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POSTURAL CONTROL IN SCOLIOSIS

A Statokinesimetric Study in Patients with Scoliosis due to Neuromuscular Disorders and in Patients with Idiopathic Scoliosis

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Statokinesimetric characteristics were analysed in patients with scoliosis which had developed in the course of degenerative neuromuscular disorders and in patients with adolescent idiopathic scoliosis. Patients with Duchenne and limb-girdle muscular dystrophy and spinal muscular atrophy showed markedly decreased oscillations of the body's centre of gravity, in addition to a forward shift of its mean position. Thus the postural equilibrium in neuromuscular patients with scoliosis is even more efficiently controlled than normal. On the other hand, patients with idiopathic scoliosis did not show any significant changes as compared with normal subjects. The present study therefore does not support the suggestion that the pathogenesis of scoliosis, at least in neuromuscular patients, is triggered by an impairment of descending postural control.

Key words: equilibrium; neuromuscular disorders; posture; scoliosis; statokinesimetry

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Several authors have suggested that an important role in the pathogenesis of scoliosis may be played by disturbed descending postural control (Yamada et al. 1969, Yamamoto & Yamada 1975).

In this study, statokinesimetry was used to investigate postural control in patients with scoliosis which had developed in the course of degenerative neuromuscular disorders, as well as in patients with adolescent idiopathic scoliosis. The method allows one to estimate the position and movements of the centre of gravity of the body (Baron et al. 1956). The purpose of the study was to see whether the postural control in these patients deviated sufficiently from the normal to be interpreted as pathogenetically important. Some of the results have already been reported (Gregorič et al. 1977, Gregorič et al. 1978, Dimitrijević et al. 1979).

A similar study of postural equilibrium in adolescent idiopathic scoliosis was recently published by Sahlstrand et al. (1978).

PATIENTS AND METHOD

Fifty-four patients with scoliosis or nonscoliotic curvature of the spine, which had developed in the course of the four commonest progressive degenerative neuromuscular disorders, were included in the study (Table 1). Of these, 37 had scoliosis and the remaining 15 had nonscoliotic curvatures. The criterion for scoliosis was rotation of the bodies of the vertebrae to the convex side. Conversely, a spinal curvature with rotation of the bodies of the vertebrae to the concave side was categorized as nonscoliotic curvature. The scoliotic curves ranged between 4° and 21° (according to Cobb) mean 9.7. Twenty-four of the scoliotic patients were in their growth period, aged 5 to 18 years, mean 11.2 years.

While all of these patients were ambulatory, some (23 out of the 37) were studied in a rather early stage of their disorder, with locomotion status ratings between 1 and 4 (Gardner-Medwin & Walton's (1974) modification of Vignos & Archibald's (1960) scale).

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Table 1. Patients included in the study

Disorder	No. of patients	No. in growth period	No. with scoliosis	No. with nonscoliotic curvature
Limb-girdle muscular dystrophy	13	1	11	2
Duchenne muscular dystrophy	8	8	4	4
Spinal muscular atrophy	20	10	16	4
Peroneal muscular atrophy	13	5	6	5
Idiopathic scoliosis	22	22	22	0
Total	76	46	59	15

In addition, 22 patients with idiopathic scoliosis were studied, all of them being in their growth period. Their ages ranged between 8 and 17 years, mean 13.1 years. The curves ranged between 3–30° (Cobb) mean 10.5°, and were mainly thoracic, 10 right, 7 left and 5 double. (In those patients with the smallest curves, 3–5°, further progression showed that they had true scoliosis.)

The morphological characteristics of scoliosis in the neuromuscular patients did not differ from those in idiopathic scoliosis (Pečak 1976, Pečak et al. 1980).

Posturographic analysis was performed by means of a statokinesimeter (Electronique Appliquée) according to the method first described by Baron et al. (1956) and implemented by computer analysis (Oblak et al. 1976). The position of the centre of gravity of the body and its variation were recorded with the patients standing on the force-platform both with their eyes open and closed. The statokinesimetric tracing was sampled over 50 seconds in each experimental condition. Other activation techniques were not used.

All patients with idiopathic scoliosis and 11 of the 54 neuromuscular patients were analysed quantitatively by means of on-line computer analysis. The following values were computed:

1. mean position of the centre of gravity of the body in the lateral and sagittal planes, relative to the centre of the supporting surface (further referred to as *mean position*);
2. mean amplitude of oscillation of the body's centre of gravity in the lateral and sagittal planes (further referred to as *mean sway*);
3. mean radius of oscillations relative to the mean position (referred to as *mean radius*);
4. total length of the statokinesimetric tracing (referred to as *curve length*); and
5. mean frequency of oscillation (referred to as *mean frequency*). This was calculated as a ratio between curve length and mean radius (unit rdHz).

In other patients, the statokinesimetric tracing was analysed semiquantitatively by measurement of the original statokinesimetric recordings. In this case the total area of statokinesimetric tracing was measured by means of a planimeter.

In each patient, two successive measurements were performed for each experimental condition.

The results of the study were compared with values collected in 15 normal subjects, matching in age the patients with idiopathic scoliosis.

RESULTS

In the neuromuscular patients with scoliosis, the group with the Duchenne and limb-girdle dystrophy and the group with spinal muscular atrophy showed marked similarity in the results of statokinesimetric measurements. Thus they could be gathered into one combined group for comparison with the normal subjects. This patient group showed no significant departure from the normal values for the mean position of the centre of gravity of the body in the lateral plane. However, there was a highly significant forward shift of the mean position in the sagittal plane in comparison with the normal values ($P < 0.5$ per cent). Furthermore, there was a marked decrease in oscillation amplitude, significant ($P < 0.5$) for all values describing this phenomenon: mean sway in both planes, mean radius and curve length. All the differences from the normal values were evident in recording conditions both with eyes open and closed (Figures 1, 2, 3). The ratio between curve length and mean radius (mean frequency) was, with eyes open 2.4 rdHz for normal subjects and 2.6 rdHz for the above-mentioned group of neuromuscular patients. The corresponding values with eyes closed were 2.8 and 3.7 rdHz. Hence the oscillations with eyes

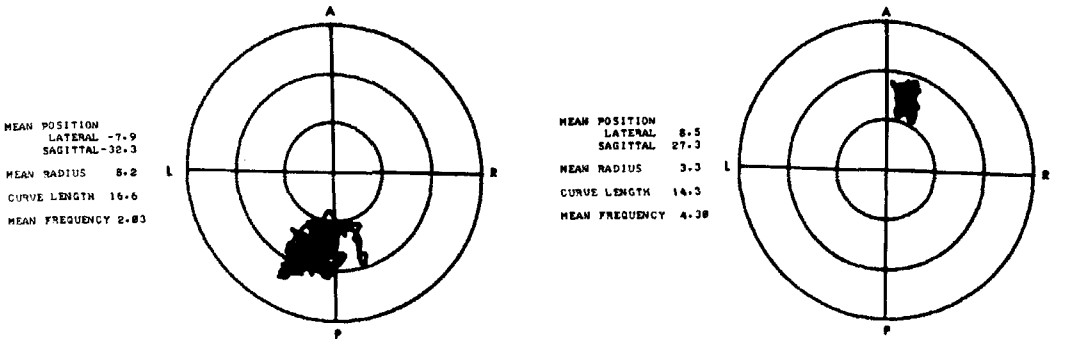

Figure 1. Recording of oscillations of the centre of gravity of the body in the X–Y plane during Romberg's test in a normal subject (left) and in a patient with spinal muscular atrophy (right) with computed values. A = anterior, P = posterior, L = left, R = right. Note the forward displacement of the mean position of the centre of gravity and the decreased oscillations in the patient compared with the normal subject.

closed became faster in the case of patients with neuromuscular disorders, but did not change significantly in the normal subjects.

On the other hand, the patients with peroneal muscular atrophy showed a completely different picture: the amplitude of oscillations was so large that it exceeded the limits of reliable measurement (in two out of four patients). Thus they were analysed only semiquantitatively.

The remaining 43 neuromuscular patients analysed by manual measurements from the original statokinesimetric recordings showed in general a tendency towards similar changes to those obtained by the computer analysis. There was no significant difference between the patients with scoliosis and those with nonscoliotic curvatures. Most of the 13 patients with peroneal muscular atrophy showed, in contrast to other disease categories, increased amplitude of oscillations, the increase being extreme in some cases, especially with eyes closed.

The observed changes in the statokinesimetric values were more pronounced in patients in a more advanced stage of their disorder. They were not related, however, to the type, side or degree of scoliotic deformity.

The patients with idiopathic scoliosis, on the other hand, showed no significant difference from the normal material (Figure 4), although in some patients there was a tendency towards increased

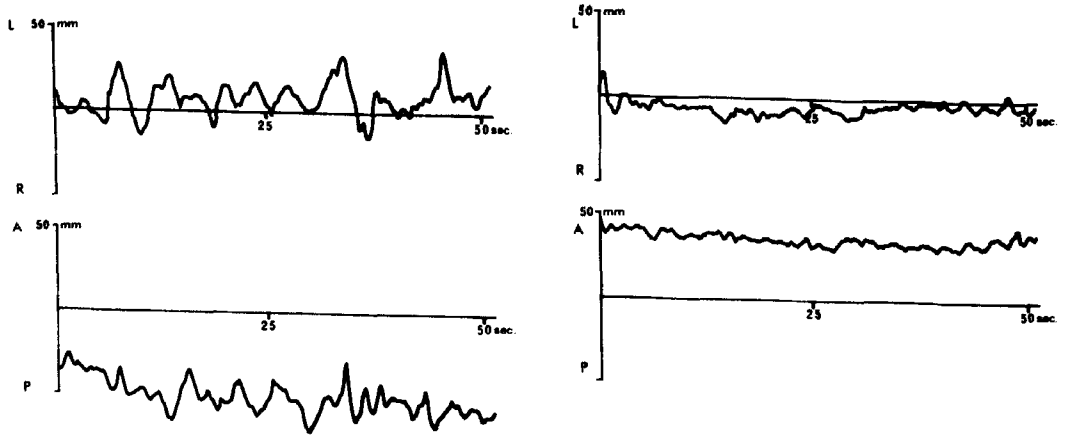

Figure 2. Time course of oscillations of the centre of gravity of the body in the lateral (above) and sagittal (below) planes in a normal subject (left) and in a patient with spinal muscular atrophy (right). A forward shift of the centre of gravity and the decreased oscillations in the patient can also be seen in this figure.

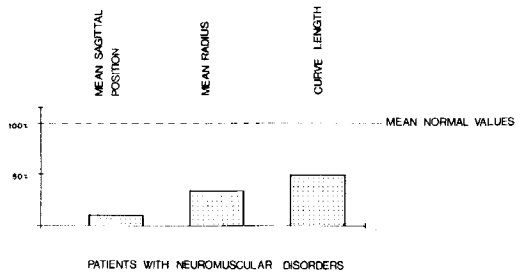

Figure 3. Mean values of some statokinesimetric parameters (mean position in sagittal plane, mean radius and curve length) from Romberg's test in patients with neuromuscular disorders, expressed as percentages of the mean values in normal subjects. The differences are significant at a level of $P < 0.005$.

oscillations, evident especially in the recording condition with eyes closed. Also the mean frequency of the oscillations was practically the same as in the normal subjects.

DISCUSSION

The results of this study show a striking change of postural control in neuromuscular patients (Duchenne and limb-girdle dystrophy and spinal muscular atrophy) with scoliosis. The same type and similar degree of change is, however, seen in neuromuscular patients without scoliosis (Gregorič, unpublished data). The change consists of:

1. a forward shift of the mean position of the centre of gravity of the body, relative to the centre of the supporting surface, and

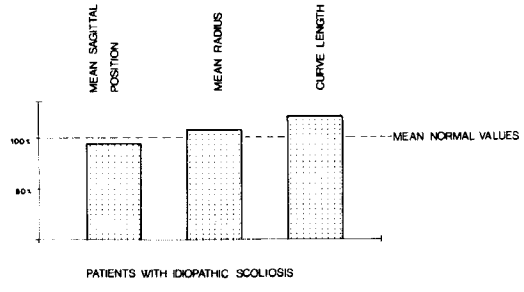

Figure 4. The same parameters for the patients with idiopathic scoliosis. The differences in comparison with normal values are statistically not significant.

2. a pronounced decrease in oscillation amplitudes. This can be interpreted as an adaptation to increasing weakness of the postural muscles, and increasing difficulty in correcting larger oscillations of the body. The same interpretation can be used for the increased frequency of oscillations when standing with eyes closed; slower and larger oscillations might well result in falling. This explanation is supported by the fact that the degree of the described changes of statokinesimetric values was correlated with the stage of the disease and the degree of proximal muscle weakness. On the other hand, it was not correlated with degree or side or type of scoliotic deformity. Even the direction and degree of the lateral shift were not correlated with the side of the scoliotic curve. It could be stated, therefore, that postural control is not only unimpaired in these patients, but rather developed to a greater degree than normal. Thus, our results make impairment of supraspinal postural mechanisms as a possible factor in scoliosis in neuromuscular patients very unlikely.

In the patients with peroneal muscular atrophy, the result of statokinesimetry was different. As expected, the oscillations tended to be large, and particularly increased when standing with eyes closed, evidently due to impairment of deep sensibility.

In patients with idiopathic scoliosis, the results did not differ significantly from the normal values. In this study, no provocative methods were used which might unmask a latent postural abnormality.

In a carefully designed and conducted study by Sahlstrand et al. (1978) the sensitivity of the statokinesimetric method was increased by using a compliant foot support on the platform. The authors found significantly poorer postural control in 57 patients with adolescent idiopathic scoliosis compared with normal children in all of their testing situations. Unexpectedly, the results were most abnormal for the subgroup with relatively small curvatures. The authors conclude that their results indirectly indicate the possibility of a postural disequilibrium as a contributory causa-

tive factor. Our own results do not support such a possibility; however, they cannot be taken as evidence against it.

In another study (Trontelj et al. 1979), we have demonstrated an asymmetry of the muscle tone in the rotators of the spine on the two sides of the curve. Conceivably this could be due either to an altered descending control of the spinal motoneurones, or to a segmental neurogenic lesion involving one or a few segments and leading to asymmetric muscle weakness.

On the other hand, scoliosis developing in the course of degenerative neuromuscular disorders does not seem to be associated with any demonstrable impairment of descending postural control.

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