

Rehabilitation of adolescent idiopathic scoliosis: results of exercises and bracing from a series of clinical studies

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S. NEGRINI, S. ATANASIO, F. ZAINA, M. ROMANO

Aim. Rehabilitation of adolescent idiopathic scoliosis (AIS) requires a careful choice from among the possible treatments, such as bracing and exercises, according to the patient's needs. According to the literature, there is little evidence regarding the efficacy of these rehabilitation instruments. During the past few years, a full series of studies has been carried out to investigate their efficacy. The aim of this paper was to summarize all these results.

Methods. Three systematic reviews (two on exercises and one on manual therapy), and four cohort prospective studies were performed. The prospective studies included two trials with a prospective control group on exercises (one to avoid bracing and one in preparation to bracing) and two trials with retrospective control group on a new brace developed by the Authors (Sforzesco brace and SPoRT concept of correction versus Lyon brace and Risser cast).

Results. Results show that in literature there is proof of level 1b on exercises but no studies on manual therapy. High quality exercises like Scientific Exercises Approach to Scoliosis (SEAS) have more efficacy than usual physiotherapy, significantly reducing brace prescription in one year from 25% of cases to 6%. Moreover, such exercises help to obtain the best results in bracing first correction. The Sforzesco brace has proved to have more efficacy than the Lyon brace, whereas it has the same efficacy — but reduced side effects and impact on quality of life — than the Risser brace.

Conclusion. With an efficient management of data collection, it is possible to develop a set of studies aimed at verifying the efficacy of clinical daily rehabilitation approaches.

KEY WORDS: Rehabilitation - Scoliosis - Adolescent - Exercise.

*ISICO, Italian Scientific Spine Institute
Milan, Italy*

Rehabilitation of adolescent idiopathic scoliosis (AIS) requires the careful choice of different possible treatments, such as bracing and exercises, according to the patient's need. Even if the Italian¹ and international² guidelines recommend such treatments to avoid surgery, many doubts have been raised regarding the efficacy of both exercises³⁻⁵ and bracing.⁵⁻⁷ During recent years, a new international scientific society, the International Society on Scoliosis Orthopaedic and Rehabilitation Treatment (SOSORT),^{2, 8-11} was established to verify the scientific basis and efficacy of these rehabilitation practices; moreover, a new journal — *Scoliosis*^{12, 13} — was launched, and now research is flourishing again after years of decline. (Negrini S. Approach to scoliosis changed due to causes other than evidence: Patients call for conservative (rehabilitation) experts to join in team orthopaedic surgeons. *Disabil Rehabilitation* 2008 [submitted]).

Alongside the new international concerns, steps are also being taken on the national level, for many years, daily rehabilitation practice for AIS was based on exercises and bracing.¹⁴⁻¹⁹ This study addresses the absence of proof regarding the efficacy of these therapies. During the last few years, the authors began a series of studies — at first bibliographical and then on patients — to verify the usefulness of exercises and bracing, in particular, their everyday use. Many of these studies focused on a specific set of exercises developed by the authors, namely the Scientific

Address reprint requests to: Negrini S., ISICO (Italian Scientific Spine Institute), Via Bellarmino 13/1, 20141 Milan, Italy.
E-mail: stefano.negrini@isico.it

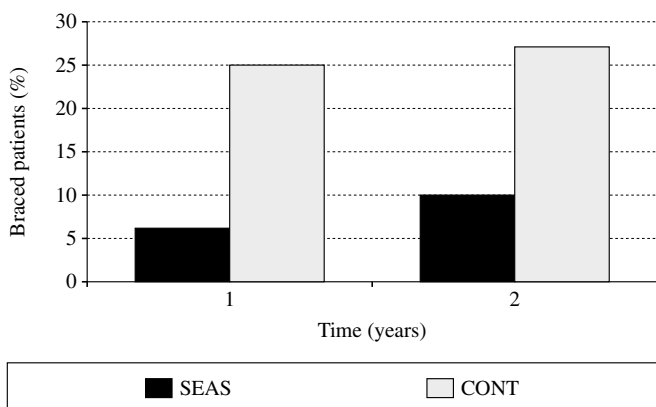


Figure 1.—Exercise SEAS treatment reduces the need for bracing. Percentage of braced patients in SEAS and control (CONT) group after 1 and 2 years of treatment.^{20, 31} (Figure reprinted from ISICO).²²

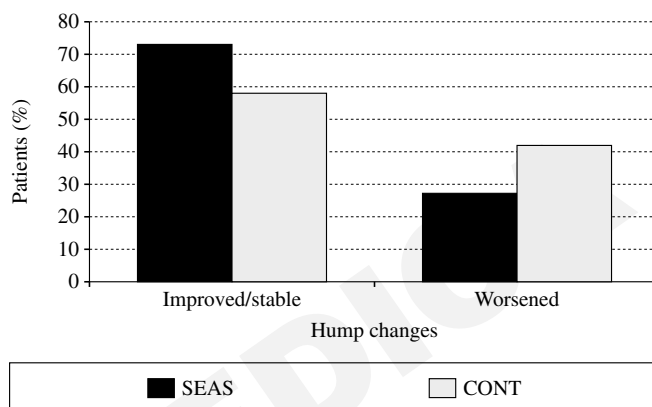


Figure 3.—Exercise SEAS treatment improves the Bunnel angle. After therapy, the percentage of patients with improved Bunnel angle in SEAS group is more than twice that of the control (CONT) group.²¹ (Figure reprinted from ISICO).²²

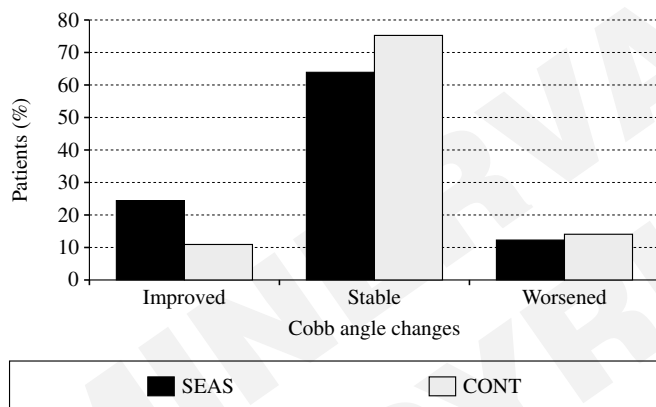


Figure 2.—Exercise SEAS treatment improves Cobb angle. After therapy, the percentage of patients with improved Cobb angle in SEAS group is more than twice that of the control (CONT) group.²⁰ (Figure reprinted from ISICO).²²

Exercises Approach to Scoliosis (SEAS)²⁰⁻²² and Symmetric Patient-oriented, Rigid, Three-dimensional, active bracing (SPoRT).^{22, 23} The aim of this paper is to summarize all the results obtained. The results section is devoted to the presentation of the methods, results and discussion of each single study, and the methods and discussion section provides a general overview.

Materials and methods

Three systematic reviews of the literature, two on exercises²⁴ and one on manual therapy,²⁵ and four

group studies were performed. Of the group studies, two exercise studies were performed (to avoid bracing²⁰ and in preparation for bracing²¹), each with a prospective control group, and two studies were performed with retrospective control groups on a new brace developed by the authors (Sforzesco brace and SPoRT concept of correction *versus* Lyon brace²³ and Risser cast).^{24, 27}

Moreover, the results of three other controlled studies on technical factors are summarised,²⁸⁻³⁰ and the population and methods of each study are in the results section.

This development of the study series was characterized by the common background of the Authors, who are all professional members of ISICO (Italian Scientific Spine Institute).²² All physicians engaged in ISICO follow exactly the same protocols and patient evaluations, allowing uniform data collection wholly based on data processing. All patients (once they agree to personal data management for research purposes) can be prospectively followed and included in specific studies. In this way, almost 1000 spinal disease-patients per year are added to the database for further studies.

Results

The results provided by the different studies have been arranged in order to answer several relevant clinical questions.

Usefulness of Exercises for AIS

The purpose of the Authors' first study, published in 2003 by Paediatric Rehabilitation³ and selected by the Cochrane Database of Systematic Reviews (DARE), was an extensive and systematic review of the literature aimed at verifying the effectiveness of physical exercises in the treatment of AIS. A search of different databases (Medline, Cochrane Library, Embase, Cinhal) was carried out together with a hand-search of the non-indexed pertinent literature. Eleven papers were found: none of the studies were randomized, six were prospective, seven were controlled, two compared their results to historical controls, and one paper had a prospective design and concurrent control group. The methodological quality of the retrieved studies was reviewed and found to be very poor. With one exception, the published studies demonstrated the efficacy of physical exercises in reducing both the rate of progression and the magnitude of the Cobb angle at the end of treatment. However, being of poor quality, the literature did not provide solid evidence for or against the efficacy of physical exercises in the treatment of AIS. Nevertheless, it has been implied that exercises could be recommended on the basis that benefits other than to avoid progression have been shown in the literature, and the results presented in published studies reviewed here suggest an effect on the primary goal of preventing progression. As a result, there is some basis for discussion of this option with patients and their families, which, in turn, allows decisions to be made according to their preferences.

Five years later, the Disability and Rehabilitation Journal accepted and is publishing an update of this systematic review²⁴ whose aim is to confirm whether the indication for treatment with specific exercises for AIS has changed in recent years. A bibliographic search with strict inclusion criteria (patients treated exclusively with exercises, outcome Cobb degrees, all study designs) was performed on the main electronic databases and through extensive manual searching. Nineteen studies were retrieved, including one randomized controlled trial (RCT), eight controlled studies, and 12 studies prospective studies. A methodological and clinical evaluation was performed on these studies. The 19 papers analyzed included 1654 treated patients and 688 controls. The most significant study (the RCT) compared two groups of 40 patients and showed an improvement of curvature

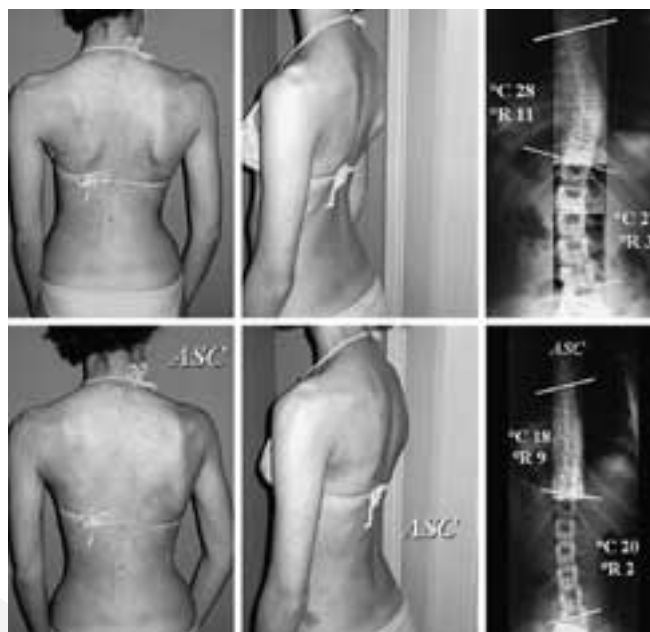


Figure 4.—From a neurophysiological perspective,³²⁻³⁴ active movement is much better than passive for learning neuro-motor behaviours like posture. Active self-correction (ASC) instead of passive autocorrection goes towards this direction with a conceptual passage from “correction” (passive corrective exercises) to “neuromotor rehabilitation” (active exercises to learn behaviours). First line: normal posture. Second line: ASC. Observe normalization of flanks, increase of thoracic kyphosis and better lumbar lordosis from radiographic results (C: Cobb; R: Raimondi rotation).²⁸ (Figure reprinted from ISICO).²²

in all treated patients after 6 months. The authors found three papers on Scoliosis Intensive Rehabilitation (Schroth), five on passive autocorrection-based methods (Schroth, side-shift), four on active autocorrection-based approaches (Lyon and SEAS), and five with no autocorrection (three asymmetric, two symmetric exercises). Apart from one study presenting no autocorrection or symmetric exercises and very low methodological quality, all studies confirmed the efficacy of exercises in reducing the progression rate (mainly in early puberty) and/or improving the Cobb angles (at the end of growth). Exercises also proved to be effective in reducing brace prescription. The authors concluded that in the past 5 years, there have been eight papers published in the indexed literature coming from all over the world (Asia, the US, Eastern Europe), proving that the interest in exercises is not limited to Western Europe. This systematic review confirms and strengthens the previous ones. The actual evidence on exercises for AIS is in level 1b.

There is no proof of the efficacy of manual therapy for scoliosis

The treatment of AIS depends on many variables. A simple observation is sufficient for less serious curvatures, but for more serious cases, surgical intervention could be recommended. Between these two approaches, there is a wide range of different treatments. Manual therapy is commonly used; the aim of this paper was to verify the data existing in the literature on the efficacy of this approach. A systematic review of the scientific literature published internationally has been performed. With the term "manual therapy," the authors refer to all manipulative and generally passive techniques performed by an external operator. In particular, osteopathic, chiropractic and massage techniques have been considered as manipulative therapeutic methods.

The systematic research was performed in Medline, Embase, Cinhal, Cochrane Library, and Pedro with the following terms: "idiopathic scoliosis" combined with "chiropractic;" "manipulation;" "mobilization;" "manual therapy;" "massage, osteopathy;" and "therapeutic manipulation." The inclusion criteria were the following: any type of research; diagnosis of AIS; patients treated exclusively by one of the procedures established as a standard for this review (chiropractic manipulation, osteopathic techniques, massage); and outcome in Cobb degrees. One hundred forty five texts were retrieved, but only three papers were relevant to the present study. However, none of them satisfied all the requirements because these studies were characterized by a combination of manual techniques and other therapeutic approaches. The lack of significant scientific data should not lead to any conclusions about the efficacy of manual therapy as a reliable technique for the treatment of AIS.²⁴

Exercise SEAS treatment to reduce the need for bracing

The aim of this section is to compare the effect of the SEAS exercises *versus* usual rehabilitation programs in terms of avoidance of brace prescription and prevention of curve progression. A prospective controlled cohort observational study was carried out, including 74 consecutive outpatients with AIS ($15 \pm 6^\circ$ Cobb, 12.4 ± 2.2 years) not previously treated and at risk for bracing. Thirty-five patients entered the SEAS Exercises Group (SG), and 39 entered the Usual Physiotherapy Group

(UPG). The primary outcomes included the number of braced patients, Cobb angle, and the angle of trunk rotation (ATR). The braced patients were 6.1% in SG *versus* 25.0% in UPG, while failures of treatment in the worst-case analysis were 11.5% and 30.8%, respectively. In both cases, the differences were statistically significant. The Cobb angle improved in the SG, but worsened in the UPG; in fact, in the SG 23.5% of patients improved and 11.8% worsened, while in the UPG the figures were 11.1%, and 13.9%, respectively. These data confirm the effectiveness of exercises in scoliosis patients who are at high risk for progression. When compared to non-adapted exercises, a specific and personalized treatment (SEAS) appears to be more effective. This study was repeated at the 2 year follow-up with similar results.(Figure 1).^{20, 24, 31}

Exercise SEAS treatment improvement of scoliosis parameters

In the previously mentioned study, exercise results were also documented with traditional measures. In terms of Cobb degrees, the percentage of patients showing a radiographic improvement was 24% in the SEAS group *vs.* 11% in the control group, whereas the number of worsened cases was superimposable even if slightly lower in the SEAS group (12% *vs.* 14%) (Figure 2). A clinical evaluation of the largest curve hump, carried out using Bunnell's scoliometer, in the SEAS group showed a stability/improvement in 73% of cases *vs.* 58% in the control groups (Figure 3).^{20, 24}

Exercise SEAS treatment normalizes balance and coordination in scoliosis patients

According to the SEAS protocol, the exercises aim to improve some specific impairments of the scoliotic patient, normalizing them and reducing the risk of progression of scoliosis, leading to better equilibrium and coordination.²⁸ In a controlled cross-sectional cohort study, 190 subjects divided into two groups (40 AIS patients and 150 controls) were evaluated; the 40 AIS patients were further divided into two subgroups (20 treated for one year with SEAS and 20 not treated). All participants were evaluated with Unterberger (Fukuda), Romberg (sensitized and not sensitized) and lower-limb oscillation tests. Patients treated with the SEAS protocol showed superimposable results to those of control subjects; on a statisti-

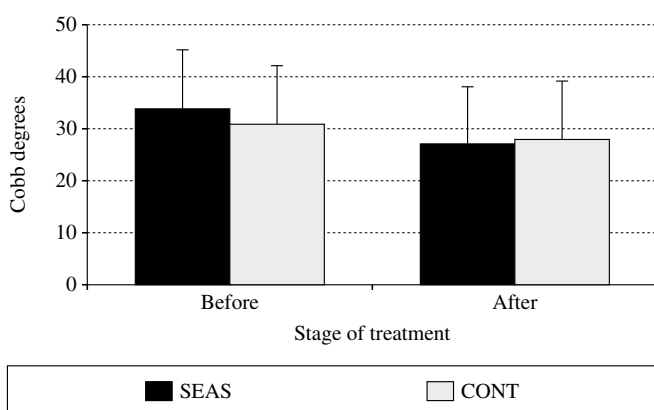


Figure 5.—Effect of SEAS pre-brace treatment. Patients who performed SEAS had a better result after bracing than controls.²¹ (Figure reprinted from ISICO).²²

cal basis in both groups, results were definitely more positive than in untreated scoliosis patients.

Use of SEAS active self-correction exercises to reduce the radiographic curve

Autocorrection has been considered by SOSORT experts as a key aim of exercises for idiopathic scoliosis; the active self-correction (ASC) is a type of autocorrection actively performed by the patient without any external aid, which is the root of SEAS (Figure 4). ASC is a selective (*i.e.* involving only the vertebrae) lateral de-flexion, sagittal correction (usually increase of kyphosis and preservation of lordosis) and horizontal derotation; however, this movement is very difficult and requires several months to learn. Twenty-seven consecutive patients requiring x-ray examination for their clinical follow-up have been included in the study. All patients underwent both standard and in ASC X-ray examinations; they were all photographed frontally and laterally to have an evaluation of the seriousness of ASC. The statistically significant percentage of reduction of scoliosis was $11.0 \pm 12.3\%$ with a reduction of rotation of $13.2 \pm 63.4\%$. This study proves that it is possible to actively reduce the curvature with a selective action and without any external aid and that expert physiotherapists can teach ASC.²⁹

Exercise SEAS treatment improvement of results in case of bracing

Although their main aim is to facilitate orthosis function, exercises play an important role in the prepa-

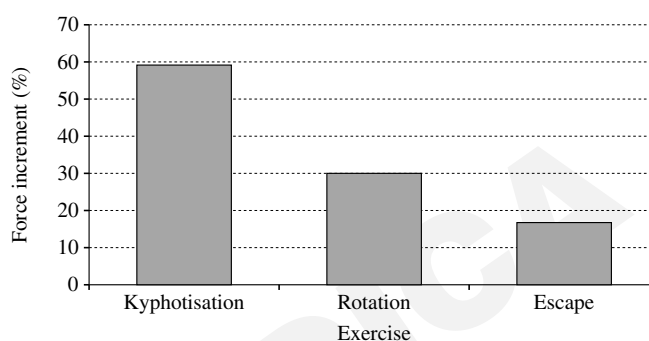


Figure 6.—The forces of brace pushes can be incremented by specific exercises. Kyphotisation can increment forces up to 60%.³⁰ (Figure reprinted from ISICO).²²

ration for brace treatment as well. To confirm whether the SEAS protocol, mobilizing and preparation for the brace can achieve this, the results obtained at the first radiographic follow-up at 4 months in 110 patients divided into two groups were compared with a controlled prospective cohort study at the beginning of brace therapy. Data showed a higher efficacy of SEAS treatment compared to standard exercises (control group) in regard to cosmetic appearance (Aesthetic Index) and Cobb degrees of the largest curve and hump (Figure 5).²¹

SEAS kyphotisation exercise as the most useful to help bracing push work

A study in 17 consecutive adolescents was carried out to quantify and compare different exercises (kyphotisation, rotation and “escape from the pad” in different positions – sitting, supine and on all fours) performed in braced condition to increase their corrective forces. The authors verified that in static and dynamic conditions, the position adopted does not alter the total pressure exerted by the brace. Kyphotisation and rotation exercises guarantee a significant increase of pressure (+58.9% and 29.8%, respectively), whereas the “escape from the pad” exercise, despite its name, does not produce any significant variation of pressure. The authors concluded that exercises in braced condition allow the application of adjunctive forces on soft tissues and, presumably through them, on the spine. Different exercises can be chosen to obtain different actions; physical exercises and sporting activities are useful in mechanical terms, although other important actions are not to be neglected (Figure 6).³⁰

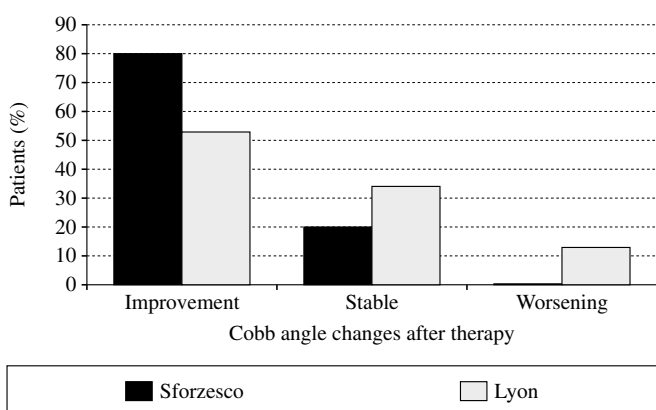


Figure 7.—The Sforzesco brace (SPoRT concept) is more effective than the Lyon brace (3 point correction) after 6 months of treatment. The number of improved patient in terms of Cobb angle is significantly higher in the Sforzesco group than in the Lyon group.^{23, 26} (Figure reprinted from ISICO).²²

Increased effectiveness of the Sforzesco brace (SPoRT concept) over the Lyon brace (three point correction) after 6 months of treatment

A prospective cohort study (Sforzesco brace, SPoRT correction concept) was carried out with a matched retrospective control group (Lyon brace, three-point correction concept) on 30 patients aged 30 years and with curves of 38° Cobb angle. It was a study on the best available practice, as the proposed brace was considered the best at the moment of treatment execution. The Sforzesco brace obtained higher mean radiographic improvements (-10° Cobb vs. -5°), as well as a better cosmetic appearance of the flanks and shoulders without the negative impact on kyphosis determined by the Lyon brace. In terms of Cobb degrees, 80% of Sforzesco group patients improved and none worsened, while the Lyon group results showed 53% improved and 13% worsened. No differences were observed with regard to humps (Figure 7).^{23, 26}

Sforzesco brace (SPoRT concept) as equally effective as Risser plaster brace

Currently, the Risser plaster brace is also proposed by the Scoliosis Research Society (SRS) as a very effective tool for the conservative treatment of AIS. The authors conducted a prospective cohort study with a retrospective control group on 41 patients aged 4 years and with curves of 40° Cobb. Eighteen patients were treated with the Risser plaster brace and 33 with the

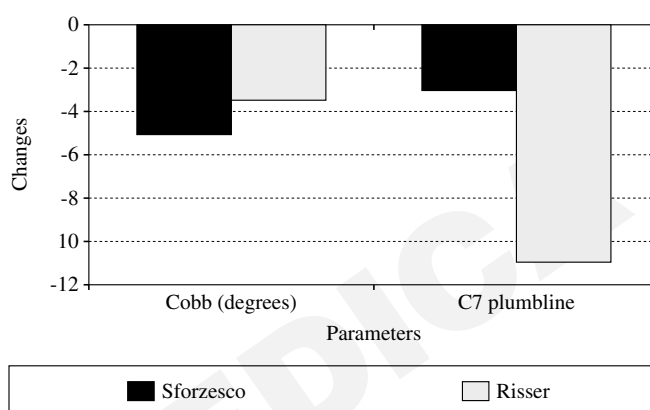


Figure 8.—Sforzesco brace (SPoRT concept) is equally effective as Risser plaster brace. The mean reduction of Cobb angle is higher in the Sforzesco group than in the Risser plaster brace group, even if not statistically significant, while the opposite happens for sagittal plane curves.²⁶ (Figure reprinted from ISICO).²²

Sforzesco brace. This was a study on the best available practice, as, until 2002, plaster had been the standard treatment for the largest curves and since mid-2004, the Sforzesco brace was systematically used. The follow-up was scheduled at 18 months, *i.e.* after the end of the corrective phase of the treatment (12 months). The first follow-up examination was done with complete clinical and radiographic data. The Sforzesco was shown to be more effective in reducing the thoracic curve, and its results were superimposable for the other regions. The Risser plaster brace was shown to be more effective on the thoracic hump and in regard to the cosmetic appearance of the flanks, but it also caused a serious kyphosis reduction. Considering the reduction in personal (in terms of quality of life) and social costs (outpatient treatment for brace, while plasters always require some kind of hospitalization and at least in day-hospital), the plastic brace can replace the Risser plaster brace (Figure 8).²⁷

Discussion and conclusions

Every single study in this field has been discussed in the results section of this paper. It was possible to demonstrate that in the literature there is proof of level 1b³⁵ (many controlled studies, not randomized, with coherent results) on the efficacy of exercises, but there is no proof at all on the usefulness of manual therapy. These data should be included in future reviews on

scoliosis treatment. Good quality exercises (SEAS) have more efficacy than usual physiotherapy, significantly reducing brace prescription in one year from 25% of cases to 6%; moreover, they help in obtaining the best results in bracing correction. The newly developed Sforzesco brace, and consequently the SPoRT concept of correction of scoliosis, has more efficacy than the Lyon brace and the same efficacy (but reduced side effects and impact on quality of life) as the Risser plaster brace. This brace should be preferred in high degree progressive scoliosis to avoid surgery.

Undoubtedly, this study series had advantages conferred by the organization of ISICO.²² All physicians of the Institute follow exactly the same approach protocols and patient evaluations, which implies a loss of some individual clinical freedom. However, in this way, it is possible to gain a uniform data collection for research and, even more important, any innovation introduced by a single physician becomes immediately (after appropriate discussion) shareable. This is the authors' approach to evidence-based medicine and clinical practice, as summarized in the ISICO principles (Table I): the mission of the Institute is to present research to the clinical — but not only clinical — world.²² Data processing can be very helpful, as it allows complete retrieval of data for research and clinical purposes; on the other hand, it compels a shared data collection. The results of these studies are only at the beginning, as each year almost 1000 spinal disease patients are added to the database. This allows the development of future large clinical studies and the verification of any single innovation introduced.

There is one further aspect that is worth discussion. During the last few years, the interest of the AIS treatment community (almost exclusively made up of orthopedic surgeons) seems to have shifted towards surgery (fusion in the case of AIS), where research has increased. Meanwhile, conservative treatment is suffering a decrease in professional interest and, consequently, research.

Accordingly, this is a need that must be addressed: AIS requires expert, committed evidence-based care, and specialists completely devoted to conservative treatment, particularly (but not exclusively) physical and rehabilitation medicine specialists, should enter the field to create better treating teams. This series of studies documents the typical tools of physical and rehabilitation medicine, such as orthosis and exercises, that have an efficacy in AIS treatment; moreover, ISICO itself is mostly made up of physiatrists, and

TABLE I.—Presentation of ISICO principles concretized in the everyday clinical practice.

1. *Efficacy*: scientifically proven validity of used techniques, excluding alternative/traditional methods without any evidence.
2. *Efficiency*: with the same efficacy, efficient protocols, *i.e.*, the least demanding ones in terms of time and costs.
3. *Research*: implemented on a daily basis during the clinical activity, as a guarantee of continuous improvement.
4. *Innovation*: new effective and efficacious techniques should be acquired and transferred to clinical practice as soon as possible.
5. *Acceptability*: techniques that can be adapted to needs and preferences of the patient, who is not the object, but the subject of treatments.
6. *Humanisation*: the single person is at the core of treatment, thanks to dialogue and psychological attention.
7. *Teamwork*: all operators take part in the patient's treatment in a close collaboration.
8. *Transparency*: complete and accurate documentation of what we do that is made available to the patient and the family practitioner.
9. *Organization*: the application of the correct organisational principles allows us to favour processes of continuous improvement
10. *Services appropriateness and reliability*: a natural consequence of the application of principles described here.

results of their physical rehabilitation medicine approach are reported here.

In conclusion, with an efficient management of data collection, it is possible to gradually develop a set of studies aimed at verifying the efficacy of clinical daily rehabilitation approaches.

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