committee approved the protocol and all participants gave their informed consent.

Figure 1. Location of photo-diodes (left) and electrodes (middle and right)
Results & Discussion

The feasibility of the approach is shown on data analysis obtained in AIS patients and healthy controls. For instance, figure 2 presents apical muscle activity and Fergusson angle course during a left lateral bending task in a scoliotic patient. It could be shown that individual alterations in muscle activity were associated with jerks in Cobb or Fergusson angle evolution.

*Figure 2*: Course of apical muscle activity (T8 and L1) and thoracic and lumbar Fergusson angles during left lateral bending in a AIS patient. Note the presence of jerks in Fergusson angle course. Little activity in lumbar erectors was observed. This is in contrast with a heterolateral (right, convex) thoracic erector activity during the second half of bending. However left thoracic erectors did not show a major activity in this patient.

Comparison between EMG patterns obtained in healthy volunteers and in AIS patients were carried out by comparing the ratios of heterolateral to homolateral rms values for a lateral bending task. Maximal apical muscle activity ratios (sites at T8/T10 and L1/L3) during left bending tasks (figure 3) showed a significant increase of relative heterolateral (thoracic convex, lumbar concave) extensor activity in the AIS (p<0.05 - Student’s t-test). This result confirms the predominance of thoracic convex muscles shown by previous studies (Alexander et al., 1978, Guth et al., 1978, Donovan et al., 1980, Reuber et al., 1983, Hopf et al., 1998, Avikainen et al., 1999, Gram et al., 1999, Mooney et al., 2000).

*Figure 3*: Ratios of heterolateral to homolateral rms values of trunk muscles during a left lateral bending. * = significant difference between AIS and control groups (p<0.05 - Student’s t-test)
Sampling of trunk EMG in AIS patients during dynamic motions has been obtained in only a few studies (Guth et al., 1978, Hopf et al., 1998, Gram et al., 1999, Mooney et al., 2000). In this preliminary study, a non-invasive and non-irradiating dynamic evaluation protocol of the scoliotic spine was evaluated, for preoperative evaluation in AIS. Preliminary results suggest the existence of segmental discontinuities during lateral bending in AIS, however further studies are needed to relate these observations to clinical, static data. Increase in the study sample and assessment of the relationships to parameters presently used in preoperative decision making and postoperative outcome are in progress.

References

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