ELECTRICAL SIMULATION FOR SCOLIOTIC PATIENTS (o)

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SUMMARY

In these last years new criteria have been adopted in the treatment of scoliotic patients.

These criteria are based on the assumption that scoliosis is due to an improper functioning of the postural control system.
The analysis of the spine regulation system suggested to direct the therapeutic action to a control level higher than mechanical level and led to consider the electrical stimulation of the spine muscles as a convenient therapeutic treatment for scoliotic patients.
The original stimulation procedure developed at "Centro Scoliosi" in Milan is described.
This procedure makes use of Electromyographic and Thermographic techniques to determine the modalities of the stimulation procedure.
The results reached in the last few years of clinical practise are reported and comparison is made with other therapeutic treatments.

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INTRODUCTION

The basic idea to use electrical stimulation to treat scoliosis arose many years ago [1,2,3].

These studies are based on the analysis of the posture control system and the statement that scoliosis is due to an improper functioning of the posture control system (fig.1).

The analysis of the system and the control of various therapies have been carried on by means of a mathematical model of the system implemented on a digital computer and by means of EMG and thermographic analysis [4,5,6].

METHODS

Various techniques can be use to stimulate patient muscles both with surface and implanted electrodes, using different shapes (pulses, train of pulses, sinusoids) at various frequencies.

In our experience, after having dismissed the trains of pulses, we prefer to use sinusoidal currents of 2,5 KHz modulated by a 50 Hz square wave (fig.2) [7] as adopted by Kots to increase muscle force (and power) of athletes [8,9]. Every application consists of ten second stimulation followed by a rest interval of 40 or 50 seconds, repeated for 20 minutes.

Kots obtained with 15 applications an increase of 30% of force using tetanic contractions in isometric conditions.

We have obtained analogous results repeating the same experiment without reaching the tetanic contraction and not blocking the movements that are the conditions used to stimulate the muscles of the back of the scoliotic patient.

Our methodology is:

- EMG analysis of the spine muscles (fig.3)
- Surface stimulation (fig.4) of the part where EMG activity is lower. Each cycle of stimulation is characterized by daily applications of 20 minutes for 15 days. This cycle is repeated every three months.
- Control of theraphy with x-ray, EMG and thermographic analysis. An example of EMG activity before (P) and after (D) a cycle of stimulation is reported in fig. 5.

RESULTS

We report now the results obtained with 24 patients treated only with electrical stimulation from a minimum of 18 months to a maximum of 30 months (with an average of 22 months).

These patients represent a total of 52 curves.

According with the classification adopted by Bobechko [10] a decrease of 5^{o} or more in the curve is rated "better, while 5^{o} or more increase is "worse" and a change of less than 5^{o} is "unchanged" (fig.6).

The treated group show 21% of the curves better, 73% of the curves unchanges, 6% worse (fig.7). The total of 94% of the treated curves have succesfully been arrested or partially corrected.

By comparison of this result with the statistical data concerning the Milwankee brace, a remarkable difference to advantage of electrical stimulation can be noted. Namely the succesful results (%Better+ + % unchanged) with Milwankee brace reach at most 74%.

If we consider also patients under treatment since less than 18 months we have the results show in fig. 8.
These results agree with the results obtained by other researches. We have observed that electrical stimulation causes a decrease of the curve with the first cycles and then it tends to maintain the results achieved.

In order to evidence the evolution of each patient and an up to date statistic, a program for automatic files managment was implemented.

It is to remember the curve which represents the progression of scoliosis given by Duval Beaupere [11] idealized as shown in fig. 9 by two straight lines of slopes P_1 and P_2.

The point which joins the two straight lines corresponds to the beginning of puberty. The bone growth stops with completion of the covering of the iliac crests (Risser's test). It is to note that in 60% of cases $P_2 \cong 5P_1$.

As it is shown in fig. 10, after an orthopedic treatment the scoliosis progression has the same slope. The graph shown in fig.11 is one of those produced by the program for automatic file managment; all data concerning the patient, controls and theraphies are rapresented on the top of the graph, and the curves (expressed in Cobb degree) as a function of the time are shown below. The letter S indicates a cycle of stimulation. Figure 11 shows the case of a boy born in 1965.

At the first X-Ray control when he was 9 years old a scoliosis dorsal right (5° Cobb) and lumbar left (9° Cobb) was noticed.

In the following two years it increased to 9° and 16° and the boy came to the Scoliosis Center of Istitute "G. Pini" of Milano for electrical stimulation.

After the first cycle the slope decreased to 6° and 10° and after two more cycles he decreased to 1° and 6° (Risser 0). The boy is going on with electrical stimulation and we are waiting for the new X-Ray control.

Fig. 12 shows the case of a young girl.

The first X-Ray control (at the age of twelve) points out a scoliosis dorsal right (8 Cobb) and lumbar left (20 Cobb). After a year it was increased to 20° and 29°.

After the first stimulation cycle, scoliosis decreased to 14° and 24° and after a second cycle it was at 13° and 22°. The girl is going on with stimulation and we are waiting for the new X-Ray control.

In fig. 13 you can also see the supposed effect of the stimulation cycle when the slope is maintained as shown by Duval Beaupere.

The fig. 14 shows a case indicated as "worse".

At first X-Ray control scoliosis was dorsal right (20° Cobb) and lumbar left (20° Cobb).

After a light decrease with the first procedure the girl maintained the curves and the appearance of Risser 1, before the menarch the curve incresed and now (after 28 months from the first X-Ray control) it is 20° and 25°.

REFERENCES

1. Crivellini M., Divieti L. (1972) "Impiego della stimolazione elettrica funzionale in ortopedia" I° BIAS - Milano.

2. Crivellini M., Divieti L. (1973) "New Hypothesis on Scoliosis treatment" Symp. on treatment of scoliosis Portoroz (Jugoslavia).

3. Crivellini M., Divieti L. (1975) "Scoliosis Project" Cybernetica Stosowana i Informatika, Warszawa.

4. Dacquino G.F., Divieti L., PedottiA, Romano' A. (1969) "A mathematical model of the vertebral spine for the study of pathogenesis and treatment of scoliosis" RI 69 - 13; Ist. Elettronica Politecnico, Milano.

5. Crivellini, M. Divieti L., Sommaruga F. (1976) "Electrical stimulation: a theraphy for idiopathic scoliosis" ISEK-3 International Congress, Pavia.

6. Dacquino G.F., Divieti L., Frassi G.A., Muller A., Sibilla P. (1976) "Emploi de la thermographie dans l'étude de la scoliose" Rev. Senologie, 4, Pag. 19-23.

7. G. Bestetti, L. Divieti, F. Sommaruga "Electrical Stimulator for Scoliotic Patients: Principle of operation and First Results" First Mediterranean Conference on Medical and Biological Eng. SORRENTO (ITALY) September 1977.

8. Kots J.M. Xvilon V.A. (1971) Teor. i pract. fis. Cult., 4, pag. 66-72. (in russian)

9. Kots J.M. (1971) Teor. i pract. fis. Cult., 3, pag. 64-67 (in russian).

10. Bobechko W.P., Herbert M.A., (1975) "Results of using electrospinal instruemntation for the treatment of scoliosis at the Hospital for Sick Children" interim report, Toronto.

11. Duval Beaupere G. (1970) "Les reperes des maturation dans la surveillance des soclioses" Rev. Chir. Orthop. Tome 56, 1, Paris pag. 59-76.

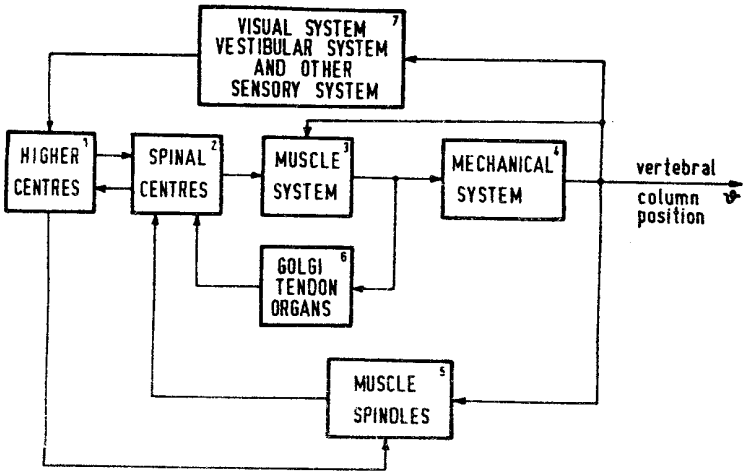

VISUAL SYSTEM
VESTIBULAR SYSTEM
AND OTHER
SENSORY SYSTEM
7
HIGHER
CENTRES
1
SPINAL
CENTRES
2
MUSCLE
SYSTEM
3
MECHANICAL
SYSTEM
4
vertebral
column
position
GOLGI
TENDON
ORGANS
6
MUSCLE
SPINDLES
5

Fig. 1.

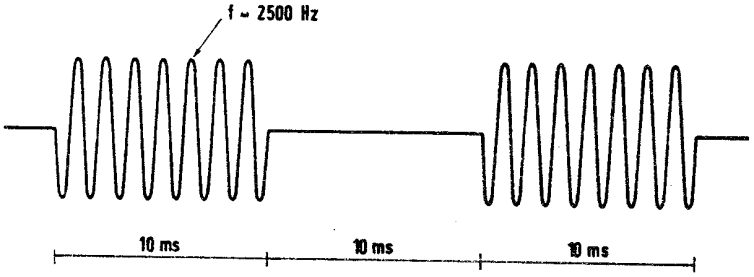

f ~ 2500 Hz
10 ms
10 ms
10 ms

Fig. 2.

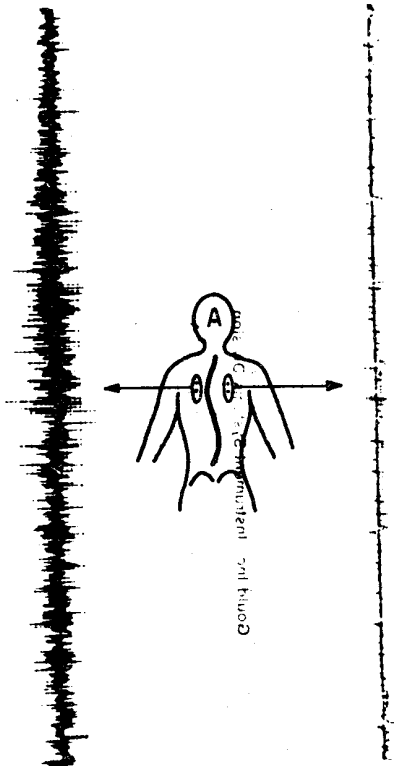


Fig. 3.

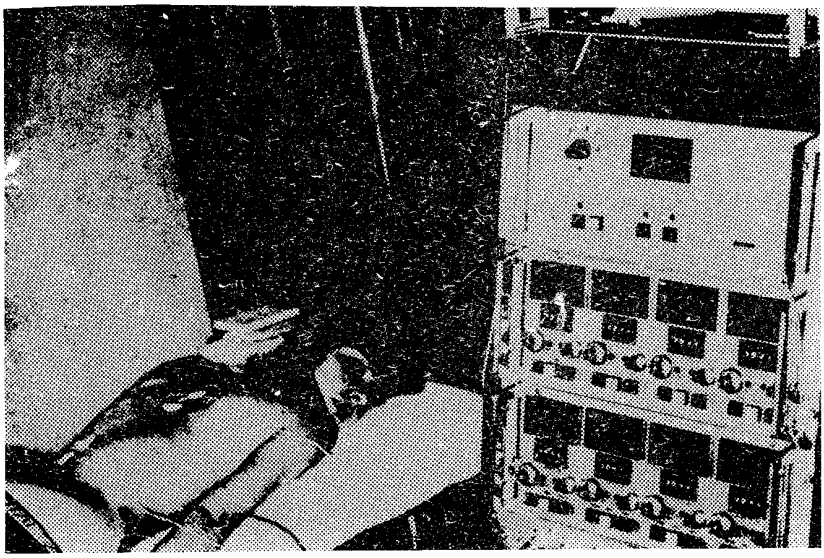


Fig. 4.

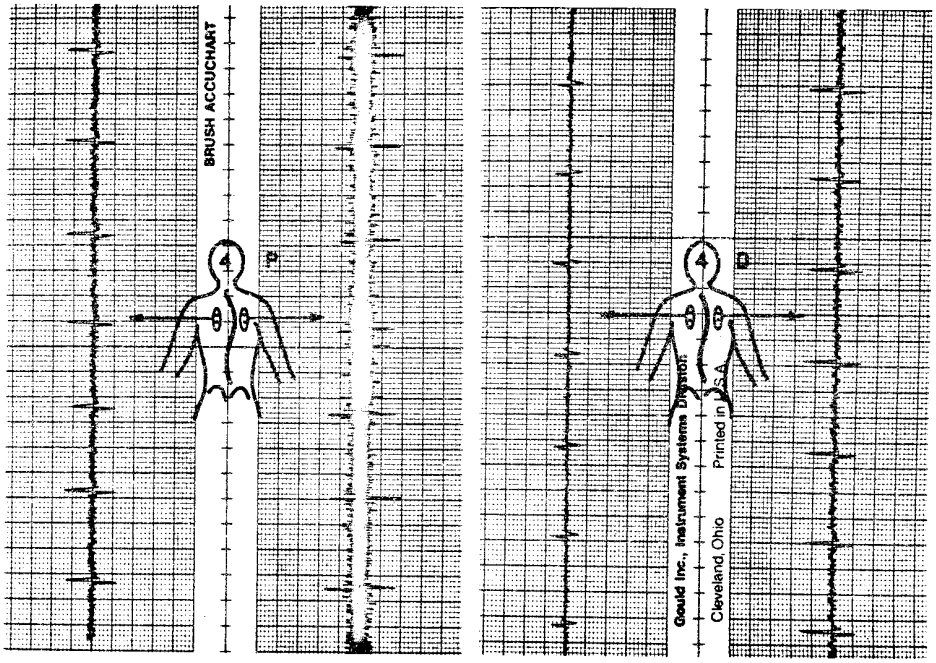


Fig. 5.

Δ° Cobb	
$\Delta \leq -5^\circ$	BETTER (B)
$-4^\circ \leq \Delta \leq 4^\circ$	UNCHANGED (U)
$\Delta \geq 5^\circ$	WORSE (W)

Fig. 6.

RESULTS OF ELECTROSTIMULATION

STIMULATIONS FOR PERIODS FROM 18 - 30 MONTHS
FOR 24 PATIENTS, AVERAGE AGE : 13 - 15 YEARS, RISSER 0 - 3 +
FOR A TOTAL OF : 52 CURVES

BETTER :	11	CURVES = 21%
UNCHANGED :	38	CURVES = 73%
WORSE :	3	CURVES = 6%

AVERAGE IMPROVEMENT : - 8°
AVERAGE STABILIZATION : - 0.2°
AVERAGE WORSENING : + 5.3°

Fig. 7.

36 PATIENTS
73 CURVES

B = 40 %
U = 53 %
W = 7 %

Fig. 8.

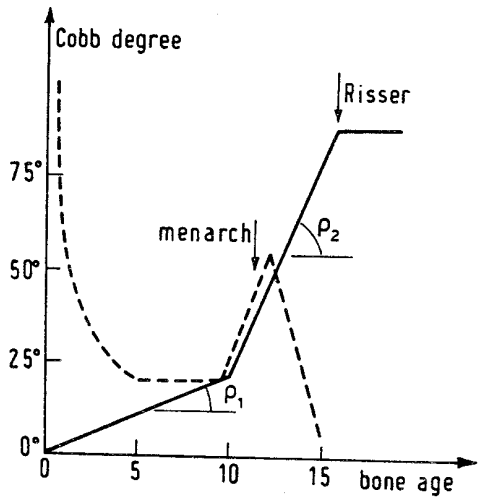


Fig. 9.

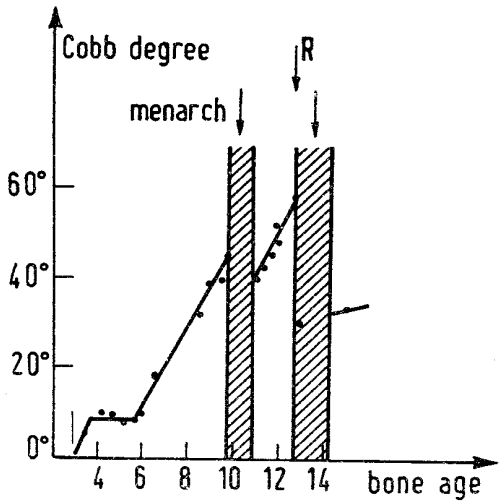
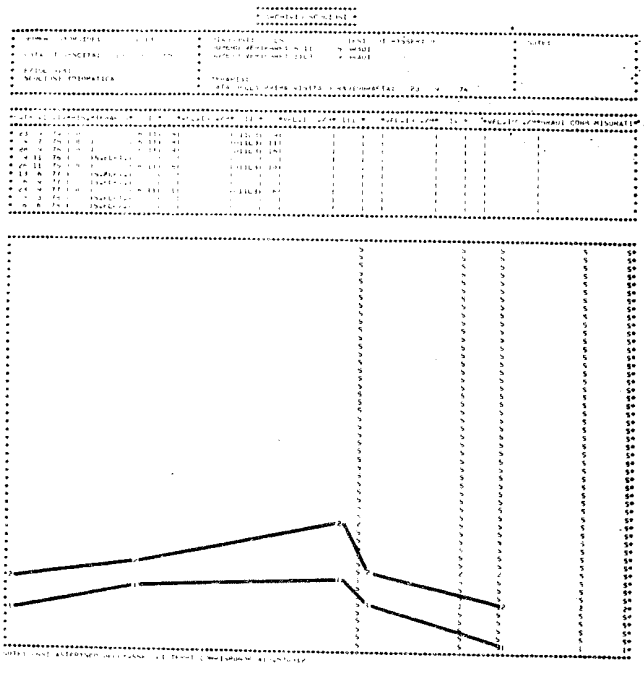


Fig. 10.



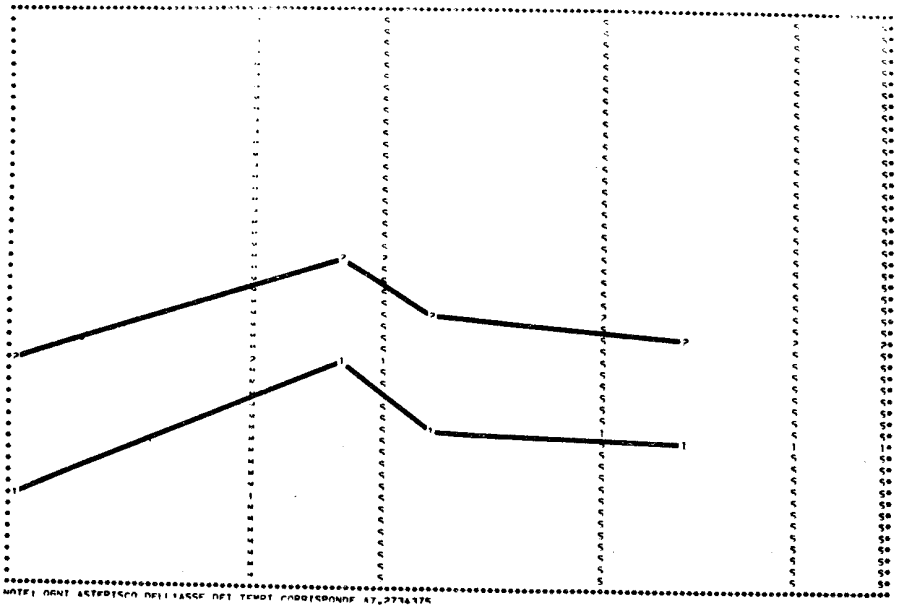


Fig. 12.

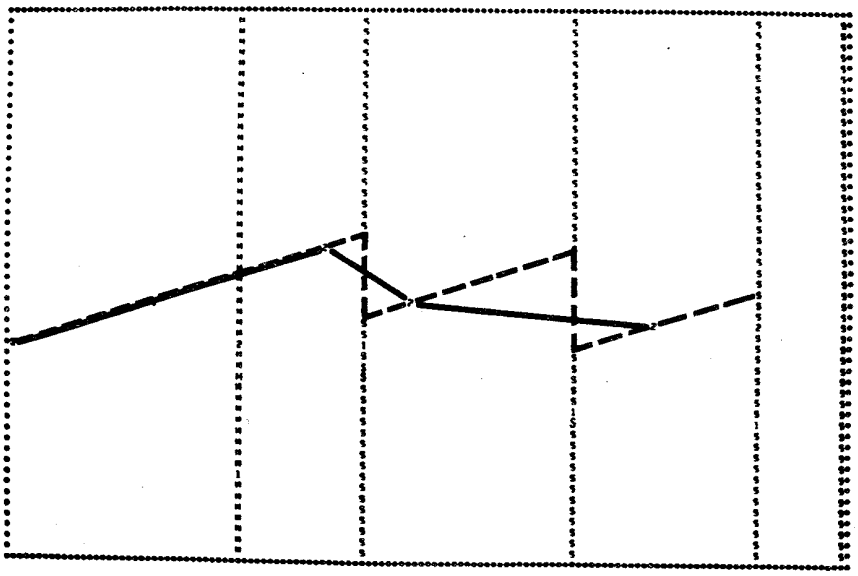


Fig. 13.

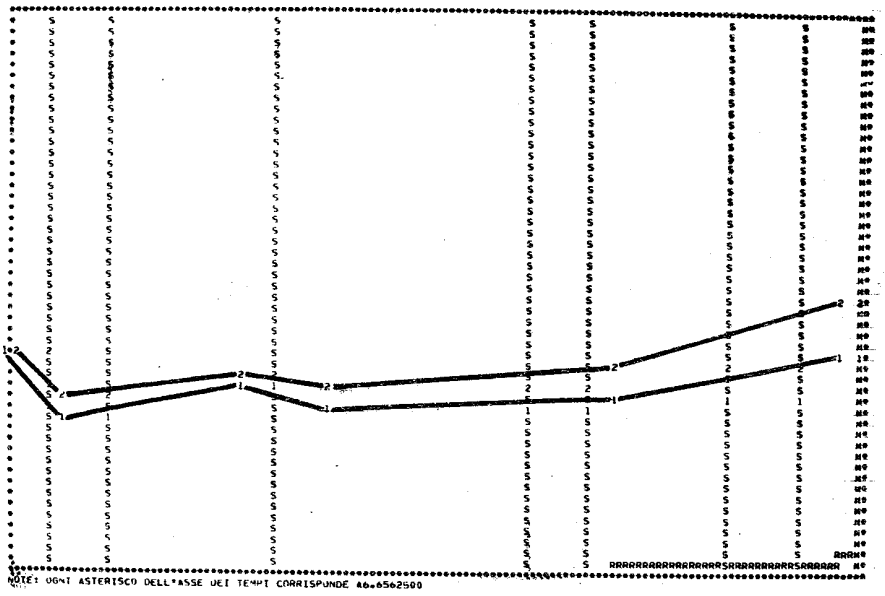

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Fig. 14.