Integrated Assessment of Back Muscles Bioelectrical Activity and H-reflex Research in AIS

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Abstract. The study of the back muscles bioelectric activity in 216 children of 10-15 years old showed that the paravertebral muscles total bioelectrical activity on the convex side of the curve top and on the concave side of its caudal part is higher compared with that on the opposite side. Investigation of H-reflex and M-response in 302 patients of 10-15 years old has created a normative database. Its comparison with the totality of the specific patient's individual electrophysiological parameters makes to determine his progression group possible.

Keywords. AIS, ENMG, back muscles bioelectric activity, H-reflex, M-answer

Introduction

Electroneuromyography (ENMG) gives an opportunity to evaluate the functional state of neuromuscular system. However, application of ENMG for the AIS clinical features and prognosis progression assessment is difficult. Therefore, the main goals of our work were: the first – to clarify the methods of back muscles bioelectric activity (BEA) integral evaluation depending on the type of scoliosis, location and magnitude of the curve; the second – to estimate the prevalence of cerebral or spinal mechanisms in formation and progression of the curve using the H-reflex technique; and the third – to identify the presence and interdependence of the surface and stimulation ENMG parameters data to optimize the list of ENMG parameters.

1. Materials and Methods - I

216 children were examined: 32 healthy children and 184 with the curve value of 5-100º on Cobb with right- (67%) and left-sided (33%) AIS forms (mean age 12,6±1,9 years old, 93% - girls). The curve top at Th_{VII-IX}, Th_{XI-XII}, L_{I-II} were in 47%, 20% and 33% of cases respectively. The muscles BEA was recorded using bipolar cutaneous electrodes with interelectrode distance of 3cm located paraspinal, at 3cm and 6cm lateral to the right and to the left of the spinous processes (at Th_{VII}, Th_{XII}, L_{II}). Electromyograph "Neuromian" (firm "Medikom LTD", Taganrog) was used. The bandwidth of signal was 10Hz-2kHz. The total BEA (in mV*sec) was recorded three times in a lying posture of patient when the test motion performes duration of 5 seconds, with an interval of 15 seconds. Data of each point of the recording were

averaged, asymmetry coefficients (AC) were calculated: the ratio of the BEA average value on the curve convex side to the BEA average on the concave side at symmetric points of registration. The results were processed with «Statistica» 6.0 and 6.1.

2. Results and Discussion - I

AC were calculated separately in the right thoracic scoliosis group (Table 1 an example of summarized results), right-sided lumbar group, left-sided thoracic and lumbar scoliosis group.

Table 1. The asymmetry coefficient (AC) of integral EMG (M±m) in patients with right-sided scoliosis.

	AC Th_{VII-IX}			**AC Th_{XI-XII}**			**AC L_{I-II}**		
	1	2	3	1	2	3	1	2	3
Control group. (32 people)	1,09 ±0,06	1,06 ±0,06	0,98 ±0,05	1,01 ±0,03	1,03 ±0,05	1,08 ±0,07	1,01 ±0,08	0,99 ±0,05	1,02 ±0,06
5-10º (6 people)	1,42 ±0,16	1,11 ±0,11	1,15 ±0,12	1,12 ±0,06	1,24 ±0,11	1,32 ±0,13	0,97 ±0,04	0,8 ±0,07	1,04 ±0,06
10-25º (27 people)	1,29 ±0,09	1,23 ±0,09	1,15 ±0,11	1,16 ±0,11	1,18 ±0,09	1,3 ±0,11	0,93 ±0,04	0,99 ±0,01	1,25 ±0,23
25-50º (36 people)	1,48 ±0,11	1,52 ±0,16	1,31 ±0.09	1,21 ±0,07	1,52 ±0,11	1.92 ±0,17	0,91 ±0,05	1,17 ±0,12	1,27 ±0,14
>50º (18 people)	1,78 ±0,37	1,86 ±0,67	1,67 ±0,28	1,32 ±0,29	1,67 ±0,4	1,97 ±0,36	0,81 ±0,13	1,11 ±0,3	1,31 ±0,32

In calculations held on nonparametric Spearman correlation method ($p<0,05$) the trend to AC increase was revealed as the deterioration of condition and progression process, particularly at the curve top in the 1st point of registration. Patients with the curve top at Th_{VII-IX} has the highest correlation coefficients between the AC at the curve bottom and progression character, as in the studies [1,2,5]. In this case the AC at the curve bottom (at L_{II}) is negative. It isn't observed in the EMG recording at other levels. An AC under deformation degree increase is observed not only in the paraspinal region, where it reflects mainly the muscle-rotators activity. The same pattern is also in the 2nd and 3rd points of registration. In these areas the activity of mm.latissimus dorsi, m.trapezius, the muscles of the scapular region (mm.infraspinatus, m.rhomboideus major) and, apparently, m.obliquus externus abdominis is basically recorded, perfoming a compensatory role of derotators on the convex side of the curve and rotator's role – on the concave side. Discriminant analysis showed the coincidence of the classification carried out only on the EMG parameters, with clinical and radiological data, depending on the curve size and type of the AIS in 72-90% of cases. It indicates a specific EMG pattern for each of the scoliosis form.

Revealed asymmetric paraspinal muscle EMG changes in AIS imply asymmetric changes in the activity of spinal motoneurons that innervate these muscles. Therefore, in the second part of the study the carry possibility of H-reflex and M-response parameters the soleus (less cortikolise) and gastrocnemius (more cortikolise) [4] muscles to the excitability of motoneurons that innervate the paraspinal muscles change, depending on the severity and nature of progression investigated.

3. Materials and Methods - II

Results of the H- and M- responses study for 302 girls of 10-15 years old with the curve top at Th_{VII-IX} (94 children, 31%), Th_{XI}-L_I (104 children, 34%), L_{I-II} (105 children, 35%) and 15 healthy children were analyzed (table 2). The average curve value on Cobb for the group was 26,17º±18,91º (5-100º). In the group with progressive form average curve was of 39,1±16,98º (12-100º), in a rapidly progressive form group – 14,24º± 7,5º(5-45º), in a non-progressive form group – 6,96º±1,83º(5-12º).

Table 2. The distribution of patients with AIS in the treatment groups by the nature of the progression of scoliosis.

Type of scoliotic deformation / Severity stage	Right-side forms		Left-side forms
	Curve top Th_{VII-IX}	Curve top Th_{XI}-L_I	Curve top L_{I-II}
Rapidly progressive forms	75 (80,7%)	44 (42%)	51 (48,6%)
Progressive forms	16 (17,2%)	39 (37,5%)	36 (34,3 %)
Non-progressive forms	2 (2,2%)	21 (20,2%)	18 (17,1%)
Total	93	104	105

Electromyograph "Neuro-MVP-04" (firm "Neurosoft", Ivanovo) was used. The study was conducted in the standard position [10]. Bipolar stimulating electrodes were used. The stimulation of the nerve in a standard single-point rectangular pulses of 0,2 ms, stimulus frequency of 1 in 10 seconds, with a consistently growing up from subthreshold to supramaximal intensity. Signal bandwidth was of 20Hz-10 kHz. The bipolar registration electrode was located in the motor points of the MGM and the SM.

4. Results and Discussion - II

In general, H/M of MGM and SM in the group of healthy subjects were higher than in the group of children with AIS (tab.3). The analysis held by Wilcoxon test for sub-groups showed a statistically significant asymmetry between convex and concave side of curve only in right-side thoracolumbar scoliosis group and in the left-side lumbar scoliosis group with the non-progressive course ($p<0,0046$ and $p<0,026$ respectively).

Table 3. The distribution of patients with AIS in the treatment groups by the nature of the progression of scoliosis.

	Number of observed	M±m	Median	Minimum	Maximum	σ
Right MGM	302	20,9±0,8	17,3	1,2	90	14,5
Left MGM	302	20,5±0,8	16,2	1,6	98	14,6
Right SM	302	44,3±1,2	43,8	1,5	100	22,0
Left SM	302	45,3± 1,3	44,2	0,0	99	22,2

H/M asymmetry on the convex and concave side of the curve in patients with right forms of scoliosis in the curve magnitude of 5-25º and its absence in the magnitude of the curve of more than 25º were found. The H/M values for both left and right MGM and right and left SM in all treatment groups had a tendency to grow as the worsening

condition and character progression, especially in right-sided thoracic and thoracolumbar scoliosis groups. In this case, our results are consistent with [3] on the left-sided lumbar scoliosis. In our study H/M amounted in healthy children 55-57% on SM, M±m=25,8±3,2 and 22,1±2,9 respectively on the right and left MGM in contrast to published in the literature [6]. It indicated the predominance of spinal abnormalities of the investigated groups in either it shows the reaction mechanisms of spinal cord on the pre-existing strain. Using the Mann-Whitney and Wald-Wolfowitz criteria differences between healthy subjects and patients with right forms of AIS were revealed, as well as between right- and left-sided forms of AIS in condition of separate treatment of patients, depending on the location of the curve top. The results of Spearman, Kendall-tau and gamma-statistics techniques correlation analysis in groups of right- and left-sided scoliosis, depending on the curve top and progression character were refined using the variance and discriminant analysis (this method was validated on the same sample using apriori classification). All this give opportunity to speak only about the degree of probability of right-side scoliosis progression if H/M on left MGM increase in the dynamics in combination with H/M decrease on the right SM, and of left-side scoliosis progression – if an H/M increase on the right MGM, in conjunction with the decrease of H/M on the left SM.

5. Conclusion

The study found the paravertebral muscles total bioelectrical activity was higher on the convex side of the curve top and on the concave side of it caudal part compared with that on the opposite side. Of great importance is the registration of the stages of deformation processes phases. The progression process is reflected in the mean-group H/M data in a single study, however is inadmissible the use only H/M responses ratio. Comparison of patient's electrophysiological individual parameters with data contained in the standard database makes it possible to define the group on the basis of progression with a high degree of probability.

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