EMG STUDY OF BACK MUSCLES IN PATIENTS WITH DUCHENNE DYSTROPHY

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Abstract

We have measured the electromyographic (EMG) activity of 10 patients suffering from Duchenne muscular dystrophy (DMD) that were performing isometric force tasks with their paraspinal muscles. No difference between the right and left muscle activity was found in the healthy subjects and the 5 DMD patients without scoliosis. The 3 patients with < 10° of Cobb angle showed a higher EMG on the concave side of their curve while one patient with a 15° scoliosis had a higher muscular activity on the convex side of his deformation. These preliminary results suggest that more activity on the concave side of the spine could be at the origin of the scoliosis in DMD patients while later on, a correction mechanism would tend to oppose the deformation.

Introduction

Duchenne muscular dystrophy implies progressive muscle weakening. Most of the DMD patients will develop a progressive collapsing scoliosis shortly after being confined to a wheelchair [2]. With idiopathic scoliotic patients, numerous studies have shown that EMG activity is higher on the convex side of the scoliotic curve and that asymmetry was correlated with the severity of the deformity [3]. The objective of our study was to characterize the paraspinal muscles EMG activity of patients with DMD in order to analyze how these muscles could be implicated in the initiation of scoliosis.

Materials and Methods

Our 10 DMD patients were boys between 10 to 17 years old either ambulant or wheelchair dependent and were able to stay in a sitting position on a backless bench. Three healthy asymptomatic boys with structurally normal spines, similar body mass index (BMI) and age were chosen as a control group.

Data acquisition was done while the subject is sitting on a low back chair. An inextensible harness was put at the shoulder level and linked to a fixed point on the ground through a steel cable. A strain gauge inserted between the cable and the point of fixation was used to measure the force generated and to provide a visual feedback to the subject. The subjects were asked to perform three task which consisted in resisting to a front pull, to a right pull and to a left pull. For each of these tasks, the maximum voluntary contraction (MVC) was determined by the mean value of 2 maximum contractions by the patient. The subjects were then asked to perform contraction at 70% and 85% of the MVC established for each different task. Each 5 s long contraction was repeated 3 times at the 2 levels of contraction and for the 3 directions of the pull. Infrared markers placed on the two scapulas were used with a motion analysis system to check that no trunk movement occurred during the tasks that were designed to be isometric and isotonic.

Eleven bipolar EMG signals were recorded with surface electrodes (10 mm of diameter, 20 mm center-to-center). The electrodes were placed on the iliocostalis and on the longissimus dorsi muscles at T10 and L1 levels and on the common mass at L5 level. Electrocardiographic (ECG) activity was recorded and used to filter cardiac activity from EMG signals when necessary. A reference electrode was positioned over the olecranon. To evaluate the noise level and the stability of the electrode recording systems throughout the tests, EMG signals were recorded at the beginning and at the end of each experimental session while the subject was in a relaxed resting position. The gain of the amplifiers (model 15A54, Grass-Telefactor, West Warwick, USA) was set at 2000 and a bandpass filter of 3-1000 Hz was used. Signals were digitized online with a data acquisition card (Model PCI 6033E, National Instruments Inc., Austin, TX) at 2000 Hz under the control of a user interface (Labview, National Instruments Inc., Austin. TX). Prior to analysis, EMG signals were filtered to eliminate interference from 60 Hz, ECG activity, motion artifacts and baseline drifts. Root mean square (RMS) values of the EMG signals of each recording site were calculated for each subject. A right/left ratio for non-scoliotic subjects and a convex/concave ratio for the others were used to identify any imbalance in EMG activity.

Results

Mean age of the 10 patients was 14.2 ± 2.2 years. Their BMI ranged from 16.3 to 36.2 while those of the 3 control subjects varied between 20.4 and 28.4. Among our patients, five did not showed any sign of spinal deviation, three could not be considered scoliotic with a Cobb angle <10° but are qualified as pre-scoliotic here. Finally, two patients had a right thoracic scoliosis

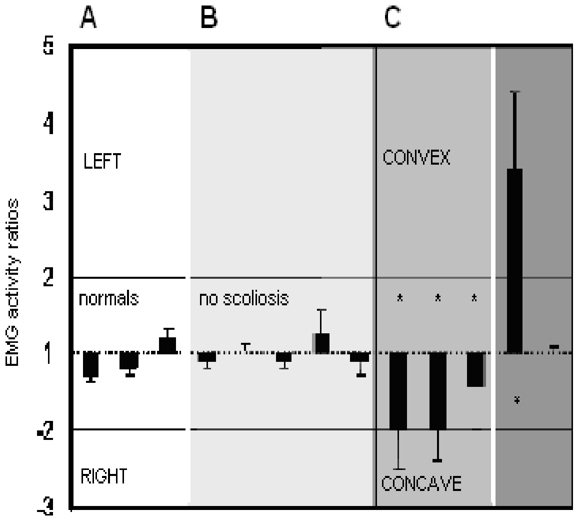

Figure 1: A; *EMG activity ratio (left/right side of the spine) for 3 normal subjects and 5 DMD patients without scoliosis.* ***B:*** *convex/concave ratio for the 3 pre-scoliotic patients* ***C:*** *same ratio for the 2 scoliotic DMD patients. *p<0.053.*

(15° with the apex at T9 and 22° with the apex at T8). During all contractions, the force developed stayed within ±10% of the target value and the trunk remained within 1.5 cm of its initial position. Considering the physical condition of the patients, those contractions were considered to be isometric and isotonic. In the lateral bendings the muscles on the side of the bending are more active than those on the other side except for the scoliotic patients who showed greater EMG activity on the convex side no matter the side of the bending.

In the task where resistance to a forward pull was produced, no significant difference was observed between the right and left signals of the control subjects and of the five non-scoliotic patients (Fig.1A). As for the patients with pre-scoliosis condition, a higher EMG activity on the concave side of their curve was observed (Fig.1B). The difference is significant for these three patients if a $p<0.053$ is considered. In average, RMS values at the concave side were twice higher than on the convex side. For one of the scoliotic patients, a significant increase in muscular activity ($p<0.01$) was detected at each recording site on the convex side of the spinal curve (except for the iliocostalis at L1 level) at both 70% and 85% MVC. For this patient, mean EMG activity of all signals on the convex side was 3.4 times higher (Fig.1C) than on the concave side. As for the other scoliotic patient, EMG levels were quite low and no significant difference between the right and left paraspinal muscle activity was found.

Discussion

While resisting to a forward pull, back muscles on the left and on the right of the spine were similarly active in healthy subjects and in non-scoliotic patients. Unless differences could exist above T10 where no electrode was placed, the eventual development of a spinal deformity in these patients does not appear to be associated to a pre-existing state of asymmetry in the EMG activity. As for the pre-scoliotic patients, it can be hypothesized that a larger muscular activity on the concave side (or weaker one on the convex side) could be an initiating factor leading to the buckling of the spine on the opposite side. The situation was different for the patient with a 15° scoliosis: paraspinal activity was significantly higher on the convex side of the deviation in agreement with results obtained with adolescent idiopathic scoliotic subjects. It would seem that following its initiation, a compensating mechanism would be set in place to counteract the progression of the spinal deformation. An uneven motoneurons input [1] is one of the various hypotheses put forward to explain this EMG asymmetry. As for our other scoliotic patient, his BMI was the second highest (29.1) in the group and his 100% MVC was the lowest in each task. The difference that could have been observed at the muscles level was probably filtered out by the fat layer separating them from the skin surface.

Conclusion

From these preliminary results, it seems that scoliosis in DMD patients could be induced by a higher paraspinal activity on one side of the spine that would lead to its bending on the other side. As the deviation progresses, a higher muscular activity would eventually appear on the convex side as a mechanism to counteract its progression. Data collection is under way with new patients to get additional evidence on these aspects. The patients will also undergo the same protocol in one year so that we can monitor the evolution of his spinal deformity in relation with his muscular development.

References

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Acknowledgements

Work supported by CIHR, MDAC and ALS.