Imbalance of electromyographic activity and physical rehabilitation of patients with idiopathic scoliosis

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Deséquilibre de l'activité électromyographique et réadaptation fonctionnelle des patients présentant une scoliose idiopathique

Résumé. Afin de contrôler les modifications des performances posturales des patients présentant une scoliose idiopathique, après un programme de réadaptation intensive en internat selon le protocole de Schrotth [17], poursuivi pendant plusieurs semaines, nous avons entrepris des explorations électromyographiques chez 316 patients présentant un âge moyen de 20 ans (extrêmes: 8-76 ans) et une courbure moyenne de 38,2° (extrêmes: 10-147°). L'activité électromyographique a été enregistrée à l'aide d'électrodes de surface placées dans la région thoracique et lombaire au niveau de la vertèbre apicale, en situation para-vertebrale de chaque côté des muscles érecteurs du rachis, lors du soulèvement du tronc à partir de la position de décubitus ventral. 259 enregistrements dépourvus d'artefacts ont été évalués. Une diminution significative de l'activité musculaire a été mise en évidence, de l'ordre de 6,85% au niveau de la convexité thoracique (P<0,05), et de 14,2% (P<0,001) au niveau de la convexité lombaire. Le rapport des activités musculaires (côté concave/côté concave) était réduit de 11,99% (P<0,001) dans la région thoracique, et de 7,91% (P<0,01) dans la région lombaire. Ces découvertes confirmant l'amélioration des performances posturales après une réadaptation intensive en internat selon le protocole de Schrotth. Le déséquilibre de l'activité électromyographique peut être influencé par les exercices adaptés qui permettent une réduction hautement significative de l'angle de Cobb chez les patients scoliotiques; il est donc considéré comme étant secondaire au développement de la courbure scoliotique et non pas comme un facteur étiologique primaire de la scoliose idiopathique.


Summary. In order to monitor changes in postural performance capacity in patients with idiopathic scoliosis after an intensive in-patient Schrotth rehabilitation programme [17] lasting several weeks, we undertook electromyographic investigations in 316 patients with a mean age of 20 years (range 8–76 years) and a mean Cobb curvature angle of 38.2° (range 10°–147°). Electromyographic activity was recorded by means of surface electrodes in the thoracic and lumbal region at the level of the apical vertebra, para-vertebrally on both sides of the erect spine muscle during trunk lifting from the prone position. Two hundred and fifty-nine recordings without artefacts were evaluated. Significant reductions in muscle activity of 6.85% in the thoracic convex region (P<0.05) and of 14.2% (P<0.001) on the lumbar convex side were found. The activity quotient (convex/concave) was reduced by 11.99% (P<0.001) in the thoracic region and by 7.91% (P<0.01) in the lumbar region. These findings confirm the improvement of postural performance capacity after an intensive in-patient Schrotth rehabilitation programme. As the imbalance of electromyographic activity may be influenced by scoliosis-specific exercises leading to a highly significant reduction of the Cobb angle, it is assumed to be secondary to the development of the scoliotic curve and may not be a primary factor in the aetiology of idiopathic scoliosis.

Key words: Electromyography – Idiopathic scoliosis – Physiotherapy – Rehabilitation programme – Aetiology

The musculature is the crucial point where the treatment of idiopathic scoliosis has to concentrate its efforts. Scoliosis-specific postural exercises can only be effective if the musculature can maintain the corrected postural stereotype in the long term [5]; on the other hand, myogenic pain symptoms can be improved by appropriate training [14, 29]. Numerous publications on this subject mention muscle strengthening [3, 11, 12, 17, 20, 23, 24]; patients feel that they have a higher performance capacity after a Schrotth in-patient treatment [29]. As far as we know, changes in postural performance capacity after a course of physiotherapy have not yet been objectively evaluated.
A great number of studies concerning the use of electromyography in scoliosis are known. Basmajian and De Luca [1] give an overview of the kinesiologic and electromyographic findings in different muscle groups in healthy subjects and scoliotic patients. They show that for electromyographic studies of kinesiologic processes it is better to use surface electrodes than needle electrodes. In kinesiologic studies, deep muscle groups should be recorded with wire electrodes. In general, however, recording with surface electrodes on a silver-silver-chloride basis is the most frequently employed method.

In scoliosis patients we generally find increased muscle activity on the convex side of the curve [1, 2, 9, 10, 13, 21, 26] (Fig. 1).

According to histological studies, scoliosis patients also have differences in fibre distribution on the convex and the concave side [25]. According to Zetterberg et al. [34], type I fibres are predominant on the convex side. There are significantly more type II fibres on the concave side, with distinctly higher capillarisation on the convex side.

Fidler and Jowett [4] found a predominance of tonic muscle fibres in the multifidus muscle of the convex side in the apical region. This seems to be an adaptation mechanism related to the increased engagement of the musculature on the convex side.

Muscle contraction can be made more economical by appropriate training methods, i.e. greater loads can then be lifted by a smaller number of activated motor units [28]. Reduced electromyographic activity with unchanged body loads (i.e. weights) is proof that certain training effects have been attained [1, 25].

Three-dimensional scoliosis treatment according to Schroth

Schroth's three-dimensional scoliosis treatment rests upon a sensorimotor-kinesthetic basis. By taking up asymmetrical exercise positions and exploiting the natural corrective postural reflexes, the scoliotic patient is taught a postural stereotype as symmetrical as possible, which should be transferred into everyday activities. The corrected postural stereotype is supported by "rotational breathing". This results in correction of the scoliotic breathing pattern [31]. This breathing correction supports expansion of the thoracic concave trunk areas, whereas expansion of thoracic convex or prominent regions is impeded by selective muscle contraction. "Rotational breathing" leads to increased rib mobilisation as well as to a highly significant increase in vital capacity [32]. Increases in cardiopulmonary performance in scoliotic patients after in-patient Schroth treatment for several weeks have also been found [6, 7].

Meanwhile, sufficient proof has been furnished that the Schroth exercise programme can also influence progression of curvature. In their cases of minor scoliosis Rigo et al. [22] found curvature improvements of more than 5° in 44% during the follow-up period, whereas progression of curvature was found in only 11%. In a comparable group allowed to progress naturally, we would have expected 23% of cases to show progression and less than 10% to improve.

In our studies [30] we have demonstrated that even the progression of curvatures exceeding 30° can be positively influenced in the long term. During the in-patient rehabilitation programme high significantly curvature improvements are found, which can be regarded as a bonus for further prognosis [33]. The favourable effect on scoliosis-related pain has been demonstrated [31].

Patients and methods

In 1987 and 1988 we performed electromyography in 316 scoliotic persons before and after an in-patient rehabilitation programme. We followed the same investigation procedure as Schmitt [25]. In
addition to the paravertebrally placed surface electrodes (silver-silver-chloride) at the level of the thoracic apical vertebra, we recorded the activity from the lumbar erector spine muscle in the way suggested by Macintosh and Bogduk [19].

The electromyographic activity was recorded for 1 min and integrated during lifting of the trunk from the prone position (Fig. 2). Then we set up the quotient of convex-side activity and concave-side activity. The routine recordings were carried out ignoring previous exercises or massages. For electromyography recordings, the patients had to interrupt exercises.

The mean Cobb angle in the above-mentioned patients was 38.2° (range 10°–147°), the mean age was 20 years (range 8–76 years). The ratio of patients with right-convex scoliosis to those with left-convex scoliosis was 25:1.

Results

Artefact-free electromyograms from 259 patients were evaluable. The results showed a significant decrease of 6.79% ($P < 0.05$) in thoracic activity on the convex side after the in-patient rehabilitation programme. A decrease of convex-side activity was also found in the lumbar region, by 14.2% (highly significant, $P < 0.001$). The activity quotient convex side/concave side had dropped by 11.99% in the thoracic region (also highly significant, $P < 0.001$), and by 7.91% in the lumbar region ($P < 0.01$).

Discussion

Taking the results as a whole, a distinct improvement in postural capacity is seen. As already shown by Klawunde et al. [16], compensation of the differences of muscle activity on each side was attained by the three-dimensional scoliosis treatment according to Schroth. This supports strengthening of the musculature as well as economisation of muscle work.

In the younger patients in our study group, some of the results were not significant or even showed an increase in muscle activity. We attribute this to retarded adaptation of the child’s muscles to the changed training conditions [1]. During a muscle training programme lasting several weeks, a distinct increase in activity occurs during the first 3 weeks; the activity then drops to the initial value [1, 27]. This means that it is quite possible that immature individuals were still in the phase of increased muscle activity.

We also found that physiotherapy or massage directly before recording of muscle activity resulted in a distinct increase of the activity potential in most cases. Within these findings there is also one reason why activity reductions in the various subgroups were not always significant. Measurements were not taken under the same conditions; the patients had to interrupt the exercises or the massages. Some higher activity values are certainly due to these circumstances.

It is surely reasonable to conduct further investigations into this subject; however, initial and final measurements have to be based on standardised conditions.

In our experience [33], highly significant improvements in curvature could be obtained during an in-patient rehabilitation programme (Fig. 3). It may be assumed that, besides the training effect, there is also a correlation between the decrease in the Cobb angle and the reduction in muscle activity. This makes the hypothesis appear probable that the muscular imbalance measured by electromyography is only of secondary origin and cannot be regarded as the causal factor of idiopathic scoliosis. Like ourselves, Klawunde et al. [16] also found that the muscular imbalance was largely compensated by the Schroth rehabilitation programme. Additionally, it would be possible to influence differences in reflex times between the two sides in the same way. Klawunde thinks that the posturographic changes which were shown in his study are due to central changes of the postural regulation by the rehabilitation programme.

A muscular imbalance, however, provokes in its turn asymmetrical proprioceptive input. This, via the spino-cerebral cords, asymmetrically activates other centres connected with the cerebellum, in particular the vestibular system. For this reason one should not, from findings of slight coordination disturbance [15] or central asymmetrical neurophysiological findings like sensory or visual evoked potentials [26], rush to the conclusion that the aetiology of scoliosis is disturbance of the central nervous system. It is certainly useful to undertake further neurophysiological studies to investigate the effectiveness of therapeutic measures, but it is doubtful whether such studies will provide the answer to the still open question of how scoliosis develops.

The theory set up by Schmitt [25] that handedness plays a role in the development of scoliosis was not supported in our group. We found a right-convex lateral spinal deviation in the thoracic region in 93.6% of the left-handed patients and in 96.4% of the right-handed patients.

Fig. 3. Female patients with adolescent idiopathic scoliosis before (left) and more than 1 year after an in-patient rehabilitation programme.
References