EUR MED PHYS 1998;34:25-31

Effect of exercise therapy on mild idiopathic scoliosis

Preliminary results

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***Objective*. The aim of this paper was to test the efficacy of exercise therapy in modifying the evolution of the deformity in children with mild idiopathic scoliosis.**
***Methods*. We recruited 34 consecutive scoliotic subjects (mean age 11.6 years, range 8.7-14.1 years) with an initial mean Cobb angle of 14.9° and a mean hump height of 7.3 mm. They were assigned to one of two physical therapists who used different techniques with the same therapeutic goals (active postural correction of scoliosis). Subjects were asked to continue their exercises at home for at least 30 minutes a day. Thus, most of the exercise programme was carried out in the home. After a mean of 2 years of a) treatment, we performed a multiple linear regression analysis for the changes in Cobb angle as a function of a) the actual involvement in the home programme (minutes per day), b) the physical therapist variable, and c) the potentially confounding variables (such as initial Cobb angle and age, Risser sign and duration of the treatment). A simple linear regression analysis was performed for the changes in hump height as a function of the level of participation.**
***Results*. Results showed that maximal participation in exercise therapy (≥30 min day) for the mean duration of 2 years, as compared to minimal participation (<10 min/ day), slowed down and even halted the progression of the deformity (curve and hump). Results did not differ significantly between the 2 therapists' groups.**
***Conclusion*. If followed rigorously, an accurate exercise programme appears to effectively limit the worsening of deformity in mild scoliosis.**

Key words: **Exercise therapy - Posture - Scoliosis.**

Submitted for publication May 29, 1997.
Accepted in revised form September 22, 1997.

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At present, the medical community has mixed opinions about employing exercise therapy alone in the treatment of children with idiopathic scoliosis. While this form of therapy is frequently prescribed in countries such as France, Germany and Italy, it receives little if any attention in other countries such as the United States.

In Italy, the picture is rather mixed. Some specialists prescribe it despite nurturing doubts as to its real effectiveness, whereas others, who fortunately represent the minority, advocate its use and are convinced of its value even in the absence of sound evidence to support their claims.

In part, this reflects the paucity of sound and exhaustive studies in this research area.

Since the 1980s, however, some progress has been made in several European countries. To our knowledge, Klisic and Nikolic's study published in 1981 [1] was the first to report a positive outcome of exercise therapy alone in the treatment of scoliosis. These investigators compared 150 subjects who underwent exercise therapy with 50 untreated control subjects. The mean Cobb angle was 15° in the first group and 13° in the second. At 3-year follow-up, they observed improvements in the scoliotic curve in 58% of the treated *vs* 26% of the untreated subjects, and a worsening in 37% of the treated *vs* 64% of the untreated subjects. Mollon and Rodot [2] performed a retrospective comparison of 160 subjects who underwent exercise therapy and 40 untreated subjects. The initial mean Cobb angle was 17° in the treated group and 13° in the untreated subjects. At follow-up, a mean of 4.5 years later, the treated group showed a lower average worsening of the scoliosis, consisting of 8.7° in the Cobb angle and 2.9 mm in the hump heigth. Using the same form of exercise therapy (Schroth's technique), Rigo *et al.*[3] and Weiss [4] observed a more favourable progression of the scoliotic curves, as compared with the natural history of the deformity.

At the Orthopaedic Rehabilitation Unit of the Institute of Orthopaedics, University of Padua, we have been using exercise therapy in the treatment of mild idiopathic scoliosis for many years. The goal of the treatment is to counteract the progression of scoliosis. In the present study, we sought to define the ratio between the impact of exercise therapy on the progression of the deformity and how much of the patients' time was dedicated to it.

Materials and methods

Inclusion criteria

From February 1991 to September 1996, 42 children with idiopathic scoliosis who come to our Unit to be treated were enrolled in this study. Inclusion criteria were: 1) the presence of a scoliotic curve with a Cobb angle ≥10° and <25°, as documented by an orthostatic radiograph; 2) a hump corresponding to the convex part of the curve, as evidenced by the standing forward-bending test; 3) Risser sign of zero [5]; 4) age ≥8 years; 5) no current or previous treatment with spinal orthoses.

Exercise therapy

Following clinical-instrumental evaluation, subjects initiated ambulatory courses of therapy held in our Unit. They were randomly assigned one of two physical therapists (MP and NM) involved in the study. Both therapists had devised their own rehabilitation protocol for scoliosis on the basis of their experience in this field (in MP's case, 18 years, in NM's 8 years). MP prescribed exercises based on those of Klapp [6] to correct and mobilize the curve, and balance exercises to reinforce the correction during upright stance. NM's exercises to correct the curves were based on Perdriolle's studies [7] and subjects performed most of the exercises in a standing position. MP frequently used a mirror while going through the exercises with her patients, while NM relied on proprioceptive stimuli. For both, the first goal was to give each subject greater familiarity and understanding of his/her own spine and postural defect. The goal then shifted to the active correction of the defect through specific exercises within the context of global postural correction. Exercises were modified according to the curve type. The corrections were then transferred to the positions and gestures of everyday life.

MP held 3 sessions per week, for 1 in every 3 months, NM held 1-2 sessions per week for alternate 2-month periods. Eight to 10 subjects took part in each of MP's 50-60 min sessions, while there were 6-8 subjects to each of NM's group sessions. Periodically, both therapists invited the children's parents to participate in order to show them how the exercises should be performed. Subjects were always encouraged to repeat the 30 minutes of exercises at home, at least 5 days a week. Therefore, 80% of the exercise therapy was done at home. In general, the subjects were given no restrictions regarding sports activities. During the two-month summer break, ambulatory and home exercise therapy was either reduced or suspended.

Control procedures

At every 4-month check-up, subjects and their parents were asked to report on involvement and active participation (i.e., minutes of exercise) in the home exercise therapy. The quality of exercise was not assessed in this study. On average, the Cobb angle was measured every 12 months. The hump height was measured (in mm) with a pocket measuring device placed on the subject's trunk in forward flexion. There is a positive correlation between such measurement of the hump and the Cobb angle.[8,9]

Two members of our team (SM and AV) evaluated subjects' participation in the programme. A third examiner (CF), who was unaware of these findings, measured the Cobb angle and the hump height; these results were communicated to the subjects only after their participation in the programme had been evaluated. The history and clinical-instrumental data were recorded on a personal form.

Subjects and variables

Of the 42 subjects, 4 withdrew from the study after the first examination, and 4 had not undergone the first radiographic follow-up. Thus, this study concerns 34 subjects, 27 girls and 7 boys, ranging in age from 8.7 to 14.1 years (mean 11.6 yrs, SD 1.5 yrs). Thirty (91%) had a single spinal curve and 3 (9%) a double curve (right and left), (hump>3 mm in both curves). In the case of a double curve, the one with the maximal angular value was considered. The curves were classified as follows: 17 at thoracic level (13 right and 4 left), 6 at thoracolumbar level (3 right and 3 left), and 11 at lumbar level (4 right and 7 left). There were 17 single thoracic and double structural curves (T+DS); there were 17 thoracolumbar and lumbar single curves (TL+L). At the first examination, the Cobb angle ranged from 10 to 24° (mean 14.9°; SD 3.5°), the hump height, from 2 to 20 mm (mean 7.3 mm, SD 4.0 mm).

The algebraic differences between the final and initial Cobb angle and hump height reflected their changes (ΔC and ΔH, respectively) over a period of time which varied from 0.7 to 4.3 years (mean 2.0 yrs, SD 0.99 yrs). The repeatability coefficient [10] was used to assess the accuracy of the measurement of differences. It consisted of 2 standard deviations of the differences between two independent successive measurements separated by 21 days, and previously obtained by CF from the radiographs of 45 single mild curves (<25°) and 45 humps of patients with mild scoliosis who were not involved in the present study. As expected, the mean differences between the two measurements for both variables did not differ from 0, (-0.07° and 0.07 mm), thus ruling out the possibility of a systematic error. The coefficient for the Cobb angle was 3.1° (95% confidence interval from 2.3 to 3.9°), for the hump height, 2.9 mm (95% confidence interval from 2.1 to 3.6 mm). Each positive or negative difference, observed in our study, greater than the upper value of each confidence interval, i.e., ≥5° and ≥5 mm, was taken to reflect real changes (increase or decrease) in the variable studied.

The subjects' effort and participation in the daily exercise therapy during the same period was inferred from the four-monthly case-history and measured on a 4-point scale, where: 1=<10 min of therapy per day; 2=10-20 min of therapy per day; 3=20-30 min of therapy per day; 4=30-40 min of therapy per day. The choice of scale was quite arbitrary. However, on the basis of our experience, dedicating <10 min a day to therapy (scale score 1) is insufficient to gain noticeable benefits, whereas 30-40 min of therapy per day (scale score 4) is ideal. If a subject's participation had been inconsistent, we relied more on the first half of the rehabilitation period for the assessment of his/her global participation level. This is because it may be supposed that making the same effort at a later stage could be less effective, since in the meantime the scoliosis might have worsened and/or became stiffer and less susceptible to improvement.

The subjects' participation was considered as a continuous variable, since the mean times at levels 1 to 4 were 5, 15, 25, and 35 min, respectively, with an average increment between levels of 10 min.

Fifteen subjects were assigned to physical therapist NM and 19 to MP. There was no significant difference in the level of participation between the two groups (p=0.40, Mann-Whitney U test). In 17 subjects, the final Risser sign varied from 2 to 5 (mean 3.6), and in 17 it was < 2 (mean 0.1). Thus, at the final examination, the first group was at far less risk of further progression of the scoliosis than the second group.[11] Two of the female subjects were menstruant before the time of the first examination, in 15 the menarche occurred between the first and the final examination, and 10 were not menstruant at the time of the final examination. During treatment all of the subjects attended physical education lessons at school, only 6 (18%) were involved in a regular sports activity other than the exercise therapy programme.

Statistical analysis

A multiple linear regression analysis for the response variable ΔC (changes in Cobb angle) was performed, including two groups of explanatory variables. The basic requisite for a correct regression analysis, is a normal distribution of the response.[12] In addition to participation, the variables included in first group were: the physical therapist (MP and NM), and the interaction term between participation and physical therapist. The latter was used to determine the effects of participation on the subjects of the two separate groups. In the second group we included the continuous and categorical variables monitored for their known [11] or potential ability to affect the trend of ΔC.[10] These were: the initial Cobb angle and hump height, initial age, gender, time lapse between initial and final measurement, final Risser sign (<2/≥2), and curve pattern [(T+DS)/(TL+L)]..

On the basis of this model, a backward stepwise regression procedure was used to either eliminate the least influent variable (or the highest p value), or to reintroduce the most influent variable (or the lowest p value).

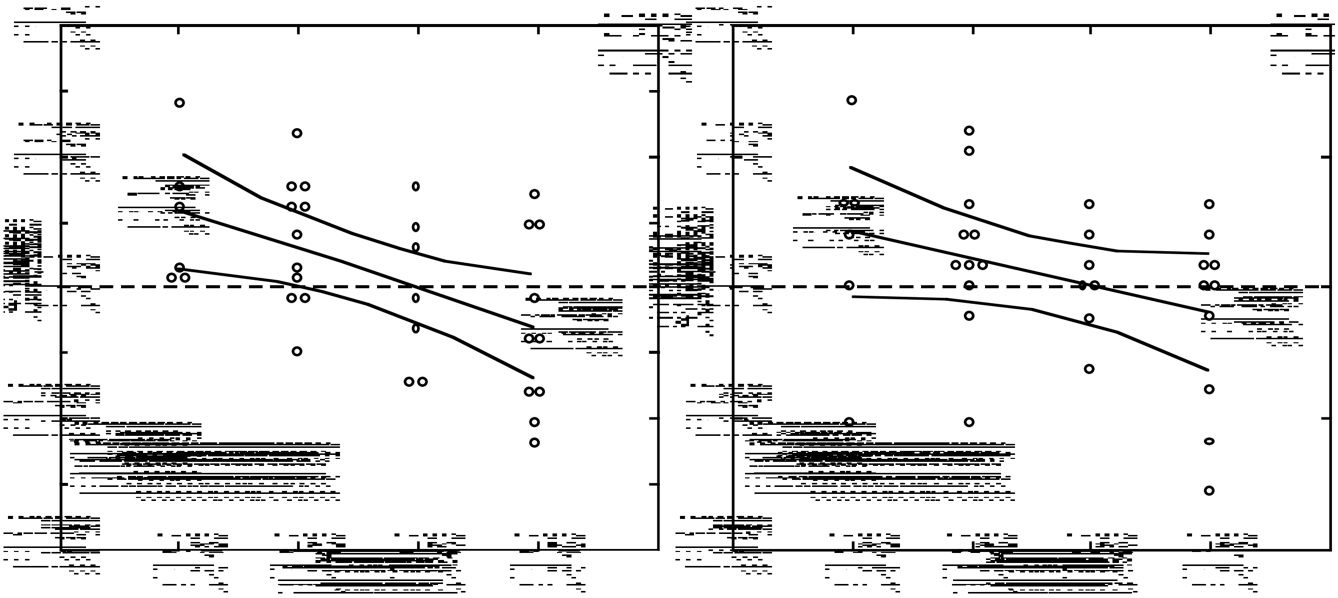

Fig. 1.—Individual changes (circles) in the Cobb angle (A) and the hump height (B). Regression lines with 95% confidence interval of the estimated means of ΔC and ΔH as a function of time dedicated to exercise therapy (Participation). The latter ranges from a level of 1 (<10 min/day) to a level of 4 (>30 min/day). Δ>0 indicates an increase, Δ=0 (horizontal dashed line) indicates a steady state. (A) Reduction in the mean ΔC value (regression line) from a maximum of 6.0° at a level of participation of 1 to a minimum of -2.9° at level 4. The negative value, indicating improvement, does not differ significantly from 0 (dashed line at level 4 included in the confidence interval). The lower increase in Cobb angle at level 4 compared to level 1 was 9° (6.0+2.9). In individual cases, at high levels of participation (3 and 4) we can observe both worsening (ΔC≥5°, in 5 cases) and improvements (ΔC<-5°, in 5 cases). (B) Reduction in the mean ΔH value (regression line) in parallel with the increase in participation from level 1 to 4. The lower increase in hump height at level 4 compared to level 1 was 3 mm (2.1+1.0).

A simple linear regression analysis was performed for the changes in hump height ΔH (accessory response variable) as a function of the level of participation.

A *p* value <0.05 was considered significant. The data analysis was performed with the computer software package SYSTAT, version 5.2.1 (SYSTAT Inc., Evanston, IL).

Results

The stepwise analysis revealed a negative relationship between ΔC and the participation variable (Pearson's *r*=-0.51). The linear regression equation was: y=8.94-2.97x, where y was the estimated mean ΔC value and x was the participation. On the basis of the regression coefficient (-2.97, SE 0.89, p=0.002), that is the slope of the regression equation (Fig. 1A), for a 10-min increase in participation, there was an average decrease in ΔC of 3°. For an increase in participation from score level 1 to 4, there was a ΔC decrease of 9° (2.97×3). At level 1, ΔC showed the maximal mean increase (6.0°), which was significant with regard to the 95% confidence interval. Although nonsignificant, the maximal reduction in ΔC (-2.9°) was observed at level 4.

The interaction term between the participation and the physical therapist was removed during the course of the stepwise analysis, because it was not significant (*p*=0.13). This indicated that the regression coefficients, calculated separately for each of the two groups MP and NM (-4.50 and -1.95), showed no significant differences. In other words, the relationship with participation did not differ significantly between groups.

The results of the regression analysis for ΔH (Fig. 1B) showed a negative relationship with respect to participation (*r*=-0.35). On the basis of the regression coefficient (-1.03, SE 0.49, *p*=0.044), when participation increased from level 1 to level 4, there was an average decrease in ΔH of 3 mm (1.03×3).

Since there was a positive correlation between ΔC and ΔH (*r*=0.46, *p*=0.007), (Fig. 2), it could be inferred that with greater participation, the Cobb angle and the hump height showed a lesser degree of worsening in the same subject.

Discussion and conclusions

The observed association between changes in Cobb angle and participation was not "explained" by changes in the other variables. Besides showing a non significant regression coefficient (at least partly due to the relatively small sample size), none of the most important confounding variables (i.e., age, initial Cobb angle, final Risser sign, and duration of treatment) appeared to affect the regression coefficient of participation. The results indicate that exercise therapy alone, performed for ≥30 min a day for a mean period of 2 years, as compared with exercise therapy performed for just <10 min daily, slowed and even halted the progression of both the curves and the humps (9° and 3 mm). With regard to the curves, the effect could be observed both in the group at a low risk of further progression (on the basis of the final Risser value) and in the group at a relatively high risk of progression (with differences of 12° and 6°, respectively).

We can rule out the hypothesis that the subjects who dedicated most time and effort to therapy were also those most likely to make more effort to voluntarily correct their spinal position during the follow-up examinations. Although we cannot rule out the possibility that our subjects may have attempted to correct their scoliotic curves during radiological examination, we can exclude the possibility of self-correction in the case of the hump, measured with the trunk in forward flexion, not only because of the strict standard procedures observed during the examination but also because the subjects had never been taught any exercises in that position.

Nor can our result be explained in terms of the level of participation in exercise therapy being prevalently feedback induced by the natural changes in the Cobb angle, since at the second radiological examination, when the subjects were still unaware of the effect of their effort, the regression coefficient was already significant (p=0.002).

The magnitude of the variations cannot be generalised to the rest of the scoliotic population, because, for ethical reasons, this study did not include an untreated group of subjects with scoliosis.

In any case, the primary goal of this study was to determine whether exercise therapy alone could slow down the progression of scoliosis, as reported by previous authors.[1-4]

Discussions of how exercise therapy acts must include a previously proposed hypothesis [13] that specifies that the angular difference between a standing and a supine radiograph is the postural component of the curve (i.e., more flexible or functional), referred to as the "collapse" by Duval-Beaupère.[14] According to Torrel *et al.*,[15] the mean difference is 9°, regardless of the curve entity, and is therefore relatively greater in cases of mild scoliosis. In such mild cases, one cannot rule out the possibility that specific systematic exercises would gradually correct the curve in its postural component. On the other hand, the momentary active correction of the postural component is fairly easy to achieve through exercise. Curve reductions are accompanied by increases in mechanical stability [16] and decreases in the stresses responsible for the asymmetric vertebral growth. Consequently, the scoliosis progresses more slowly. In the present study, both of the physical therapists might have reached a postural correction of the curves of their subjects: in fact, a slower rate of progression was observed in both groups (6° in PM and 14° in MN).

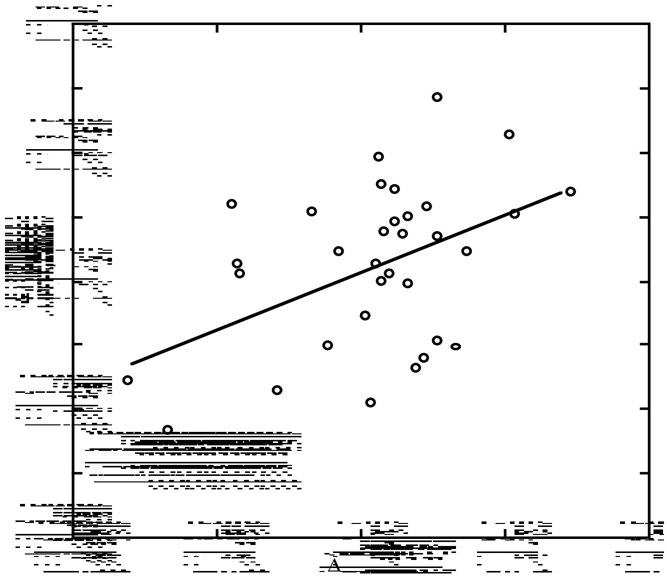

Fig. 2.—Significant positive correlation between variations in Cobb angle (ΔC) and hump height (ΔH). Each subject is represented by a circle. Circles have been shifted slightly to avoid overlapping.

As suggested by Scheier,[17] it is even possible that the improved biomechanics of the spine secondary to exercise therapy might have a corrective effect on the growth. In our sample, this was confirmed by the real improvements in the curves, which varied from 7° to 12° (mean 8.6°) and occurred in 6 out of the 17 subjects who showed high-participation in exercise therapy (levels 3 and 4), *versus* a single case of improvement (5°) out of the 17 subjects who showed

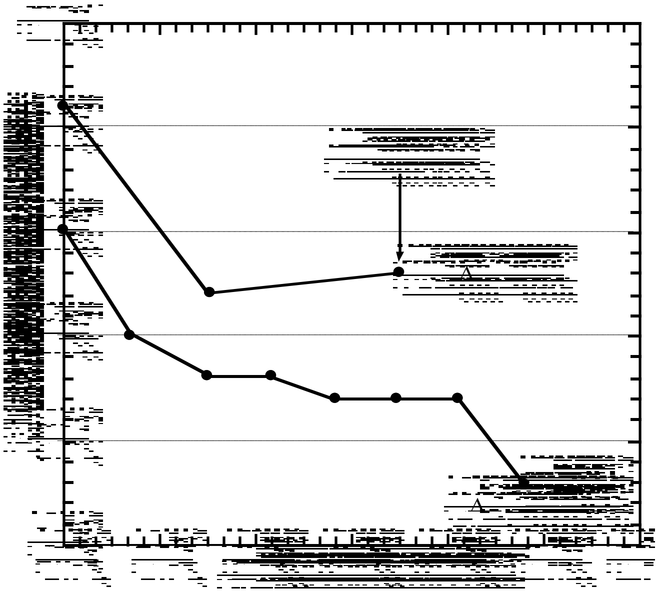

Fig. 3.—Improvement in Cobb angle and hump height in a 12.8 year-old girl with right thoracic scoliosis, whose participation in exercise therapy was optimal for 2.4 years. The final X-rays showed the complete excursion of the iliac apophyseal ossification center (100%, according to Risser's original measurement method), and therefore scoliosis, in addition to a noticeable correction of both the curve and the hump, could probably be considered stabilized.

low-participation in exercise therapy (levels 1 and 2), (Fig. 1A). In some of the most favourable cases, there might have been an improvement not only in the postural component of the curve, but also in the structural component (i.e., more rigid).

It was interesting to note the progress of two subjects who made the greatest effort to follow the exercise programme. The first case was a 12.7 year-old boy who was treated for 2.8 years (until Risser 4). The boy's single right thoracic curve decreased progressively from 17° to 11, 7° and 5°, and the thoracic hump (the most obvious sign of structural scoliosis in mild curves) from an initial height of 8 mm regressed to 3 mm (with decreasing values every 4 months). The second case was a 12.8 year-old girl who participated in the exercise programme for 2.4 years (Fig. 3). The girl's single right thoracic curve decreased from 21° to 13°, and the thoracic hump, which was measured every 4 months even after the final radiographic examination, improved progressively from 15 mm to 3 mm. It was indeed surprising to achieve such hump reductions (5 mm and 12 mm, respectively) in idiopathic scoliosis, without resorting to braces or surgery.[9]

In reality, even untreated, mild scoliosis can improve spontaneously, at least in terms of Cobb angle.[11 18] It is likely that the subjects who are most responsive to exercise therapy are those whose prognosis is more favourable at onset. On the other hand, if considered individually, they may also worsen, despite their excellent participation in exercise therapy (Fig. 1A). In these cases, rather than ineffective, we would suggest that exercise therapy alone is insufficient to counteract the progression of scoliosis.

Our results provide no support for the contention that exercise therapy is ineffective in the treatment of scoliosis. Of note, despite their differences, all of the exercise therapy programmes that have met with success both in this study and elsewhere,[2-4] share a common goal, namely, the postural rehabilitation of scoliotic patients. They are based on the subject's awareness of the deformity through the evocation of external and proprioceptive afferences, active postural correction, reinforcement of the balance reactions, and stabilisation through corrective mechanisms.[19 20] Less specific, more mechanical exercise therapy techniques [21 22] in the treatment of scoliosis failed to yield such favourable results.

Much remains to be learnt about exercise therapy in the treatment of scoliosis. One question concerns the actual mechanism underlying the steady correction of the postural component during therapeutic exercise; an interesting hypothesis concerns the rebalancing of the neuromotor system for the postural control of the spine. Above all if we consider that among the supposed causative factors of idiopathic scoliosis [22-26] are primitive functional disturbances of the central nervous system,[23-27] mainly attributable to its delayed maturation.

At least two clinical aspects warrant further investigation. The first is the possibility that exercise therapy may reduce the prescription of braces for scoliosis. Beyond the possibility of slowing down the rate of progression, this is the most ambitious goal: we think this would be the way for exercise therapy to earn its place among the acknowledged treatment techniques. In this study, for a worsening of the curve of ≥5° and with a curve angle of ≥20°, the braces prescribed (for part- or full time use) to subjects whose participation ranged from levels 1 to 4, were, respectively, 2,4,2, and 2, with a non-significant (p=0.6) linear reduction in the prescription of 4%.

The second issue regards young scoliotic patients willingness to follow exercise therapy. It is noteworthy that 18 of our 38 patients (47%) failed to make the necessary commitment to the home programme (<30 min/day). The long treatment periods are probably among the main causes of this problem. Our quest for the future will be to devise more adequate strategies,[22] to overcome the monotony of the home programmes.

Riassunto

L'effetto della cinesiterapia nella scoliosi idiopatica lieve. Risultati preliminari.

Obiettivo. Verificare se nei soggetti in età evolutiva portatori di scoliosi idiopatica lieve un programma specifico di cinesiterapia modifichi l'andamento della deformità.

Disegno sperimentale. Indagine prospettica e retrospettiva per valutare la relazione tra la cinesiterapia effettuata secondo vari gradi di impegno e le variazioni osservate nell'angolo di Cobb e nell'altezza del gibbo.

Ambiente. Cinesiterapia ambulatoriale presso il Servizio Autonomo di Riabilitazione Ortopedica della Clinica Ortopedica dell'Università di Padova.

Metodi. Erano reclutati consecutivamente 34 soggetti scoliotici dell'età media di 11,6 anni (DS 1,5 anni; ambito 8,7-14,1 anni), con l'angolo di Cobb medio iniziale di 14,9° (DS 3,5°; ambito 10-24°) e l'altezza media del gibbo di 7,3 mm (DS 4,0 mm; ambito 2-20 mm). Affidati permanentemente ad uno dei 2 fisioterapisti, che adottavano tecniche diverse con obiettivi terapeutici analoghi (correzione posturale attiva della scoliosi), i soggetti erano invitati ad impegnarsi negli esercizi appresi per almeno 30 minuti al giorno a casa. Pertanto la maggior parte del tempo da dedicare alla cinesiterapia era occupata da quella domiciliare. Mediamente dopo 2.0 anni di trattamento (DS 0,99 anni; ambito 0,7-4,3 anni), per le variazioni dell'angolo di Cobb era eseguita un'analisi di regressione lineare multipla in funzione dell'effettivo impiego domiciliare (min/die), della variabile terapista, e di possibili variabili confondenti (come angolo di Cobb ed età iniziali, segno di Risser e durata del trattamento); per l'altezza del gibbo era eseguita un'analisi di regressione lineare semplice in funzione dell'impegno.

Risultati. L'analisi dimostrava che, quando la cinesiterapia era praticata con il massimo impegno (≥30 min/die) per la durata media di 2 anni, confrontata con la cinesiterapia praticata con il minimo impegno (<10 min), le curve e i gibbi progredivano mediamente di meno (9° e 3 mm), tendendo alla stazionarietà. I risultati non differivano significativamente nei due terapisti.

Conclusione. Un adeguato programma cinesiterapico, se svolto con il massimo impegno sembra poter mediamente contenere la progressione delle scoliosi lievi. Questo anche quando le tecniche sono diverse, purché siano medesimi gli obiettivi terapeutici del programma.

Parole chiave: Cinesiterapia - Postura - Scoliosi.

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