The Evidence Based ISICO approach to spinal deformities

isico

www.isico.it
isico@isico.it

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isico
(Istituto Scientifico Italiano Colonna vertebrale - Italian Scientific Spine Institute)
Via Carlo Crivelli 20, 20122 Milan (Italy)www.isico.it - isico@isico.it

THE EVIDENCE BASED ISICO APPROACH TO SPINAL DEFORMITIES

EDITOR

Stefano Negrini

AUTHORS

Salvatore Atanasio

Alberto Negrini

Alessandra Negrini

Antonio Negrini

Gabriella Negrini

Stefano Negrini

Silvana Parzini

Michele Romano

Nevia Verzini

Fabio Zaina

ISICO - Italian Scientific Spine Institute

Via Carlo Crivelli 20

20122, Milan - Italy

isico@isico.it

www.isico.it

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Summary

1 Premise

The goal of this booklet, which is mainly written for the healthcare personnel but also for the patient, is to provide a thorough overview of the therapeutic approaches to spinal deformities that are used by **ISICO (Italian Spine Scientific Institute)**, an organisation fully devoted to rehabilitation and conservative treatment of scoliosis and back pain, and that constitutes an example of a **highly specialised institute in the field**. This "super-specialty"--a strong belief in the Evidence-Based Clinical Practice approach implemented by its founders--a peculiar history of treatment for these diseases in Italy and southern Europe, as well as the geographical characteristics of our country, had led us to develop an approach that is in some ways unique. In fact, as you will learn in this text, the ISICO approach and concepts (SEAS for exercises, SPoRT for bracing, and the overall ISICO rehabilitation approach) combine the most current scientific knowledge with solutions that are high-tech, low-cost and readily accessible in order to provide **advanced, correct rehabilitation to people encompassing a wide geographical region.**

In this booklet you will find many practical proposals but also quite a number of pages dedicated to theory, on the basis of scientific knowledge. Please consider that, once the principles are recognised, the action to be taken is only a consequence: doing something without understanding why we do it will certainly lead to mistakes. Moreover, it's important to have an idea of what to do, even if learning requires a long period of specific training. Therefore, the **two main concepts** developed by ISICO over the years (**SEAS**, or Scientific Exercises Approach to Scoliosis; and **SPoRT**, or Symmetric Patient-oriented, Rigid, Three-dimensional, active bracing) will be presented as follows:

- **Why and when to apply this treatment**: The efficacy of every concept is based on its correct medical indications.
- **Theoretical basis**: This is the scientific knowledge that has led to the development of the concept and its continuous quality improvement.
- **Practical applications**: Some examples of what to do, even if these concepts are learned and correctly applied, require formal education and years of use. It appears easy because these concepts have the strength of simplicity, but actually they are not simplistic at all.
- **Results**: These constitute the statistics and scientific publications regarding the concepts.

Subsequently, after discussing the Evidence-Based methods used in case of kyphosis, spondylolisthesis and adult scoliosis (whether painful or not), the **ISICO approach** will be discussed with focus on key points such as the role of a systematic and thorough evaluation, the fact of exclusively proposing

outpatient rehabilitation (with obvious advantages for patients and society in terms of comfort and money), the methods developed to offer high competence at the patient's home, the cognitive-behavioural team approach proposed and the key role of counselling, and finally the high-tech solutions employed to help clinicians and enhance research. Today ISICO offers a new type of healthcare that is centred on the patient and evidence instead of focusing on the rehabilitator. Readers will appreciate that this approach and its concepts stem from our ten principles (Table 1), which define the mission of ISICO: "**to promote and develop an innovative model of approach to spinal pathologies**".

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 as soon as possible be acquired and transferred to clinical practice;
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 to 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.	**Organisation**: The application of the right organisational principles allows us to favour processes of continuous improvement;
10.	**Services appropriateness and reliability**: They are a natural consequence of the application of principles described here.

Table 1. The ISICO Principles

2 Background

2.1 Institutional background

2.1.1 ISICO history

ISICO (Istituto Scientifico Italiano COlonna Vertebrale, or **Italian Spine Scientific Institute**), was established at the end of 2002 to promote and develop an innovative model of approach to spinal pathologies. This approach is the result of a history that began as long ago as the **early 1960s**, when in Vigevano (Italy) Antonio Negrini and Nevia Verzini founded the Scoliosis Centre "**Centro Scoliosi Negrini**" (CSN). The therapeutic activity was mainly directed at scoliosis and kyphosis treatment, making use of rehabilitative methodologies that in those days were the most popular ones in Italy. Year after year these methodologies were enriched through the exchange of information and experiences with the most qualified European scoliosis centres: France (Lyon, Paris and Berck), Switzerland (Geneva), Sweden (Goteborg and Stockholm), Belgium (Bruxelles), the Netherlands (Antwerp) and the USSR (Moscow). Particularly, the CSN began a collaborative effort in the study and research of scoliosis with the **"Centre des Massues" in Lyon, France** (Fig. 1), which in those days was considered one of Europe's most prestigious centres for scoliosis treatment. Together with this French institution, in 1980-84 the CSN took part in an international research study on the efficacy of exercise in the treatment of minor scoliosis.[91] This contact with French centres allowed the CSN to establish study and updating relationships with well-known researchers like Stagnara, Duval-Beaupère, Perdriolle and Mollon.

Fig. 1 – From the left: Mr. and Mrs. Stagnara, Mollon and Negrini at the International Congress in Florence (1975)

The huge quantity of scientific studies on the spine, as published in the **international literature** throughout the 1970s and '80s, allowed the CSN to gather considerable data regarding scoliosis aetiology and pathogenesis. To delve further into this reality, in 1978 Antonio Negrini, together with a group of Italian specialists and physicians, promoted the foundation of **GSS** (the acronym for Gruppo di Studio della scoliosi e delle patologie vertebrali, or the Italian Study Group on Scoliosis and spinal pathologies - Fig. 2), which today continues its thirty-year legacy in the pursuit of professional training based on scientific evidence for Italian professionals in the field of rehabilitation and prevention.

Fig. 2 –The logos of Scoliosis Centre Negrini (www.centronegrini.it) and the Italian Study Group on Scoliosis and Spinal Pathologies (www.gss.it).

At the same time it became possible to develop a new approach to the scoliotic patient, in which exercises were directed toward **therapeutic objectives specifically derived from the data provided by scientific research**. The principle of working only on the basis of science began to be applied, and this was the embryo of what would later be proposed by "Evidence-Based Medicine" in a more advanced way: a concept that now is at the root of every protocol applied by ISICO. This exercised-based approach became widespread in Italy during the 1980s and '90s thanks to the presence of CSN at many rehabilitation centres, courses in rehabilitation and physiotherapy, professorships in academic classes for physiotherapists and specialists, through the teaching practices to which the centre was open, with the elaboration of experimental degree dissertations, and with papers presented at the most important national and international conferences.[96,97,101,117,120,121]

The 1985-1995 decade saw the beginning of a permanent cooperation with one of the major Italian rehabilitative structures, the "**Fondazione Don Carlo Gnocchi**." This institution promoted the protocols developed by CSN in Vigevano with the medical and scientific collaboration of Dr. Sibilla, the physician in charge of the Scoliosis Unit at that institute. **Paolo Sibilla** (Fig. 3) was an orthopaedic spinal surgeon who had decided to dedicate his

life to the conservative treatment of scoliosis in order to reduce, as much as possible, the numbers of patients undergoing surgery.

Fig. 3 – Negrini, M.me Duval-Beaupére and Sibilla at the International Congress of Rome (1985)

He obtained much of his experience at Gaetano Pini Hospital in Milan, where he primarily attended, among the others, the orthopaedic schools (whose principles he assimilated) run by Stagnara in Lyon (EDF plaster and Lyonnaise brace);[150,152] by Agostini in Padova (Risser's plaster);[80] and by Chêneau (the homonymous brace, in its first version dating back to the 1980s).[23,24] Another important contribution to his professionalism came, after the initial training at the rehabilitation school in Lyon, from continuous contact with rehabilitators who were deeply involved with medical exercises for scoliosis, which he firmly believed he could personally verify based on the results, and thanks to which he could develop other therapeutic ideas.[29,101,144-146] The later years of his life developed into a rehabilitative reality much like that of the "Fondazione Don Carlo Gnocchi" in Milan, which became a research institute financed by the Italian Health Ministry, with the possibility for further development of his theories. Therefore, Dr. Paolo Sibilla has been a pioneer of new and more effective orthotic solutions for scoliosis, but it was most of all his rigor and deep humanity that brought him professional success.

Amid this confluence of clinic, scientific, human and professional experiences, **ISICO's founders** could develop their experience regarding scoliosis. The combination of all this with organisational and managerial skills, the use of new technologies and the know-how for high-level, rigourous scientific research became a concrete reality with the foundation of ISICO. In all this is reflected the **mission** that ISICO has espoused as the foundation of its activities: to promote a scientific approach to the

rehabilitation of spinal pathologies in Italy, proposing itself as a **highly specialised institute in the field of rehabilitation for patients with spinal diseases**. Accordingly, ISICO wants not only to accomplish the application of this approach within its structures but also to promote its circulation, thanks to its role as a "bridge" among the different realities in this field (Fig. 4): the structures of the territory, the world of research, the world of industry and society as a whole.

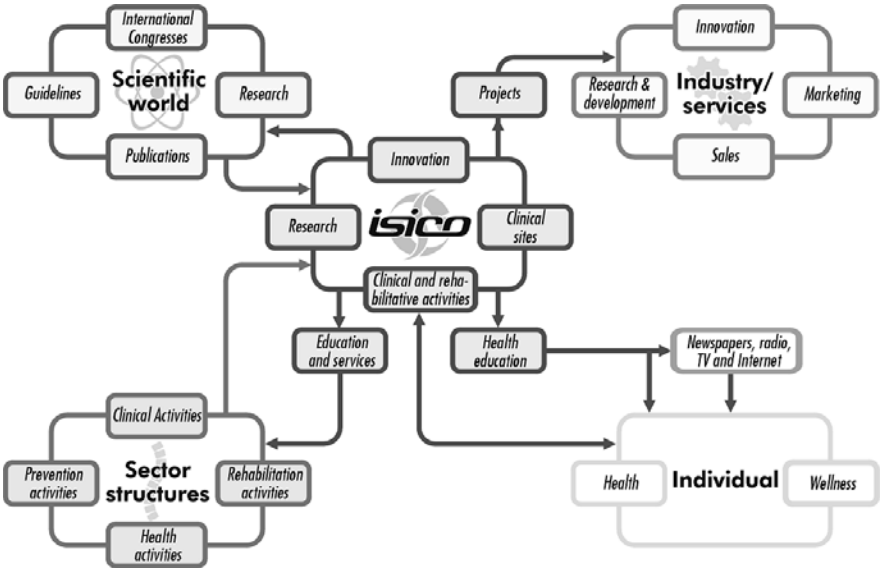


Fig. 4 ISICO is born to build bridges between different worlds that sometimes have difficulties to communicate: working directly in the scientific and clinical fields, the aims of ISICO include also education, mass media communication, prevention, and research projects for industries.

2.1.2 Looking at scoliosis from the dual perspective of Evidence-Based Medicine and Evidence-Based Clinical Practice

The **foundation** we wanted to give to ISICO's work, on the basis of our history, has been clearly discernible from the beginning: to derive clinical and therapeutic choices (**Evidence-Based Clinical Practice**, EBCP) from scientific knowledge (**Evidence-Based Medicine**, EBM). In a context such as spinal rehabilitation, in which unsuitable treatments based on beliefs and opinions are very frequent, we felt the need to do something more stringent. We chose to have more certainties on which to base our approach, as well as an **external reference** instead of an internal, self-centred one. In that respect, science is a reference we can trust, because it is not based on the

ideas (even if creative and clever) of one or more persons but on the proof of research integrated with the thoughts (expert opinions) of an entire community--the scientific community--that continues to study and grow.
EBM has been defined as the "**integration** of the best scientific proof coming from research with clinical experience and patients' values"[141]. Therefore, it is not a supine application of the **scientific knowledge** to our patients (this alone could be meritorious as compared with the application of one's preconceived ideas, which is a distinguishing feature of many physiotherapeutic and therapeutic methods) Instead, it is the integration of this knowledge in one's **clinical experience** in order to produce a proposal that must then **interact with the patient**, who is no longer a mere spectator of the medical act but a participant, because he/she must be enabled to consciously choose on the basis of his or her principles and values. In that respect, EBM tells us that evidence is only the background from which medical practice derives.
Considering the field of conservative treatment for spinal deformities we must make another remark, which is to say that from the publication of the Italian guidelines on scoliosis it is clear that there is a **lack of research in this field.**[106,107] A comparison of the available publications on this subject versus other musculo-skeletal pathologies is striking: A Medline search of "low back pain" produced more than 13,000 publications, while there were only about 2,100 for idiopathic scoliosis. Moreover, in regard to its conservative treatment there were no more than fifty-two! Among these there are no randomised controlled trials (RCTs), i.e., the more consistent (reliable) ones. The strongest scientific evidence has to do with brace treatment, but as to exercises the data seem to suggest their efficacy. Given this situation, from our perspective Evidence-Based Clinical Practice is possible by:

- Maintaining the **actual evidence** as the stable foundation of the clinical process;
- Activating a **continuous quality improvement process** by measuring and constantly verifying clinical outcomes, in comparison with the best existing standards;
- Integrating in the approach other ethical, economic and managerial variables such as those defined in the **ISICO principles** (Table 1): efficacy, efficiency, research, innovation, acceptability, humanisation, teamwork, transparency, organisation, services appropriateness and reliability;
- Stimulating and participating in a **worldwide research effort** (we contributed to the creation of **SOSORT**, or the Society on Scoliosis Orthopaedic and Rehabilitation Treatment) so as to integrate international experiences and develop new clinical studies, but also theoretical "basic science" reports that could in the near future prove useful in clinics, such as those on classification and measurement systems.

When science is not so clear, there is room for individual and collective beliefs; for the patient's and operator's principles; for philosophy that, in ISICO's case, is clearly defined by our principles; and by the country of origin, Italy. From this come:

- An **underlying humanity**, even if in the rigour of science and in the demand for a result;
- Continuous **attention to the patient**, but with awareness that psychological attention can never surpass the physical one;
- **Consideration for cosmetic appearance and style**, which is innate in being Italian.

However, let's return to the basic issue: if there are so many variables concurring to build a clinical approach, **does EBM really help? We think it does.** We established our organisation to give EBM answers to patients, and EBM has become a daily clinical practice at our facilities. The Italian guidelines on scoliosis,[106] that are rigourous and internationally innovative, and fully an EBM national project that ISICO helped to develop, for our organisation are a definite policy of clinical practice. Additionally, this means we are always ready to change our ideas in the face of new scientific evidence in the literature. We continuously investigate our results to build our daily clinical approach on objective results, not on ideas, presumptions, traditions and trends. EBM is a way of thinking that becomes a daily behaviour.

2.2 Scientific background

2.2.1 What scoliosis is, and what is important for treatment

Scoliosis is a three-dimensional deformity of the spine (Fig. 5).[99,155,157] Today it is anachronistic to describe it as "**a lateral deviation of the normal vertical line of the spine . . . scoliosis consists of a lateral curvature of the spine with a rotation of the vertebrae within the curve**," as would still be apparent when looking at the Scoliosis Research Society website and the related Terminology Committee.[149] It is a pathology that presents very complex aspects and, in some ways, even a certain appeal for healthcare professionals who want to cure it. For these reasons, we believe the definition proposed in the Italian National Guidelines[106] is more complete: "**a complex structural deformity of the spine that turns on the three spatial planes: on the frontal plane, it manifests itself with a lateral flexion, on the sagittal one with a change in the curvatures (very often causing their reversal), and on the axial with a rotational movement**."

Based on the **age at detection**, we can distinguish infantile (until three years of age), juvenile (from three years until puberty), adolescent (from puberty until complete bone maturity) scoliosis. In fact, more than 80% of scoliosis is diagnosed during adolescence. It is normally accepted that the earliest the occurrence is the worst the prognosis will be.[74]

Considering curvatures > 10° Cobb, the scoliosis **prevalence rate** is 2%-2.5%. If we take into consideration curves > 6°, the rate increases to 4.5%;

beyond 21°, the prevalence diminishes to 0.29%. It is interesting to note that while **distribution** based on sex is nearly identical for curvatures of 6°-10°, for those beyond 21° the ratio of females to males is 5.4:1, while it increases to 7:1 if we consider scoliosis patients who undergo treatment (brace or surgery).[169]

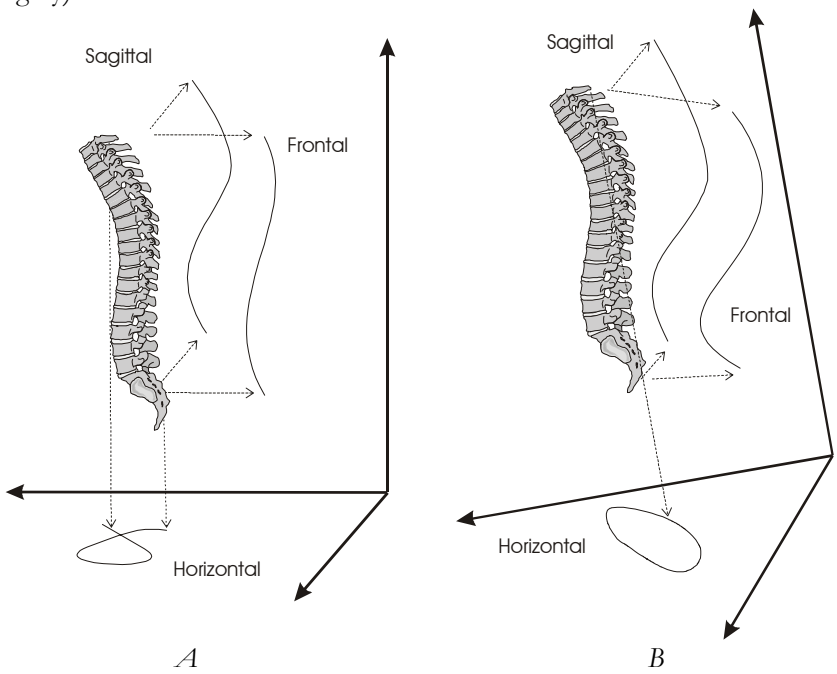


Fig. 5.3D representation of a real pathological spine (right thoracic, left lumbar scoliosis). In this figure the projections of the spine in the three spatial planes are represented: the frontal (xoy) plane is usually seen in the AP radiographs, the sagittal (yoz) is the one of the typical LL x-rays, while the horizontal (yoz) plane (Top View) is not usually considered and it is the one studied here. The Top View doesn't allow to see the effect of the y axis, but joins together the sagittal and frontal plane deviations: in this respect it represents a useful auxiliary plane to have a quasi-3D projection of the spine. The Top View can be seen in a global (bodily) reference system (on the left: A) in which the vertical (y) axis is the gravity line, or in a spinal reference system (on the right: B) in which the vertical (y) axis is the line joining C7 and S1. In this case, the one that proved to be useful and it is adopted throughout our studies, the entire reference system rotates with respect to the gravity line, as it can be seen on the right (B). These figures refer to the same single subject: note the differences between global (A) and spinal (B) Top Views.[98,99,114]

Only in a few patients is it possible to determine the **cause of scoliosis.** Among these causes, the most frequent ones are congenital malformations of the spine or thorax, and pathologies correlated to neurological or muscular disorders. For all the others, we use the definition "**idiopathic scoliosis**." Perhaps it wouldn't be far from the truth to think of these scolioses as a family of several types of pathologies that are more or less

prevalent in every single patient. Scoliosis could probably be considered a complex, multifactorial genetic pathology. Often (but not always), we find a positive family history, but the heredity model is not completely clear.
Regarding **natural history,** too, we must admit that we lack truly exhaustive knowledge, even though in recent years we have filled in some gaps thanks to some long-term studies. We can therefore indicate some cardinal points (exclusively referring to adolescent idiopathic scoliosis), as follows:[4,16,60,74,109,169]

- No reduction in **life expectancy**;
- **Cardiopulmonary function** is compromised only in high-grade thoracic curvatures (> 80°) associated with hypo-kyphosis;
- For curves < 30°, at the end of bone maturity **worsening in adult age** is exceptional;
- **Back-pain** incidence is comparable to that of the general population but prevalence is significantly higher; pain intensity does not correlate to curve magnitude; and curve type can be associated with more severe pain; thoraco-lumbar curves seem to be the most painful, while the double curves are less painful;
- Mild to moderate curves do not worsen during **pregnancy**; there are no differences in childbirth type (natural or Caesarean) nor in complications during or after childbirth;
- **Psychosocial implications** do not seem to be correlated to the magnitude of curvature; small curves can have a great psychological impact with real problems in social life, while other patients with serious deformities accept their condition in a positive way. It is interesting to note that **cosmetic** concerns are main reasons adult patients with untreated adolescent idiopathic scoliosis seek consultations with surgeons (Fig. 6).

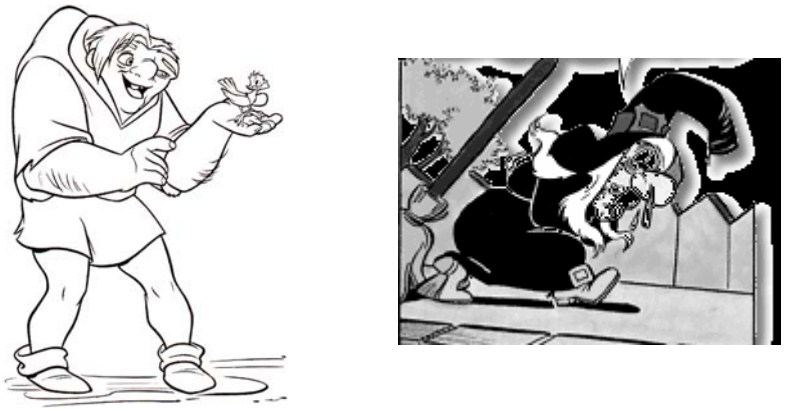


Fig. 6. Two adult scoliosis very well known are those of Nostradamus, the Hunchback of Notre Dame, with an important thoracic scoliosis, and some Disney representations like Witch Hazel, who is anteriorly and laterally flexed on the lumbar spine due to a lumbar scoliosis.

Knowing the natural history of a pathology means having the tools to understand whether the therapeutic measures thus adopted will be effective or not. Most therapeutic decisions are made on the basis of curve progression or its potential evolution. We found several factors that influence **progression probability** in a skeletally immature patient, as follows:[74,169]

- Two factors correlate with the **curvature**: double curvatures have a greater tendency to progress when compared to single ones; the greater the curvature at detection, the greater the risk of progression will be.
- Other factors relate to **growth** (Fig. 7): age and bone maturity both correlate to progression, in the sense that the earlier the onset is the greater the risk of worsening will be;
- Other factors are **biomechanical**: some authors have underlined the loss of thoracic kyphosis for thoracic curvatures and the presence of laterolisthesis for lumbar curves.

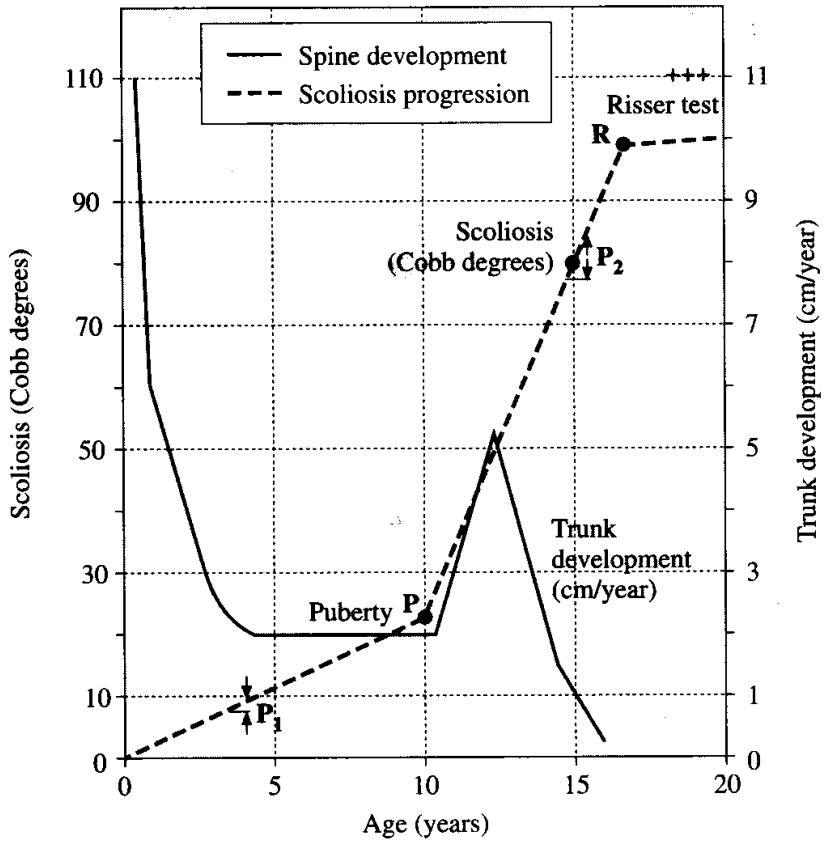


Fig. 7. The graph of Duval-Beaupére represents the progression history of scoliosis.[150] It has been developed for neuromuscular scoliosis, but it fits quite well also for idiopathic scoliosis, in which anyway generally the slope of each single tract of the graph is reduced

The cause of most scolioses is unknown, so it is not possible to implement a primary prevention. Therefore, early diagnosis must enable us to implement at least a secondary prevention.[106] The validity of **scoliosis screening** has been extensively debated in recent years (Fig. 8). On the basis of analyses regarding the cost-benefit relationship and risks of hyper-treatment in parts of the population that should not undergo specific scoliosis therapies, we have the quasi philosophical contrast between two groups: those who believe they have good weapons with which to fight the progression of scoliosis, reduce cosmetic impact caused by deformity and avoid permanent disabilities,[16,74,106] and those who, in a fence-sitting logic, reserve treatment (at this point only surgical) to scolioses that exceed certain curvature values.[35,53]

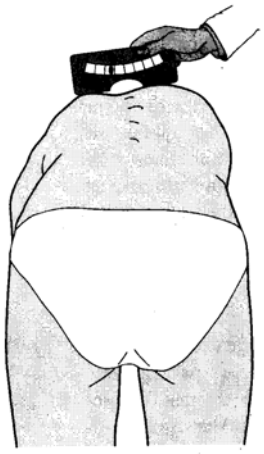


Fig. 8. The Bunnell measurement during Adams' forward bending test is the best known and most used evaluation during screening for scoliosis. A value threshold of 5° to 7° Bunnell degrees according to different authors is considered significant for scoliosis[16,74,106]

Serious attention must be paid to **pathogenetic mechanisms** that, starting from an unknown aetiologic moment, cause the formation and the development (over time and on the three spatial planes) of spine curvature. Beginning with Stokes' studies,[13,83,159] the establishment of a real **vicious cycle** has been emphasised to a considerable extent (Fig. 9): Scoliotic curvature increases during growth because of the asymmetry of loads that act on each vertebra. According to **Heuter-Volkmann** law[19,174] (saying that an increase of compressive loads on a fertile epiphysis reduces growth, while on the contrary an increase of distractive forces accelerates growth) it will happen that, in a scoliotic curve, load asymmetry will cause a growth reduction on the concave side of the vertebral plate and an increase on the convexity side. This is the essence of the vicious cycle that determines curve progression, if only because of increased height as a result of growth. From this comes the extreme importance of the earliest possible diagnosis and of adequate therapeutic strategies against the progression of scoliosis.

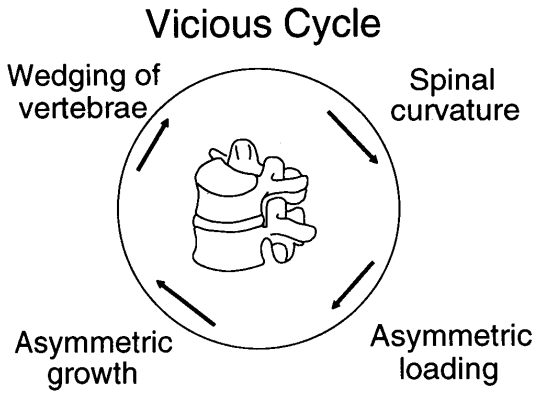


Fig. 9. The "vicious cycle hypothesis of pathogenesis" by Ian Stokes[84,154,156,158,159] is considered today as one of the best representations of the biomechanical progression of scoliosis: the hypothesis is that in progressive scoliosis vertebral body wedging during adolescent growth results from asymmetric muscular loading in a "vicious cycle" by affecting vertebral body growth plates (endplate physes).

We believe in **scoliosis conservative treatment**. This not for merely faith but is based on scientific studies,[95,105] and because daily experience shows us the efficacy of treatment.[189] Therapy must be early, adequate and prolonged, as follows:[144,145]

– Therapy must begin **early** because, if it is true that the earlier the onset the greater the progression, we must be likewise early in implementing therapies in the presence of clear signs of progression.
– Therapy must be **adequate** to prevent gravity and the future potentials of the single scoliosis we have to face, with options that go from exercises to braces and then to the choice of daily brace-wear hours (Fig. 10).

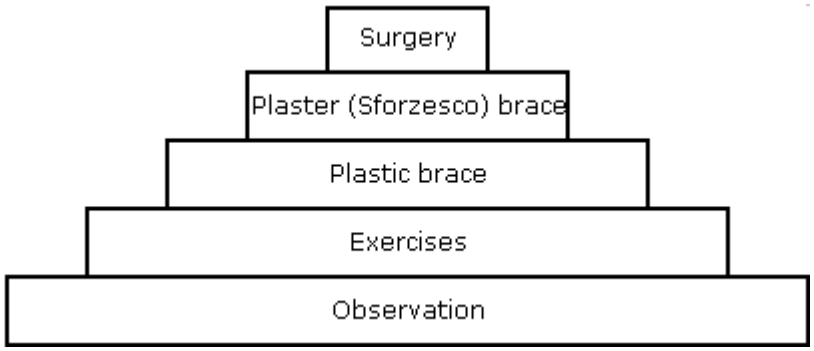


Fig. 10. Representation of the "step by step" Sibilla's theory[144,145] of treatment of scoliosis. each step represents an increase in strength of treatment, but also in requirements to patients: good physicians are able to start from the right step, so avoiding over-treatment with higher impact on quality of life, as well as under-treatment that engenders progression

– Therapy must be **prolonged** until the end of bone maturity.

To be successful, the therapy must use the active cooperation of the entire **therapeutic team**: physician, therapist, orthotist. The team includes also, and most of all, the young patient and his/her family, whose confidence and cooperation we must gain. That is an indispensable requirement for success in treatment.

All this is said without forgetting the ineluctable usefulness of **scoliosis surgical therapy** in the most serious cases. Surgery, however, means the **failure of *orthopaedy*** (from the ancient Greek, "the art of having children grow straight") (Fig. 11).

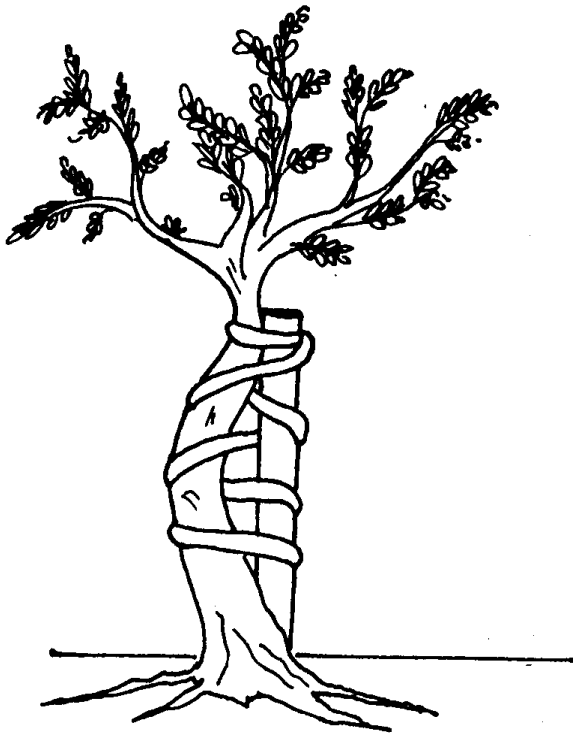


Fig. 11. The original logo of orthopaedy.

2.2.2 Why and when to treat scoliosis

The SOSORT consensus paper, "Why do we treat adolescent idiopathic scoliosis? What we want to obtain and to avoid for our patients"[109] lists the **goals of treatment** in order of importance, as defined by SOSORT experts:

- Aesthetics
- Quality of life
- Disability
- Back pain

- Psychological well-being
- Progression in adulthood
- Breathing function
- Radiographic and clinical data
- Need for further treatment in adulthood
- Outcomes related to posture, balance and movement
- Cognitive outcome

These outcomes are ISICO's outcomes. We are not interested in straight spines but in **spines that provide good functioning in adulthood, present within well-developed bodies and psyches**. Bearing this in mind, during the contact with a single patient and his/her family we continuously shape the principles of treatment to derive the unique proposal that is needed. This way, basing our behaviour on data from literature that indicate the need to be as far as we can from the two **recognised thresholds of scoliosis** (50 degrees, i.e. the near certainty of progression in adulthood; and 30 degrees, i.e. possible progression) (Tab. 2),[108] and considering that risk does not mean the certainty of progression, we determine the choices of treatment case by case.

Cobb degrees	**Possible problems in adulthood**			
	Progression	**Pain vs general population**	**Disability**	**Aesthetic impact**
0-10°	No scoliosis			
10°-30°	Not probable	No more	No	Unusual
30°-50°	Possible	Increased prevalence	Unusual	Usual
Over 50°	Highly probable		Possible	

Table 2. The meaningful thresholds of scoliosis according to possible problems in adulthood based on the current knowledge in literature.[109] All treatments must be adapted according to these thresholds, so to remain as far as possible (according to starting point) from possible future problems. In this perspective, scoliosis treatment is always secondary prevention.[106]

We will have patients for which **aesthetics** is not a problem, while others feel their bodily appearance as the core of their treatment. **Quality of life, disability and psychological well-being** in early adolescence are different from those at the end of growth or in childhood. Additionally, we know they change according to environmental and family factors. Therefore, we must take care of these outcomes in the short but also in the long term, which means deciding today according to the already proposed thresholds so as to reduce the future impacts of the pathology. **Breathing function** is a

potentially life-threatening issue, and together with **pain** it's a very well understood aim for parents, not for the patient him/herself. **Outcomes related to posture, balance and movement** greatly contribute to quality of life and the reduction of disability in adulthood: they are rarely perceived by the family as being important but must always be so in our minds. **Cognitive outcomes** are crucial to understanding treatment and goals; obtaining compliance; recognizing what are real possible and correct results versus parental dreams; and finally, acting in a proper way throughout the treatment and beyond.

Accordingly, we start with **fixed radiographic goals** because they will presumably be the most important determinants of our patient's future,[109] defined according to the starting point of treatment. For example, if we start with 50° curves, Risser 0, and the first signs of puberty, obtaining 30° at the end of treatment is almost always only a dream. On the contrary, we aim at finishing between 20° and 25° whenever possible. Bearing these goals in mind, **we continuously adapt ourselves** according to what we obtain, and to how the patient behaves and feels, thus respecting the other aims. We establish and constantly renew a contract with the patient and his/her parents, who in this way are fully integrated in the rehabilitation team.

3 The SEAS concept of exercises for scoliosis

3.1 Why and when to apply exercise treatment

Exercise treatment is **the key to a good rehabilitation approach** to scoliosis. In fact, rehabilitation by definition is focused on the entire person [1]. It does not look only at the **disease** or the **impairments** it causes but also (in particular) looks at the **disabilities** and **limitations of activities**, with consideration for the **limitations of participation** (in the past called handicap).[1,160] Therefore, in a musculo-skeletal disease like scoliosis, in whom impairments have been recognised beyond the mere state of deformity, and in which all treatments (from bracing to surgery) cause psychological as well as physical and functional disabilities (transient in case of bracing, definitive in case of surgery), a good rehabilitation approach requires **the means to compensate, or prevent if possible, such secondary damage**: this is exercise treatment.

Looking at scoliotic disease, when other therapies are not yet considered, exercise treatment is mainly the **prevention of scoliosis progression** and should be applied every time the risk of progression is significant. However, a brace could be avoided.[106] As Sibilla used to say, "Scoliosis should be treated step by step, but the problem is starting with the right one"[144,145] (Fig. 10).

Exercises immediately follow observation alone, and come before bracing[106]. Several formulae in the literature have been developed to calculate the risk of scoliosis progression, but they have all been derived from populations with a high degree of scoliosis, with the avoidance of surgery being the primary objective. Our aim with exercises is to **avoid or at least postpone bracing,** and to arrive at the end of growth with **a presumably stable curvature** (as much as possible far from 30°, so that a value between 20° and 25° can be acceptable).[74] Therefore, these formulae cannot be applied, and the risk of progression is considered looking at a combination of factors, including:

- There is **evidence of scoliosis progression** coming from radiographs and/or clinical changes superior to the known measurement error (5° for radiographs, 2° for Bunnell, 3 mm for hump height);[56,120]
- The **starting radiographic and clinical data** are near to previously defined acceptable boundaries (i.e. around 15° Cobb, or 5° Bunnell, or 5 mm of hump);[106] these points should be considered provisional and should be better understood in the future with new research;
- There is a very **high postural component**, as evidenced by an important decompensation and/or by the Aesthetic Index;[194]

– There are high risks due to **other known factors of progression**, such as a family history of an important scoliosis, flat back, start of puberty, etc.[16,74,169].

On the other hand, i.e., when looking at the **highest boundaries for exercise treatment** we must consider that as far as we know today, exercises do not reduce the curvature[105] (even if recently we ourselves raised some doubts about this hypothesis)[119] nor, importantly, change the cosmetic appearance.[119] So, exercises should never be proposed (in favour of bracing) when **30° curves** have been attained unless the pubertal growth spurt is very far in the future and an important postural component is presumed, with the only aim of postponing (possibly avoiding) bracing.[106] Moreover, exercises should be proposed when there are **uncertainties regarding the application of a brace**, even in curvatures exceeding 25°, and there is the possibility of stability due to the absence of other progression factors and a relatively advanced age. In such cases it is important to decide together with the patient and his/her family. Regardless, due to the very short period of research in this field[177] all these points will have to be thoroughly studied and refined in the future.

When a **brace** has already been **prescribed,** exercises are mandatory in order to avoid all side effects of bracing, to increase its function, and to allow the spine to be stable during the weaning period and when the brace is abandoned.[106,136] These points are thoroughly discussed elsewhere in this chapter.

3.2 Theoretical basis of the SEAS concept

SEAS is an acronym for "**Scientific Exercises Approach to Scoliosis**"[118,119]. As we are used to seeing with software products, after the acronym there is a dot followed by a number, to indicate the protocol version and the year in which substantial changes were introduced. Today we have version ".06." SEAS originated long ago (about 30 years)[97,101,121], but it doesn't really appear very old because during this period it has continuously updated. Therefore, it's with the times. How can an exercise-based approach remain young? This can only happen if it isn't based on a rigid original idea but can update itself by following acquisitions proposed by the scientific world.

Among the best-known exercise treatments (Fig. 12) here are some, like the ones of Mézières, Sohier and Klapp[101,121] that have remained almost unchanged over time, and other more dynamic ones, like the Global Postural Rehabilitation according to Souchard, or Schroth[129,172,175,176], which have changed over time with the stimulus of new proposals claimed by the original authors and their followers (however, it must be said that today only Schroth[129,172,175,176] and Dobosiewicz[40,41,43], together with SEAS[118,119], have results published in indexed literature).

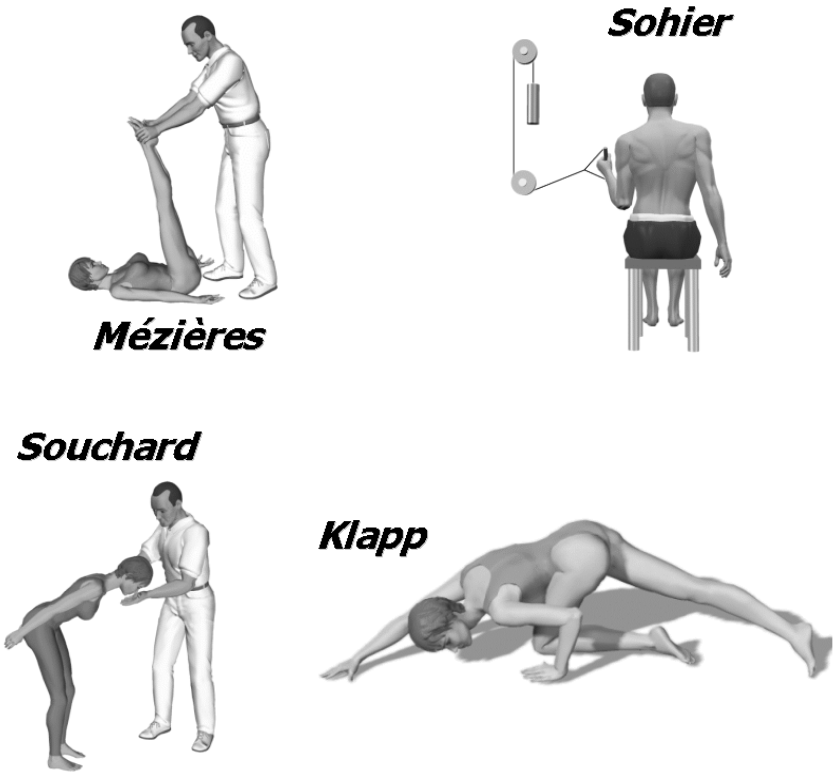
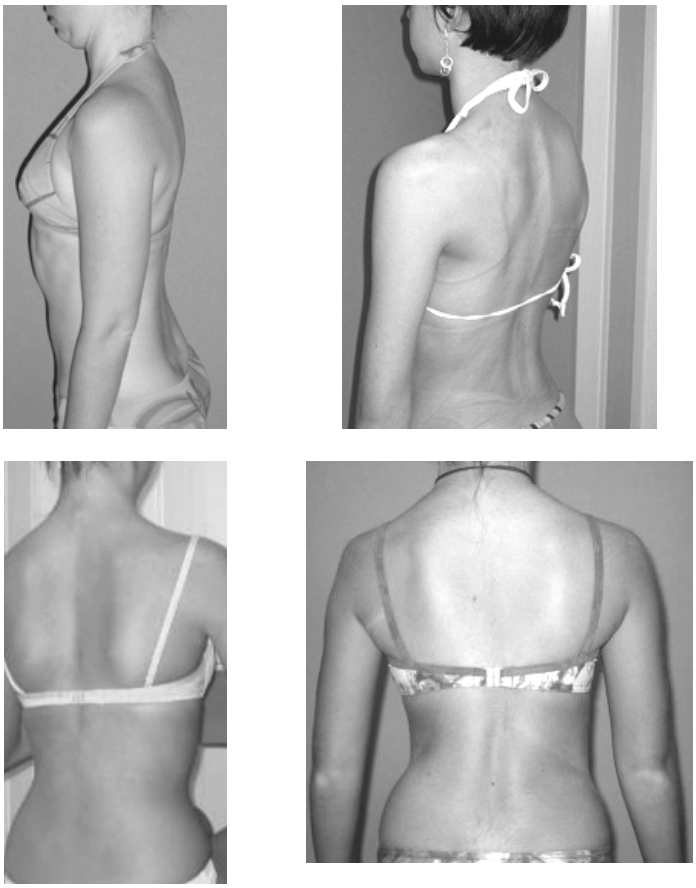


Fig. 12. Some of the most known exercise treatments for scoliosis: Mézières, Sohier, Klapp, Global Postural Rehabilitation according to Souchard. Only Schroth[129,172,175,176] and Dobosiewicz[40,41,43], together with SEAS[118,119], have results published in Indexed literature

The difference from SEAS, however, is that these innovations are directly suggested by the present leader's intuition, and that some exercises have remained basically unchanged since the beginning, contrary to SEAS, which regulates its **changes according to evidence coming from new developments proposed by scientific research**. For example, in the beginning the Active Self-Correction movement (which is currently proposed as a methodological basis within SEAS[100] (Fig. 13 B) was a simple auto-elongation (Fig. 13 A) because scientific knowledge in the 1970s (in a consistent way with Harrington's fusion and Milwaukee brace techniques) saw in this solution the best correction.[89] Today, however, everything has radically changed because of the knowledge about three-dimensional deformity,[131] and auto-elongation has been almost completely abandoned, having been replaced by Active Self-Correction on the three spatial planes, according to what is reported below.[100] So, by definition SEAS can radically improve in accordance with new developments, regardless of the original ideas of the person who first devised it.



A B

Figure 13. SEAS originated long ago (about 30 years)[97,101,121], but it doesn't really appear very old because during this period it has continuously updated. Therefore, it's with the times. The evolution of SEAS can be well represented by the passage from autoelongation (A) to active Self-Correction (B): in the beginning the Active Self-Correction movement (which is currently proposed as a methodological basis within SEAS100 (B) was a simple auto-elongation (A) because scientific knowledge in the 1970s (in a consistent way with Harrington's fusion and Milwaukee brace techniques) saw in this solution the best correction.89 Today, however, everything has radically changed because of the knowledge about three-dimensional deformity,131 and auto-elongation has been almost completely abandoned, having been replaced by Active Self-Correction on the three spatial planes.

Another distinctive element of SEAS is that it acts **outside the typical precepts of exercise-based techniques** and is founded upon the principle of a cognitive-behavioural approach typical of ISICO, which in our view is an indispensable element in chronic disease rehabilitation. In our field, this goal is pursued through regular moments of **family counselling**. Besides the possibility of reassuring the patient and his/her family, and the ability to

encourage compliance, family counselling must let the patient feel that we are close to him/her and that the entire team is working together to obtain the best possible result. The **team** concept is at the origin of the other important prerequisite of SEAS. We believe that we can obtain the best results only if every single element of a heterogeneous team contributes by giving the best of his/her specific competencies, and if effective communication instruments are warranted. The team that ISICO proposes is an extended group that in its "therapeutic" segment includes the physician, the physiotherapist, trainer and orthotist along with the patient and his/her family.

3.2.1 From a biomechanical perspective, what are exercises for? Neurophysiology developments indicate the role of Active Self-Correction

To fully understand the biomechanical role of exercises in scoliosis treatment (which, as we will see later, have other equally important roles),[89,101,121,152,178] and to understand why SEAS has certain unique characteristics relative to other exercise treatments, an in-depth consideration is necessary. Every biomechanical treatment for scoliosis tries to **contrast the "vicious cycle"**[158] described by Stokes (Fig. 9), favouring a less pathological growth of affected vertebrae. In that sense, Active Self-Correction is seen by all experts as the crucial moment of treatment, as was confirmed by the SOSORT Consensus Conference.[177] However, the point is: how can exercises influence this "vicious cycle"?

Consider the following:

- Correction obtained with exercises lasts only for the duration of exercise execution;
- Even in more "aggressive" exercise methodologies, in which for certain periods patients are required to do an inpatient exercise treatment lasting up to eight hours per day,[180,181] it would not be possible to hold the real correction for more than two or three hours, taking into consideration pauses and exercise intervals;
- No one would ever think of proposing a corrective brace for such a short time.

Given all the above, it is obvious that **exercises can work from the biomechanical point of view but only through a permanent change in posture**. So, the real question is: how can I work better to modify my patient's posture? Which is the best **learning method** by which to obtain a new posture? Over the years, we have seen a definite evolution from a purely mechanistic model--in which motor learning was considered as related only to obsessive repetition--to a more complex functional model in which repetition plays a role, but its execution in confounding situations facilitates the creation of the correct cortical engrams.[14,64,66] Moreover, another question must be asked here: does obtaining the maximum possible correction work better for learning a new posture (**passive auto-**

correction), or is it better to accept a smaller correction but actively obtained without external aids, i.e. limb attitudes, supports or muscles that are not peculiar to the spine (**Active Self-Correction**)? According to the same literature,[14,64,66] and from a neurophysiological perspective, active movement is much better than the passive one to learn neuro-motor behaviours such as posture (obviously once accepted that posture is not only a matter of anatomy but also of neuro-motorial behaviour). Moreover, this Active Self-Correction can be replicated in a thousand different exercises with "distracting" situations, thereby "strengthening" the neuromotor behaviour. The SEAS answer specifically addresses this direction, with a conceptual passage having a precise neurophysiological basis that brings the patient from "**correction**" (passive corrective exercises) to "**neuromotor rehabilitation**" (active exercises to learn behaviours) (Fig. 14).

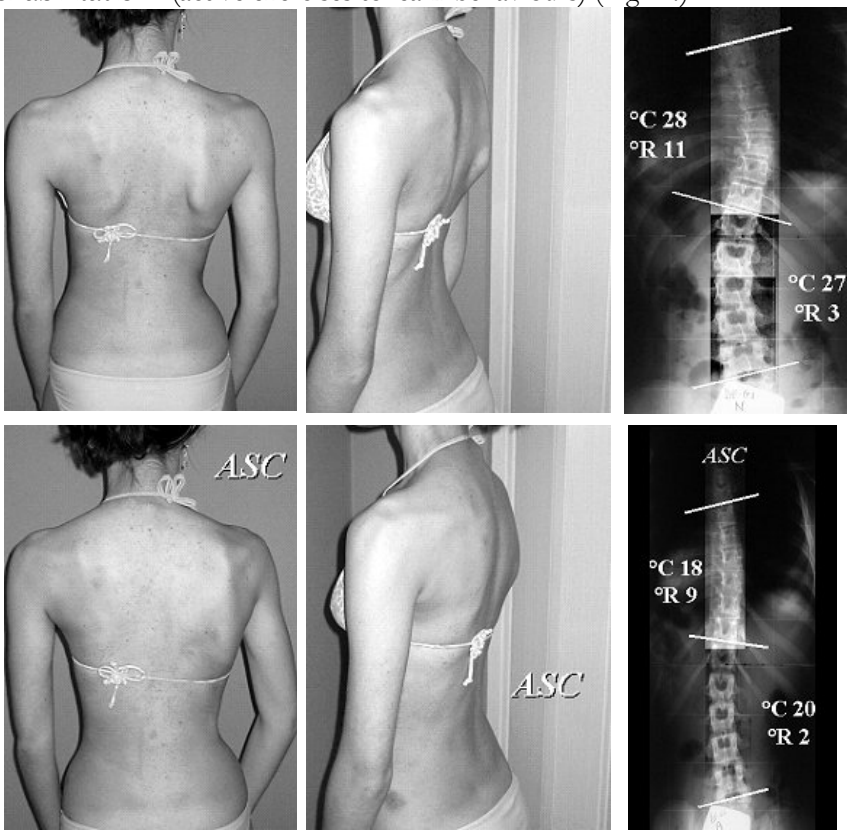


Fig. 14. From a neurophysiological perspective,[14,64,66] active movement is much better than passive one to learn neuro-motor behaviours, like posture. Active Self-Correction instead of passive autocorrection, goes towards this direction, with a conceptual passage from "correction" (passive corrective exercises) to "neuromotor rehabilitation" (active exercises to learn behaviours). First line: normal posture. Second line: Active Self-Correction (ASC). Observe normalization of flanks, increase of thoracic kyphosis and better lumbar lordosis, radiographic results (C: Cobb; R: Raimondi rotation)

Therefore, even if during the SOSORT Consensus Conference[177] the importance of auto-correction has been underlined, we must notice that almost every school of exercise, with the exception of SEAS,[100] is based on a passive auto-correction approach. From our point of view, auto-correction to become Active Self-Correction should be done by the patient exclusively through the spinal deep paravertebral musculature, without external help, thus pursuing the precise control of movement without using muscular contractions strategies that drive the spine into a passive alignment (for example, contraction of concavity psoas muscles in order to reduce lateral flexion component in a lumbar scoliosis).

3.2.2 SEAS therapeutic goals

Exercises do not have a strictly biomechanical role[89,101,121,152,178]. Before we explain the essential principles on which SEAS is based, it is necessary to underline two other preliminary remarks:

- From a scientific point of view, we are still far from defining the **cause of idiopathic scoliosis**.
- Regarding idiopathic scoliosis, we are certain of only a few elements regarding the **functional impairments** it causes or those with which it is associated. The research has chiefly served to clarify a series of dysfunctions that the scoliotic patient experiences and that exercise treatment based on the SEAS approach tries to reduce.

The treatment schedule points to the identification of a series of **therapeutic goals** that vary depending on the phase of treatment and that must be pursued each time with the most effective weapons available. The main dysfunctions experienced by a scoliotic patient can be schematically described as follows.

3.2.2.1 Posture and stability impairments

Increasing **spinal stability** is a primary therapeutic goal of the SEAS approach. The importance of this rehabilitation aspect is derived from a series of fundamental studies. Duval-Beaupère[44] showed that scoliotic curve magnitude is not only the result of a structural deformation but that there is also a postural component signifying a difficulty of the stabilizing system in the spine to counterbalance the alignment loss (Fig. 15).

This component, which is always present, is particularly important in the scolioses < 20° Cobb[164] that are most targeted by exercises for preventive purposes. From these observations, as well as Bunch and Patwardhan's[15] studies--which showed how the load threshold beyond which the spine begins to get deformed (**critical load**) diminishes as curvature increases--emerge the importance of improving spinal stabilisation in order to reduce postural collapse and the consequent spinal structural deformation potentials.

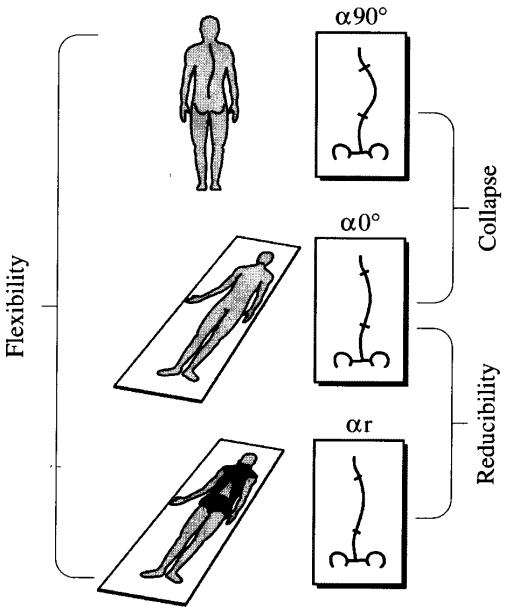


Fig. 15. Curve magnitude is not only the result of a structural deformation, (Cobb degrees in supine) but there is a postural component too (Difference in Cobb degrees between standing and supine radiographs), sign of a difficulty by the stabilizing system of the spine to counterbalance alignment loss.[44]

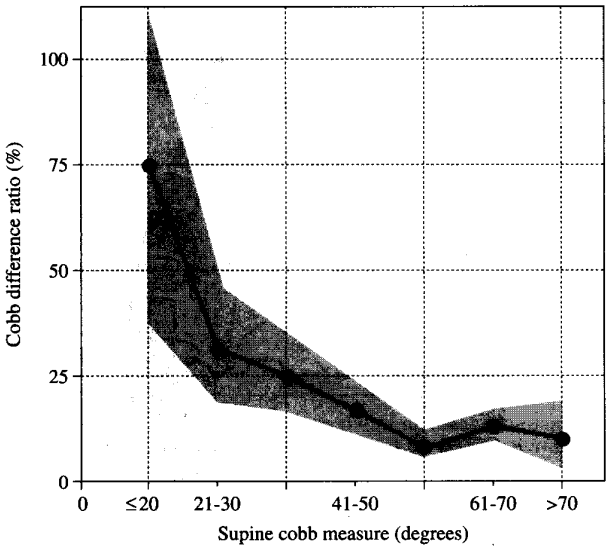


Fig. 16. The postural component has been measured,[164] *and corresponds to almost 10°, whose importance is obviously higher in scolioses < 20 °Cobb, that are the ones most targeted by exercises for preventive purposes.*

The **importance of improving spinal stability** derives not only from scientific experiments but also from clinical evidence: a scoliotic spine can be seen as a structure whose constituent elements, being subject to stimuli causing a loss of balance, are no longer able to maintain their physiological alignment and primitive stability. The natural history of a progressive scoliosis could therefore be a postural collapse on several planes, which afterwards becomes a bone deformity in accordance with the "vicious cycle" theory ideated by Stokes[158] (Fig. 16).
Even during the **SOSORT Consensus Conference**, which took place in Milan in 2005,[177] in regard to defining the most important therapeutic goals for scoliosis conservative treatment, the pursuit of vertebral stabilisation was indicated as the second priority. The difficulty probably lies in the practical way that such result can be obtained. The therapeutic strategy proposed by the SEAS approach is based on improving reactions to force of gravity and on enhancing the function of those muscles that have a major stabilizing vocation (Fig. 17).[68,153]

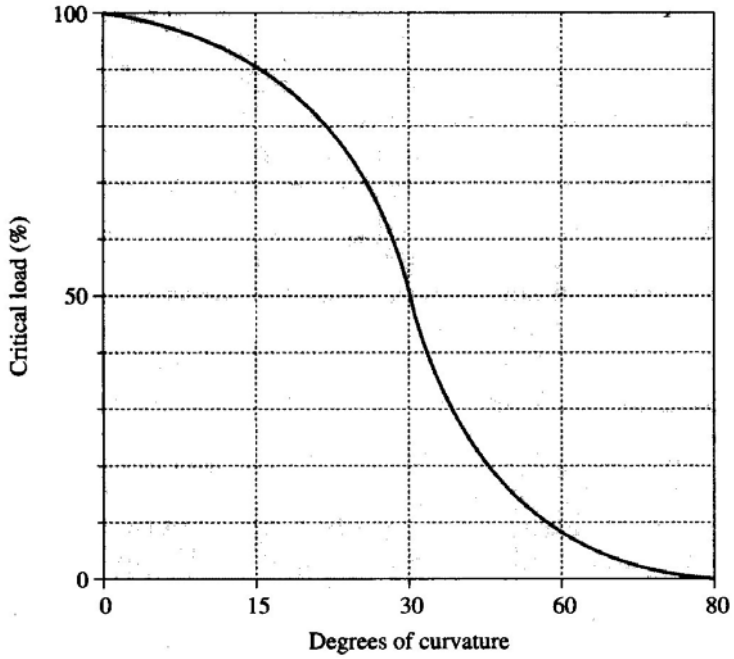


Fig. 17. Load threshold beyond which the spine begins to get deformed (critical load) diminishes as curve increases.[15]

3.2.2.2 Neuromotor impairments

High experts in scoliosis research, like Dubousset,[42] Nachemson,[94] and Stagnara[150] and Herman (Fig. 18)[65] have intuitively postulated the correlation between postural deficits and spinal balance/stability. More recently, several authors[58,79,86] have also identified, among the aetiological cofactors for

scoliosis, balance dysfunctions. This is because a correlation between idiopathic scoliosis and postural control proved to be evident, even if the relationship between deficit magnitude and the progressive potential of curvature has not yet been clarified. On the basis of these observations and the research results, we can say that the development of **balance reactions** is a fundamental therapeutic goal to which the treatment schemes proposed by SEAS devote particular attention.

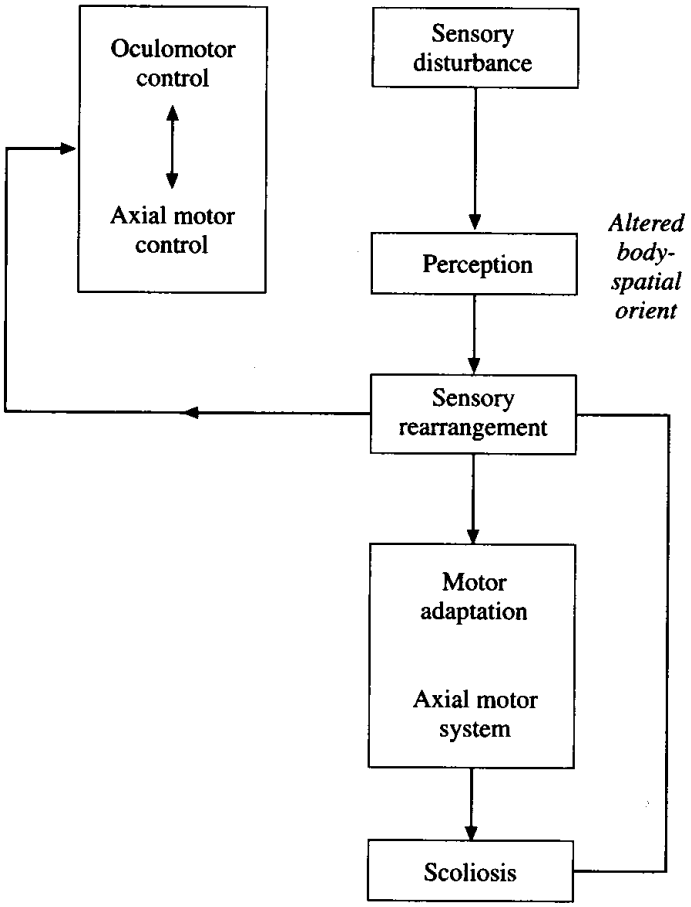


Fig. 18. *Herman's theory, awarded with the Harrington Lecture by SRS, that considers scoliosis as a compensation to neuromotorial dysfunctions.*

3.2.2.3 Sagittal plan impairments

Several researches, among which those of Perdriolle[131] and Graf[54] in particular indicate that the evolution of scoliotic curvature is characterised by a reduction of the curves on the sagittal plane (flat or hollow back), a biomechanical condition that, according to White and Panjabi,[183] also facilitates axial rotation. In the exercises proposed by the SEAS approach,

the **search and preservation of a physiological sagittal orientation** in the scoliotic spine is also a main therapeutic goal.

3.2.2.4 Other impairments

Finally, we cannot neglect the impairments that scoliosis causes at an **organic** (aerobic) level, with a reduction of both vital capacity and oxygen conduction ability (VO_2max),[37-39] the latter of which, among other things, proves to be disproportionate to vital capacity reduction but related to deficient physical conditioning. Furthermore, the **psychological aspect** is a crucial one: it is partly due to the age at which the pathology appears but also to the often iatrogenic influence on the psyche as determined by treatments and healthcare operators. All these aspects are taken into consideration within the SEAS approach.

3.2.3 SEAS and brace treatment

The effects of an exercise regimen for a patient with adolescent idiopathic scoliosis wearing corrective braces can be divided into two areas:[9,20,33,89,101,121,152] general and specific. The former includes all those beneficial modifications (obtained through the activation of muscles, the stimulation of ventilatory exchanges and psychological help) that **physical activity** induces in the patient, reducing impairments and disabilities due to the orthosis. Let's look at these one at a time:

- **Activation of muscles**: In braced patients, it is normally thought that the supporting action of trunk muscles is reduced;[9,50,87,89,97,101] exercises are proposed to avoid this effect, which could be more pronounced in adolescent patients using braces all day long. They have the effect of stabilizing the spine when the brace is removed;
- **Stimulation of ventilatory exchanges**: Vital capacity and VO_2 max are often reduced in patients, like ours, whose scoliosis exceeds 30° Cobb.[26,39] VO_2 max is usually reduced beyond a level that might be explained by a decrease in vital capacity alone. This reduction is usually due to a lack of physical exercise,[67,69] and therefore exercises are proposed to increase vital capacity, train the patient so that both the cardiovascular and the musculo-skeletal systems have an increased capacity to use oxygen, and improve respiratory ability from a neuromuscular point of view;
- **Psychological help**: Braces induce a "negative body image"[46] in a growing child that could in turn lead to an immature personality in adulthood. Exercises are proposed to reduce the disability induced by the brace (the extent of which is not as great as that induced by the impairment itself) and the patient's feeling of inferiority with respect to his/her friends.

The area of **specific effects**, on the other hand, relates to the pressure that braces exert on the spine through the soft tissues. Specific exercises have been proposed by Stagnara[150,152] and many others[9,20,33,50,87,89,146,166] with the rationale of increasing corrective forces applied by the brace, somehow using movements as "dynamic tools" to amplify the corrective "static" forces

applied by the orthosis. Such movements are obviously instantaneous, but the immobilisation of ribs and spine that they induce (the former having modelling and the latter derotatory and deflective effects) could in time and with repetition play a major role in bringing about a positive effect of the brace.[150,152] Moreover, it is necessary to consider that:

- According to many aetiological theories, the central nervous system could play an important role in the origin of the deformity;[65,73]
- It has been supposed that soft tissues are not able to passively withstand the forces that should be applied by a brace in order to correct a scoliosis;[191]
- The brace corrective effect on Cobb angle reduction is strongly correlated to pad pressure;[190]
- Strap tension should be set as high as possible for right thoracic curves[78];
- Muscular contraction has been supposed to play a major role in the effect determined by braces[5,191] and estero- and proprioceptive stimuli have also been considered important elements in causing a rearrangement of the postural system.[65]

On the basis of these assumptions, the forces applied during specific exercises and physical activities are important not only from a biomechanical perspective but also from a neurological one, helping the patient to develop a new spinal behaviour. In this respect, exercises that are able to act on the spine by increasing the forces of the brace and driving vertebrae in the direction of the correction through the "escape from the pad" movement[152,163] could be extremely useful.

3.3 Practical application of SEAS concept

3.3.1 Goals of exercises according to SEAS protocol

Scientific research showed that scoliosis causes **functional impairments** at a neuromotor, biomechanical, organic and psychological level[102,103,121]. Based on the knowledge of these impairments, we derive therapeutic goals to be pursued through exercises in order to prevent and reduce them in the treatment of both low-degree scoliosis and progressive forms in association with bracing. Furthermore, exercises allow us to slow down and in some cases stop progression in low-degree scoliosis,[91,118] while in braced ones this kind of therapy is useful to increase the orthosis corrective action and avoid its side effects.

3.3.2 Exercises in low-degree scoliosis treatment

Goals at the neuromotor and biomechanical levels are directed towards postural control and spinal stability, while the goals at the bodily and psychological levels are directed towards aerobic functioning and development of a positive body image.

3.3.2.1 Postural control and spinal stability

Nachemson[94] claimed that good spinal stability could neutralize postural deficits and thereby stop the progression of an initial scoliosis. The **therapeutic modalities** to obtain postural control and spinal stability are postural rehabilitation, muscular endurance strengthening in a correct posture, development of balance reactions and neuromotor integration.[28] Let's take into consideration these modalities.

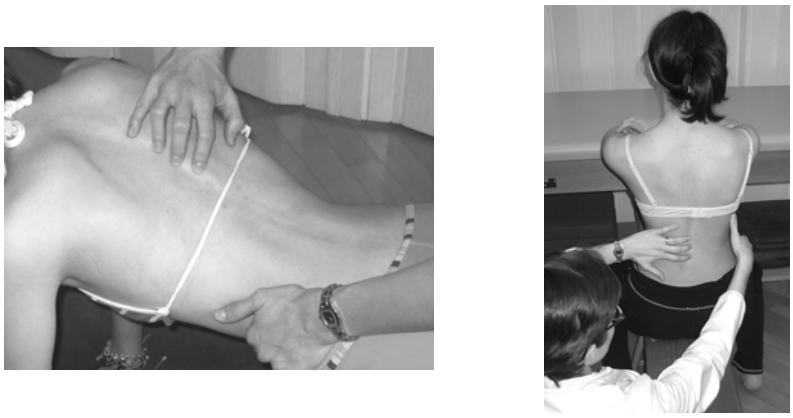
3.3.2.1.1 Postural rehabilitation

It includes becoming aware of body posture, becoming aware of defects of posture and Active Self-Correction on the three spatial planes. Becoming aware of body posture and defects of posture is obtained through visual (mirror) and tactile (contacts in the various postures) biofeedback and rehabilitator guidance.

3.3.2.1.2 Active Self-Correction

Active Self-Correction on the three spatial planes is the most important individualised therapeutic moment directed towards one's own deformity. It includes several phases, as follows:

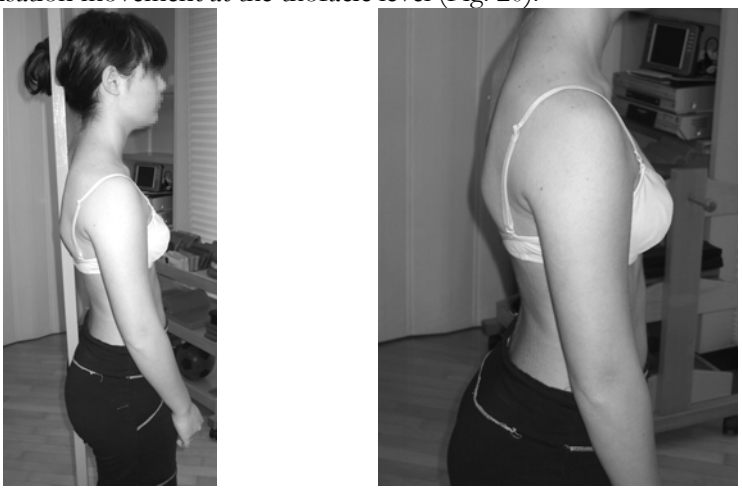
– The first phase includes **becoming aware of curve apex translation towards concavity on the frontal plane**, and is done in several postures (Fig. 19). For example, in the case of a double-curve scoliosis, first we teach how to execute thoracic curve translation and then lumbar curve one; subsequently, we associate the two movements, beginning with lumbar translation.



A B

Fig. 19. Active Self-Correction on the frontal plane. A - The therapist puts his/her fingers on the spinous processes correspondent to thoracic curve apex, while the patient lets the vertebrae shift towards concavity side. B - The therapist puts his/her fingers on the spinous processes correspondent to lumbar curve apex, while the patient lets the vertebrae shift towards concavity side. The counter-support of the therapist's hand on the hemitorax and hemipelvis opposed to curve convexity avoids imbalances.

– The phase immediately following includes **becoming aware of correction on the sagittal plane**. The studies of Perdriolle,[131] Graf,[54] White and Panjabi[183] highlighted that idiopathic scoliosis, in the case of progression, reduces physiological curvatures on the sagittal plane, favouring vertebral rotation. Exercises must ensure thoracic kyphosis and lumbar lordosis. At the lumbar level, we ask the patient to do pelvis anteversion and a kyphotisation movement at the thoracic level (Fig. 20).



A B

Fig. 20. Active Self-Correction on the sagittal plane A -By leaning against the upright, the patient then does a pelvis antiversion (to recreate lumbar lordosis) and a thoracic kyphotization (to recreate thoracic kyphosis). B- The patient does the same exercise without the help of the upright, at first looking at him/herself in the mirror.

– Finally, we associate **active Self-Correction movements on the frontal and sagittal planes**. According to Dickson's studies,[34] an action done on two spinal planes (frontal translation and kyphotisation and/or lumbar increase of lordosis) causes an involvement of the third plane (cross-sectional derotation).

Following the end of the initial learning phase, Active Self-Correction is performed by the patient in an independent manner and applied in every standing exercise.

3.3.2.1.3 Muscular endurance strengthening in the correct posture

Muscle endurance strengthening aims at developing **paravertebral, abdominal, lower limbs and scapulo-humeral girdle muscles** through isometric contractions. It uses loads that are one-third to two-thirds of maximal load in Active Self-Correction. We ask the patient to execute an Active Self-Correction movement and to hold it for the entire duration of isometric contraction of the chosen muscles (Fig. 21). Panjabi and Abumi's studies showed that the spine needs good muscular support in order to guarantee greater stability in a scoliotic spine.

Fig. 21. Muscular endurance strengthening in the correct posture. We ask the patient to execute an active Self-Correction movement and to hold it for the entire isometric contraction of the chosen muscles duration

3.3.2.1.4 Development of balance reactions

This is aimed at improving **axial, static and dynamic balance of the trunk**. Proposed exercises are always done in Active Self-Correction, even on unstable planes, developed with growing difficulties (Fig. 22). Stagnara[150] claims that the development of balance reactions must be one of the main goals of rehabilitation because scientific research has shown the presence of some impairments in cortical centres that control balance in scoliotic patients.

Fig. 22. Development of balance reactions Proposed exercises are always done in Active Self-Correction, even on unstable planes, developed with growing difficulties

3.3.2.1.5 Neuromotor integration

This aims at **integrating in everyday behaviours** a more correct and better-balanced spinal posture, progressively developing the ability to react with correct functional attitudes (Active Self-Correction) to the different requirements of social life. We propose exercises that associate Active Self-Correction with global movements, e.g., walking with a simple gait and oculo-manual education exercises, even on unstable planes. In this conclusive phase of treatment, we give **ergonomy information** so as to avoid spinal damage in adulthood.

3.3.2.2 Aerobic functioning and development of a positive body image

These goals are reached through modalities that aren't specific to the therapeutic field: we are discussing, in particular, **motor and sport activities** that stimulate aerobic functioning (vital and oxygen uptake and consume capacity) and help develop a positive body image. When the patient does not wear a brace, we advise against competitive sports that require an increased range of motion of the spine, particularly in maximum thoracic extension and/or lumbar flexion. According to Stagnara,[152] for a scoliotic patient every motor activity done at a recreational level is beneficial. Such activities, for their limited duration and intensity over time, cannot determine structural changes but offer huge benefits at the bodily and psychological levels.

3.3.3 Exercises in brace treatment

The main goals of exercises in brace treatment are: **elimination or reduction of side effects** caused by immobility (muscular hypotrophy), or the brace itself (reduction of sagittal curves, mainly kyphosis, and breathing impairment) and **accentuation of brace corrective pushes**.[95,136,152] Such goals are pursued through specific therapeutic modalities, subdivided into treatment phases:

- **Preparation for bracing**: We request the execution of exercises aimed at increasing the range of motion of the spine on all planes, so as to allow the brace to exert the maximum possible correction (Fig. 23). We also continue proposing mobilisation exercises in the first phase of brace wearing, when it is worn for at least 21 hours per day.
- **Brace wearing period**: We initially propose exercises of "wriggling out of supports" by using the upper and lower limbs so as to facilitate adaptation to brace usage for the recommended number of hours (Fig. 24).

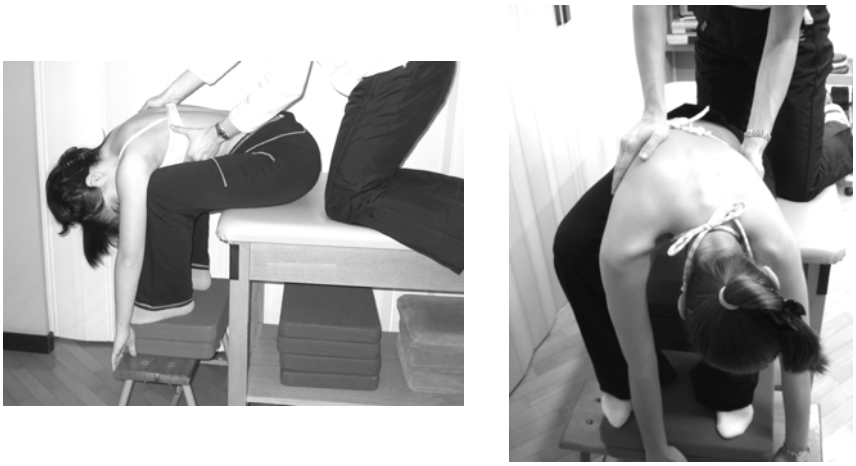
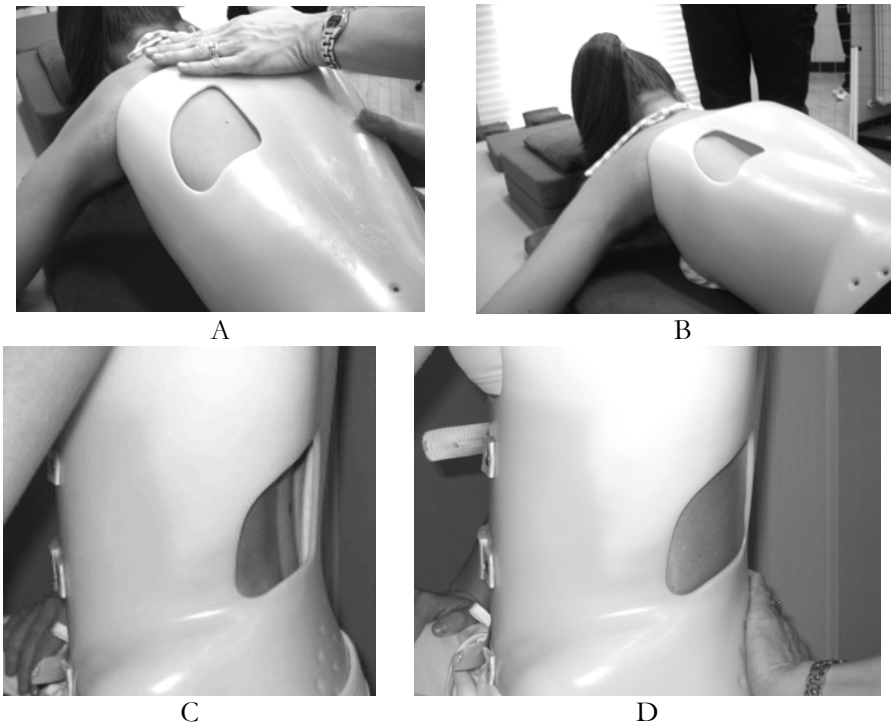


Fig. 23. Preparation to bracing. Exercises aimed at increasing range of motion of the spine on all planes, in order to allow the brace to exert the maximum possible correction



A B C D

Fig. 24. Modeling exercises in brace. A - The patient is in a relaxed position. B - The patient moves away from sternal upright to do a maximum thoracic kyphotization movement. C - The patient is in a relaxed position. D - The patient moves away from abdominal upright to maximally exert a pressure on the lumbar pressure pad

We require the execution of: **modelling exercises** in order to increase brace pressure on humps (Fig. 25); **muscular endurance strengthening**

exercises, requiring **lumbar lordosis and thoracic kyphosis preservation**, while frontal and cross-sectional plane correction is guaranteed by brace pushes. We propose specific **breathing activation exercises** only when we detect some significant reductions of vital capacity.

Fig. 25. Muscular endurance strengthening exercises. We propose strengthening exercises, requiring lumbar lordosis and thoracic kyphosis preservation , while frontal and cross-sectional plans correction is guaranteed by brace pushes

– **Complete brace weaning**: We teach **ergonomy** elements aimed at avoiding spinal damage in adulthood.

During brace treatment, it is of fundamental importance to pursue continuatively these other two goals: aerobic functioning and development of a positive body image. For that reason, we recommend intensifying participation in **motor and sport activities, both agonistic and/or recreational**, even with a brace that must be worn full time (Fig. 26).

Fig. 26. Aerobic functioning and development of a positive body image
During brace treatment, we recommend to intensify participation in motor and sport, both agonistic and/or recreational activities, even while wearing a brace, like in the two cases presented.

The presence of the brace should never force any limitation upon the young patient's personal and social life.

3.4 Results of SEAS

3.4.1 Scientific results

3.4.1.1 SEAS treatment reduces the need for bracing

The main objective of exercise treatment is to avoid that patient's progress of scoliosis so that a brace would be needed. To verify the efficacy in this respect of the SEAS protocol, we compared in a prospective and controlled cohort study[119] the results obtained in 69 patients at risk of brace treatment; they were divided into two groups and were followed up for a period of one year. Among patients treated with our protocol (SEAS group), bracing was prescribed in one out of twenty cases (6%), while in those treated with standard exercises (CONT group) bracing was prescribed in one out of four cases (25%). This result is statistically significant, and it is relevant because it demonstrates how correctly designed exercises can guarantee scoliosis stability in most cases, thus avoiding more invasive treatments. The follow-up examination after two years of treatment in 38 patients confirmed the differences already highlighted at one year (10% SEAS vs. 27% other group), even if with a reduction of the gap between the two treatments (Fig. 27). Further studies with longer follow-up periods and larger study populations will offer more definite results, but already today we know that with correct exercises we can reduce the number of prescribed braces or at least delay their prescription. Because the end of brace treatment always coincides with the end of bone growth, this delay at the start of therapy is another significant result from the patient's point of view.

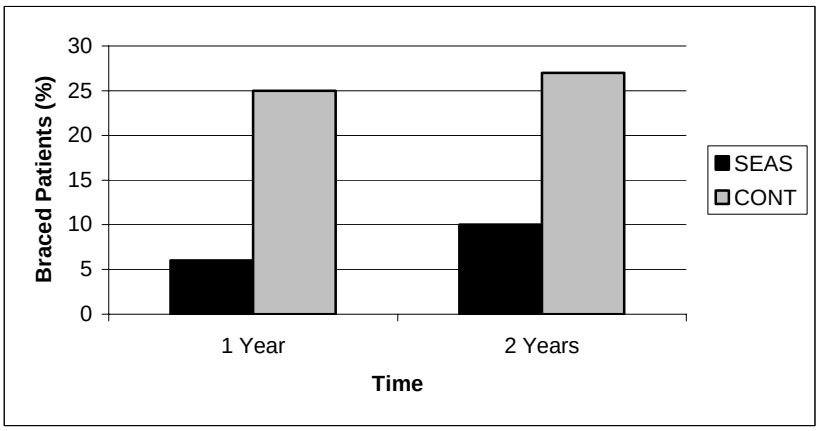


Fig. 27. Percentage of braced patients in SEAS and control (CONT) group after 1 and 2 years of treatment[119]

3.4.1.2 SEAS treatment improves scoliosis parameters

In the study already mentioned[119], we also documented exercises results with traditional measures. In terms of Cobb degrees, the percentage of patients who showed a radiographic improvement was 24% in the SEAS group vs. 11% in the CONT group, while the number of worsened cases was

superimposable even if slightly lower in the SEAS group (12% vs. 14%) (Fig. 28).

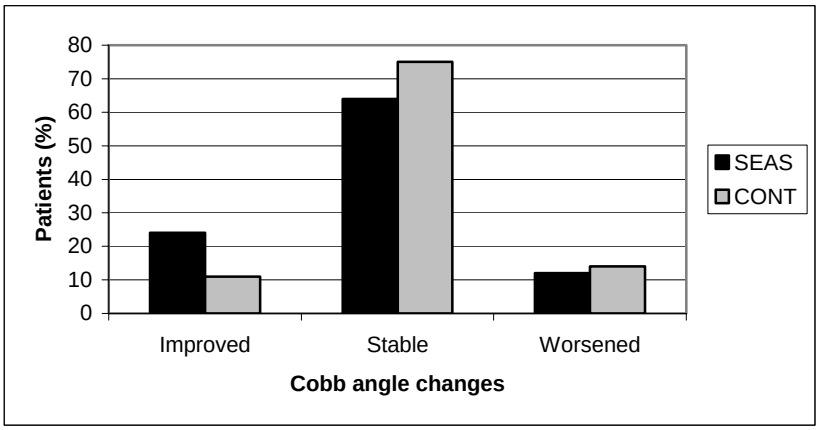


Fig. 28. Patients improved, stable or worsened in terms of Cobb angle. After therapy, the percentage of patients with improved Cobb angle in SEAS group is more than twice that of control (CONT) group[119]

Upon a clinical evaluation of the largest curve hump using Bunnell's scoliometer, in the SEAS group we noticed a stability/improvement in 73% of cases vs. 58% in the CONT groups (Fig. 29).

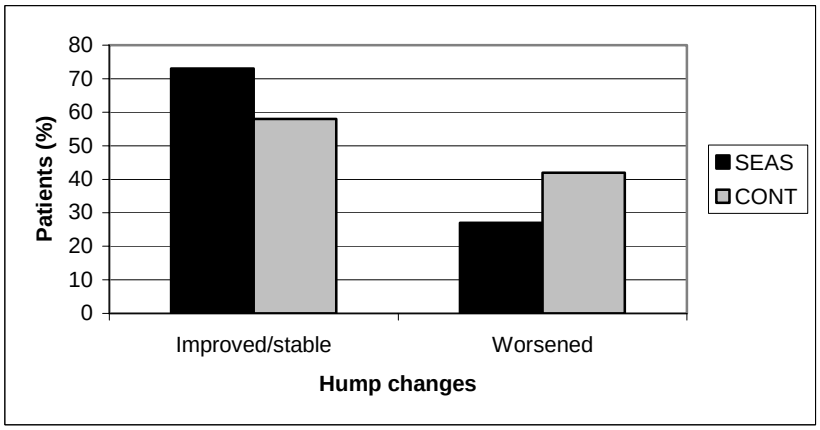


Fig. 29. Patients improved, stable or worsened in terms of Bunnel angle. After therapy, the percentage of patients with improved Bunnel angle in SEAS group in more than twice that of control (CONT) group[119]

3.4.1.3 SEAS treatment normalizes balance and coordination in scoliosis patients

According to the SEAS protocol, exercises aim at improving some specific impairments of the scoliotic patient so as to normalize them and reduce the risk of progression of scoliosis. Among these, we have equilibrium and

coordination. In a controlled cross-sectional cohort study,[138] we evaluated 190 subjects divided into two groups (forty Adolescent Idiopathic Scoliosis patients and 150 controls), and those patients were divided in two sub-groups (twenty treated for one year with SEAS and twenty not treated). All participants were evaluated through Unterberger (Fukuda), Romberg (sensitised and not sensitised) and lower-limb oscillation tests. Patients treated with the SEAS protocol showed results that were superimposable to the ones of control subjects, and on a statistical basis both groups were definitely better than untreated scoliosis patients.

3.4.1.4 Active Self-Correction according to SEAS principles reduces 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 kind of autocorrection actively performed by the patient, without any external aid, that forms the base of SEAS (Fig. 14). ASC is a selective (i.e. only on the vertebrae involved) lateral de-flexion, sagittal correction (usually increase of kyphosis and preservation of lordosis) and horizontal de-rotation: this movement is very difficult and require some months to be learned. 27 consecutive patients under treatment that required x-ray examination for their clinical follow-up have been included in the study[100]. All patients performed x-ray exam both standard and in ASC; moreover, they all were photographed frontally and laterally to have an evaluation of the quality of ASC. The statistically significant percentage of reduction of scoliosis was 11.0±12.3%, with a reduction of rotation of 13.2±63.4%. This study proves that it is possible to reduce actively the curvature with a selective action, without any external aid, and that expert physiotherapists can teach ASC.

3.4.1.5 SEAS treatment improve results in case of bracing

Exercises play an important role in the preparation for brace treatment too, where they aim at facilitating orthosis function.

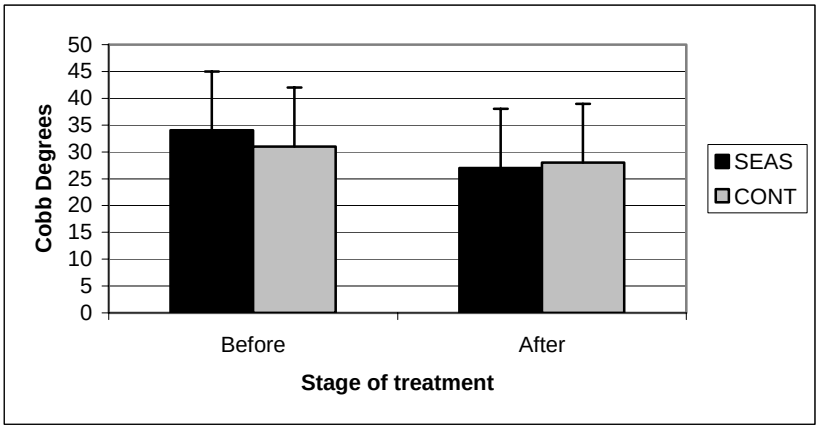


Fig. 30. Effect of SEAS pre-brace treatment. Patients who performed SEAS had a better result after bracing than controls[118]

To confirm whether the SEAS protocol, mobilizing and preparatory to the brace, had this ability, we compared, with a controlled prospective cohort study[118] of the beginning of brace therapy, the results obtained at the first radiographic follow-up at four months in 110 patients, divided into two groups. Data showed a higher efficacy of SEAS treatment, compared to standard exercises (CONT group) in regard to cosmetic appearance (Aesthetic Index) and Cobb degrees of the largest curve and hump (Fig. 30).

3.4.1.6 SEAS kyphotisation exercise is the most useful to help bracing push work

We performed a study[136] in seventeen consecutive adolescents 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 so as to increase their corrective forces. We 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), while the "escape from the pad" exercise, despite its name, does not produce any significant variation of pressure. We concluded that exercises in braced condition allow the application of adjunctive forces on soft tissues and, through those tissues, presumably on the spine. Different exercises can be chosen in order to obtain different actions; physical exercises and sporting activities are useful in mechanical terms, although other important actions are not to be neglected (Fig. 31).

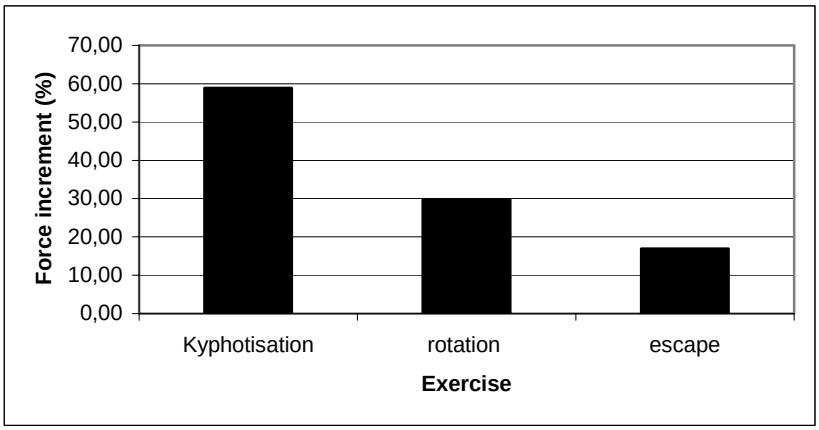


Fig. 31. Forces of brace pushes can be incremented by specific exercises. Kyphotisation can increment forces up to 60%[136]

4 The SPoRT Concept of bracing for scoliosis

4.1 Why and when to apply brace treatment

Brace treatment must almost always achieve a very good aesthetic body shaping (Fig. 32). It is intended to achieve radiographic results that are compatible with good functioning of the spine in adulthood, while the quality-of-life impact and psychological disturbance due to the brace must be minimised.[109,111,134]

Fig. 32. Brace treatment must almost always achieve a very good aesthetic body shaping. Elisa started her treatment pre-menarchial at Risser 1, with 58 and 59 degrees curve and refusing to be operated on. At the end of treatment she reached a very good aesthetic while reducing the curves. She has already had some experiences in the fashion world.

With respect to scoliotic disease, the goal of brace treatment varies according to the degree of curvature considered, and forces (in terms of strength of brace and hours of usage) are consequently administered.
The extreme cases to be considered are:

– In **mild progressive adolescent scoliosis** (up to 30° Cobb) that cannot be controlled through SEAS exercises, the first aim is to avoid progression while allowing the maximum possible freedom in activities of daily life and reducing the discomfort caused by the brace. In such cases, the chosen brace will be less rigid (Sibilla) (Figure 33) and will have to be worn for eighteen to twenty-one hours each day until the end of the progressive period (up to Risser stage 3). The patient will then enter the weaning period;

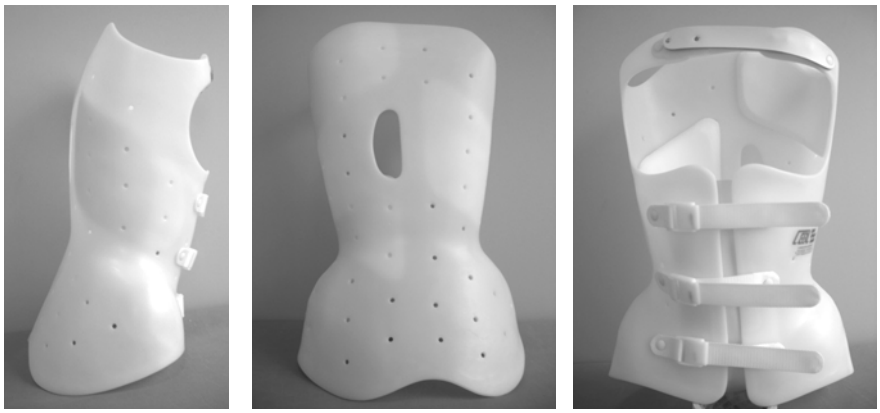


Fig. 33. The Sibilla brace.

– In **severe adolescent scoliosis** (up to 45°-50°, and over if the patient doesn't want to be operated on or if surgery is not possible) the aim is at least to avoid progression (and surgery) and possibly also to reduce the amount of curvature, which does not guarantee stability in adulthood. In these cases, a brace is worn all day long for at least one year, and the most rigid one is chosen (Sforzesco brace) (Figure 34). Afterwards, brace wearing is gradually reduced by one or two hours every six months, while maintaining the results, even if the hours are maintained up to 18 per day until Risser stage 3;

Fig. 34. The Sforzesco brace, whose study lead to the development of the SPoRT concept of scoliosis correction.

– In **juvenile and infantile scoliosis** over 25°-30°, a brace is proposed for at least eighteen hours per day according to the degree of curvature. We almost always choose the less rigid version (Sibilla) because of the reduced forces necessary to possibly reach a stable curve of 10°-15° (see paragraph

4.4.2.1 and Fig. 49). Then the brace is progressively weaned with the aim of taking it out, possibly before the pubertal growth spurt, when the new history of adolescent scoliosis begins.

In all other cases between these extremes, treatment is tailored according to individual preferences, anthropometric characteristics and other risk factors such as rotation, hump, lumbar curve take-off, unbalance, etc.

Treatment is carried out by wearing the **brace full-time** until the period of rapid growth is over and we foresee not having to face other pushes of the pathology. This is usually achieved at Risser stage 3. Actually, the applied full-time concept is again tailored between 18 and 23 hours per day, where eighteen is considered a reasonable compromise between efficacy (full-time wearing twenty-one to twenty-three hours per day)[71,184] and acceptability (eighteen hours per day means half a day--e.g. school--without a brace) with the goal of obtaining compliance. Moreover, in this period it is already possible to start a partial weaning, and we think this is a crucial event for the final results. **We don't use night-time bracing**[30,51] because our experience has told us that we can achieve at least the same results with SEAS exercises (which are in any case less invasive) while the possibility of controlling a progressive curve is not increased by wearing a brace for such a short time.

To understand the role of the **weaning period** at whichever age it is applied, and whose goal is to maintain the results previously achieved, we must carefully consider what happens when we take out the brace. According to all current theories, the brace places the spine in the best possible correction and causes it to grow in this position.[19,77,158,174] Whenever the brace is taken out, correction is progressively loosened, and the daily number of hours without the brace determines the real result achieved in that stage of treatment (which is why we perform x-rays almost every year, only without the brace and after the weaning period). In fact, each time the spine regresses from the maximum correction the vertebrae are again pressed toward deformity. This explains why the maximum correction achieved through bracing is never maintained, but also why weaning the brace for a longer than usual period causes pain. In this way, scoliosis brace treatment can be seen as a concertina therapy (Fig. 35) in which we reach a correction that we allow to loosen to a certain degree in the unavoidable hours without the brace. The weaning period means gradually increasing the hours without the brace while allowing the patient to be able to maintain the achieved correction. This is why we reduce brace wearing by no more than two or three hours every six months, and why stabilizing SEAS exercises are so crucial during this period.

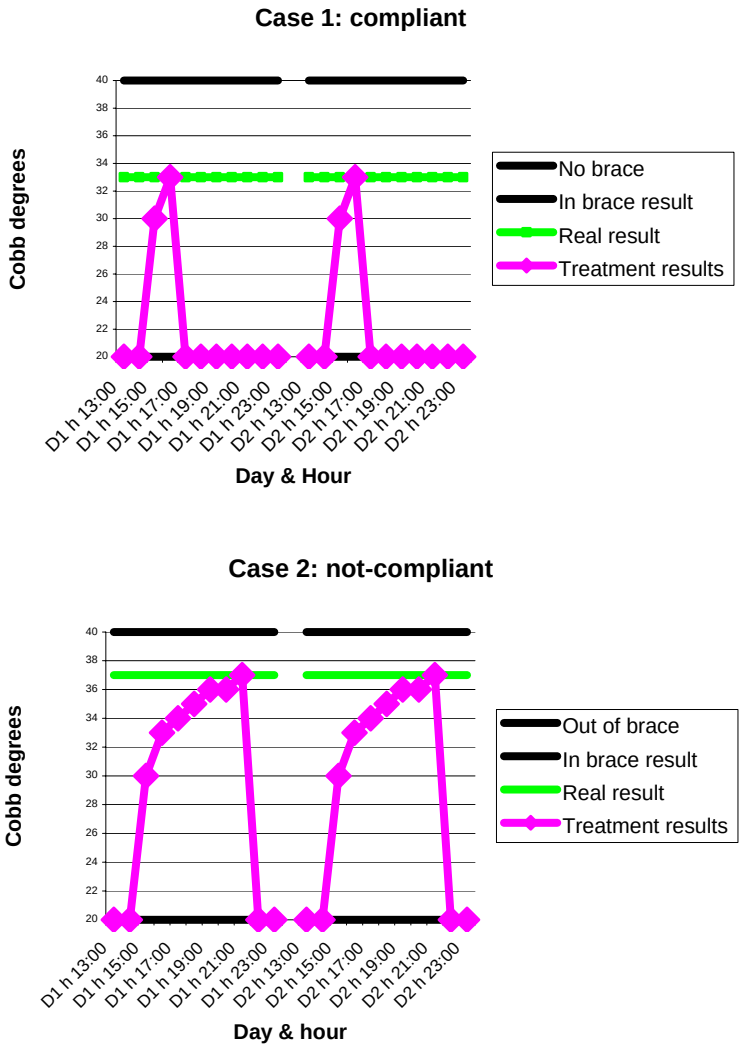


Fig. 35. The concertina effect hypothesis of scoliosis bracing. In these graphs two hypothetical clinical cases are represented: in both cases the out-brace starting point is a 40° curve, with an in-brace reduction to 20° that goes back to 30° as soon as the brace is taken out to reach 33° in one hour without the orthosis. Case 1 is a compliant patient, and he wears again the brace as prescribed after one hour; Case 2 is a not-compliant patient, that wait six hours before wearing the brace. The consequence in the latter is that the correction is loosen so to reach a 37° curve. Final result is that the deformity coming back compresses again the vertebrae and, according to the vicious cycle hypothesis, bones are not allowed to grow better. Result will be the one reported with the line touching the apex of worst correction: 33° for case 1, 37° for case 2.

4.2 Theoretical basis of the SPoRT concept

The SPoRT concept[110-112] was born while we were looking for a new brace, not for a new method of correcting scoliosis. We were searching for a way to **avoid casting for our worst patients**, because of the significant costs involved both at an individual (side effects including cast syndrome, skin problems, great psychological impact, no shower for months, etc.) and a social (inpatient repeated treatment) level. For that reason, we developed the new Sforzesco brace and, while applying and developing it, we ended up with a new, highly efficacious concept of bracing called SPoRT (**Symmetric, Patient-oriented, Rigid, Three-dimensional, active)**.
From a practical point of view, we started on the basis of the following braces:

– **Risser cast**[80,135,144] (Fig. 36): Gives the highest corrections through its localised pushes and **rigidity**, partly due to the material and partly to the fact that it is a one-piece structure. Most of all, we tried to maintain rigidity, using for the brace only two large pieces and localizing pushes through fully modifiable inserts;

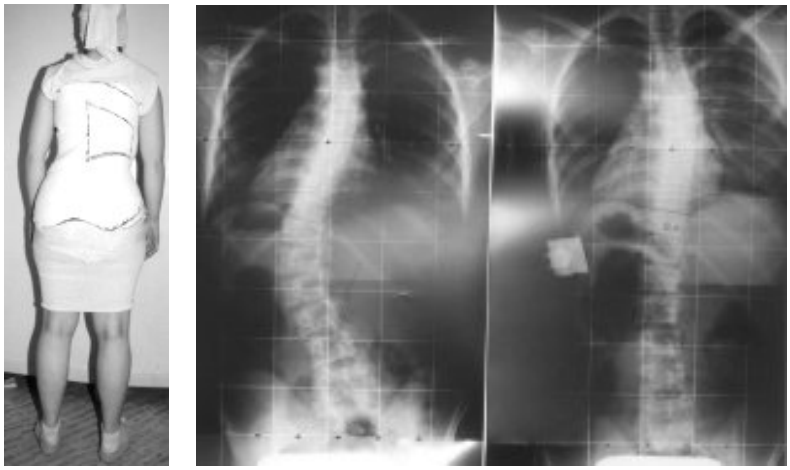


Fig. 36. Risser plaster brace for a thoraco-lumbar scoliosis, with radiographs showing the correction obtained (the radio-opaque push can be clearly seen).

– **Lyon brace**[150] (Fig. 37): We used to think of this brace as the most effective one for scoliosis treatment, fully based on a three-point concept, and with localised pushes on humps and curves. We maintained the **material** of this brace, as well as its vertical **aluminium bar**;

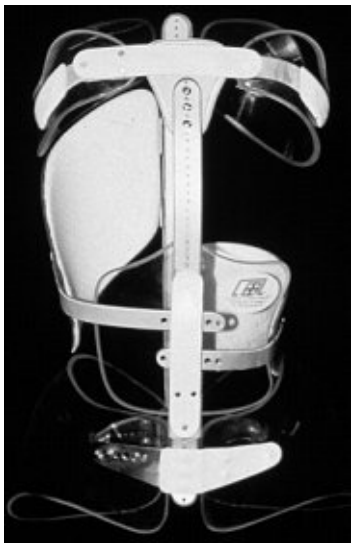


Fig. 37. The Lyon brace

– **Chêneau brace, modified by Sibilla**[144,145] (Fig. 38): The highest value of this brace was in the modelling effect obtained through its **symmetrical construction,** which accompanies the whole body towards corrections. In the SPoRT concept this brace is maintained as a less rigid alternative to the Sforzesco one, even if modified according to new understanding and insight;

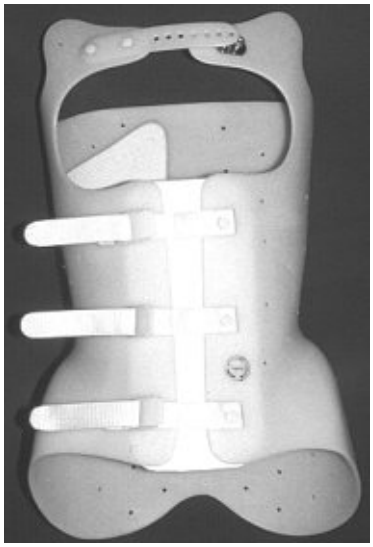


Fig. 38. The Sibilla-Cheneau brace in its last evolution.

– **Milwaukee brace**[10,88] (Fig. 39): This brace was not in our minds at the beginning, but we verified that the SPoRT concept reaches correction through an **elongation obtained by pushing from behind** but not with

a traction. This allows us to maintain/restore the physiological curves while correcting scoliosis (3-D action).

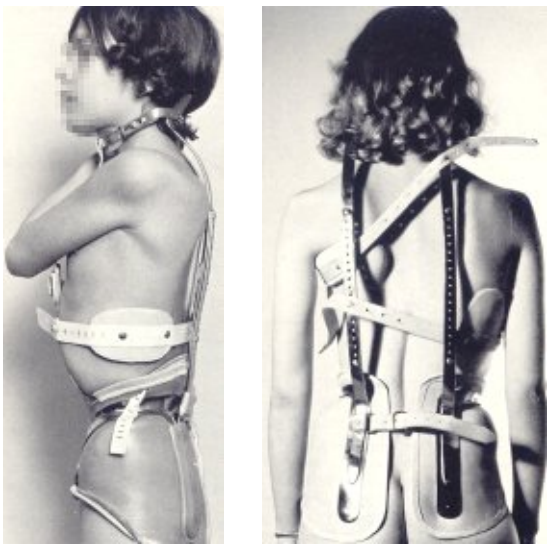


Fig. 39. The Milwaukee brace

4.2.1 Bracing and principles of correction

From a theoretical perspective, we started this search with very well established **principles of correction** that we had developed over the years, such principles being divided in terms of efficacy and acceptability.

The efficacy principles of correction include:

- **The active brace principle**: The Milwaukee brace[10] has historically been considered an active brace because it required the patient to escape vertically, while all other braces based on pushes were considered passive. This is theoretically correct, but a passive brace becomes more and more active as **the patient is allowed (encouraged) to move freely**, thus greatly increasing through his/her movements the corrective pushes against the brace (each time you try to move "incorrectly" you receive a corrective push; moreover, if the brace can serve as a neurological resetter through esteroception and proprioception, this action is greatly increased by movements)[136]. To make a brace active, it is necessary to ensure complete freedom of movement to the limbs, to have a perfect styling by the orthotist, to allow and even drive patients to perform physical activities at school and outside, and to train them through specific exercises in braced condition;[136]
- **Mechanical efficacy**: This is achieved through the correct positioning of **pushes**, as well as through **escape ways** and proper **drivers** of the forces and **stops,** as described in the section on practical application;

- **Versatility and adaptability**: A perfect brace can last a maximum of two or three months due to the continuous changes in the growing child, but clearly it is not possible to change a brace with such a rhythm. This means the possibility of adapting its action through inserts in order to **refine its mechanical action as continuously as desired**. Moreover, pushes must be adapted when checking the brace at first wearing, because the initial project is not always confirmed by the patient's reaction and some rigid areas can require specific increases of pushes. Finally, in most important curvatures we sometimes need a couple of months before reaching the best possible correction, and many times it is necessary to adapt the brace. We think this precludes an orthosis based only on the external envelope for its action;
- **Teamwork**: This is seemingly only a secondary element because only very well trained CPOs, MDs, PTs and other healthcare and education professionals can achieve the best results, which are greatly increased by teamwork and thorough discussions and braces controls working together;
- **Compliance**: Bracing is useless without compliance. In turn, compliance is certainly due to the patient and his/her family, but also to all the previous principles and to the following acceptability principles.

The acceptability principles of correction (meaning compliance as well as a human approach to the patient) include:

- **Perfect body design and minimal visibility**: Patients want correction and an invisible brace. Therefore, to make the brace visible you must carefully justify it and be sure that it's really necessary. In our experience, this can be minimised and while checking the brace for the first time. This is our chief concern, so the patient understands that we are on his/her side. Afterwards, we can require everything necessary.
- **Maximal freedom in the ADL (Activities of Daily Life)**: This is part of the active principle (movements), but it also means comfort. It must be possible to walk, run, sit, carry, wash, exercise and so on, freely or with the smallest degree of limitation possible. Any unavoidable limitation must be explained and motivated to the patient. SPoRT concept braces allow total freedom of movement for the limbs while requiring trunk movements only inside the brace, so as to be corrective;
- **Assumption of responsibility**: This way you run risks with adolescents, but it's possible to achieve much better results. That means, for example, freedom in the strength of closure and/or in taking out the brace through an anterior opening, and so on;
- **Cognitive-behavioural approach** by the entire professional team: "Explain and you will obtain (useful behaviours and increased compliance)." This is true in adults, but it's even truer in adolescents.

4.2.2 SPoRT brace concept

To achieve all these goals, the Sforzesco brace has been developed through progressive changes and verification, and consequently the Sibilla brace has

been modified (and the Risser cast and Lyon braces abandoned) in order to achieve the SPoRT concept of correction. The starting point was rigidity and an almost complete **exoskeleton** that is totally adherent and symmetrical according to the theoretical shape that the patient's body would have had without scoliosis. In practice, this is accomplished by reducing the space where there are pathological prominences and allowing room where there are undue depressions. This way, it is the deformity that creates pushes and spaces within this external envelope. The fact that this brace is a complete symmetrical wrap has added another key point since the beginning, which we called **humility**: there would have been pushes and spaces even if we had not considered this important in theory. In this way, we made ourselves ready to learn from the brace and gradually understood the concept of "**drivers**," as is explained in the practical section. Afterwards, **pushes** are inserted. These are considered in a fully three-dimensional manner. Because three-dimensionality is too complex to be easily understood,[116,155] we split the different **3-D actions**. However, since the beginning we have been very careful about each plan and curve, and in regard to total spinal morphology without conflict. Finally, we discovered we had something new, and summarised it in the **SPoRT acronym**, whose meaning is:

- **Symmetric**: On the outside the brace is almost perfectly symmetrical, according to the starting hypothesis we have just explained. This was a good beginning, but it was gradually overcome as we furthered our understanding of the brace action. Nowadays, the external construction is not so symmetrical, even if it is grossly maintained to reduce visibility and preserve as much as possible a theoretically perfect body shape.
- **Patient-oriented**: This brace is not visible, according to the acceptability principle. What patients care most about is having a brace that will be seen as little as possible, not to have less material on. This is why they would always choose a TLSO instead of a Milwaukee brace,[27] even if the first one causes the patient to feel hot during the summer. The Sforzesco brace has its own design (Fig. 40), which makes it somewhat fashionable, and this is how patients feel their braces. This is the most important achievement that allows us to increase acceptability, followed by compliance and efficacy;
- **Rigid**: The chosen material and the fact that the brace is made in two large pieces strongly connected with aluminium allow us to achieve a high rigidity that gives rise to higher pushes than in other braces;
- **Three-dimensional**: The brace has a three-dimensional action on the spine, and all its features have been developed with this purpose in mind, starting from its symmetrical and sagittal physiological external appearance. This is discussed extensively in the section on practical application.

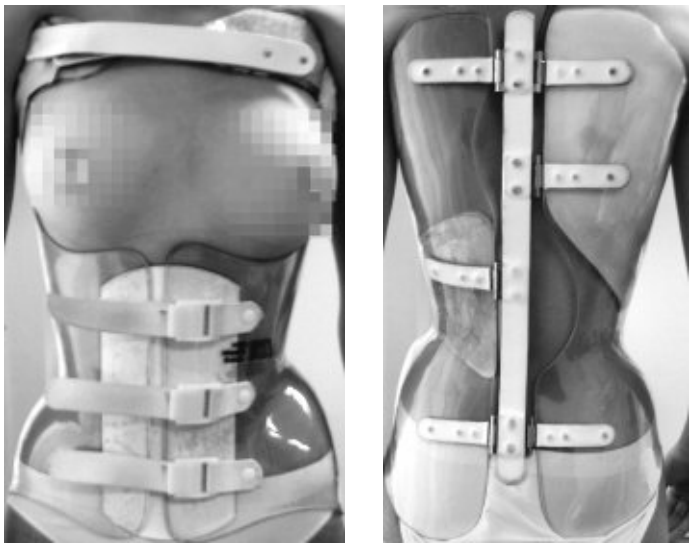


Fig. 40. The Sforzesco brace has its own design, generally appreciated by patients, in particular if they already used another brace.

– **Active**: This is also a property of the brace, in the sense that the Sforzesco allows total freedom of movement for all four limbs, as well as the complete possibility of normal behavior in activities of daily life, obviously with the exclusion of trunk flexion, bending and rotation (at least from the external point of view: inside the trunk moves only towards correction, while movements towards the progression of pathology are completely blocked).

4.3 Practical application of SPoRT concept

The SPoRT concept always requires a **customised construction of the brace** according to the patient's individual requirements. In the opinion of Sibilla,[144,145] bracing is a meal served according to a "menu à la carte" in which one chooses all the elements needed to achieve the best individual result. It's possible to apply CAD-CAM technologies, which usually allow us to obtain the best results in this case, but without using pre-built forms stored in databases, as is usually done. Orthotists must directly shape the scanned trunk according to the patient's requirements, and the physician can check this first draft before final carving. Once done, a **final test** must be made on the patient so as to change the first theoretical project and adapt it in the best possible way, depending on the real interaction between the body and the brace. This check is made using eyes and hands because one single change is usually not enough, and because it isn't possible to perform repeated radiographs to verify what has been done.

4.3.1 Elements of SpoRT braces

The brace is developed in consideration of the following key points:

- **Foundation**: Like a building, at the base of the brace we need a fix point, which **is the pelvis**. On one hand, this is a theoretical concept because the pelvis is not a fixed point. On the other hand, proximally applied pushes will always produce counter-pushes on the pelvis, and provided that the brace does not rotate in any 3-D direction on the pelvis, pushes will be correctly applied. If the brace decompensates (i.e., it rotates or it flexes in an antero-posterior or lateral direction), this can be corrected by pushing on the pelvis or by changing pushes on the spine so as to regain a balanced action;
- **Construction**: The brace must be carefully constructed on the **sagittal plane**, because once built it will not be possible to truly and effectively change this configuration;
- **Pushes**: The brace is a somewhat rough instrument. We try to refine it as much as possible, but current research does not allow us to be as precise as we would like. Usually, we develop a project of correction and then check and change it on the patient. These thoughts and our experience have led us to believe that pushes are **not points** as conceived by others but are **areas** developed according to curvature characteristics;
- **Escapes**: These are crucial, and are conceived according to curvature characteristics and desired correction. Therefore, they **must be considered three-dimensionally**. Braces built according to the SPoRT concept seemingly lack escapes because they finish with drivers so as to allow the most important one -- **vertical escape**;
- **Drivers**: These are the areas that control and drive pushes and escapes to obtain the **real 3-D action** so as to avoid wrong deviations with respect to the desired correction, as well as over-pushes or over-escapes;
- **Stops**: These are commonly referred to as **counter-pushes**.

The **construction (sagittal shaping)** of the brace almost always changes according to the curve, even if there are individual variations:

- **Lumbar scoliosis**: The construction must be **in lordosis,** and with this objective we need an antiversion of the pelvis with a retro-positioning of the upper trunk over the apex of lordosis, while the abdomen must also be allowed to escape anteriorly;
- **Thoraco-lumbar scoliosis**: This must usually be **in lordosis**, which is due to the tendency of this curve to evolve in junctional kyphosis. In this case, the apex of lordosis must coincide with T12-L1;
- **Thoracic scoliosis**: This must be almost always **in kyphosis**, which is achieved through the previously described **good construction in lordosis** and through an important retro-positioning of the higher trunk so as to use the **force of gravity** to induce the spine to posteriorly "sit" in the given space while superiorly shaping the brace in an anterior direction.

4.3.2 Correction of a thoracic scoliosis

Because general brace action according to the SPoRT concept is too complex to be adequately described in these few pages, we will now give a complete example of the means to correct a thoracic scoliosis. The figures have been obtained from an actual case, so they do not always totally coincide with the theoretical description. However, as already stated, theory is always and continuously changed according to individual needs and reactions to the brace.

Terminology is defined according to a posterior-anterior radiograph. Accordingly, convexity and concavity refer to the considered scoliosis curve, not to trunk protuberances. This means that the convex side posteriorly coincides with posterior rib hump and anteriorly with rib depression, while the concave side coincides with anterior rib hump and posterior depression.

4.3.2.1 Action of deflection

The mechanisms needed to achieve deflection (Figg. 41 and 42) action are:

– **Lateral distal convex push** (a): This is obtained through brace modelling and a direct pad; to reach the spine using the ribs it is necessary to have **posterior** (1) and **anterior** (2) **convex drivers**, while the counter-push is given by the **lumbar lateral stop** (3). This push drives the spine to the **anterior-superior escape** (A) through the **concave lateral driver** (4), which does not allow a direct lateral shift;

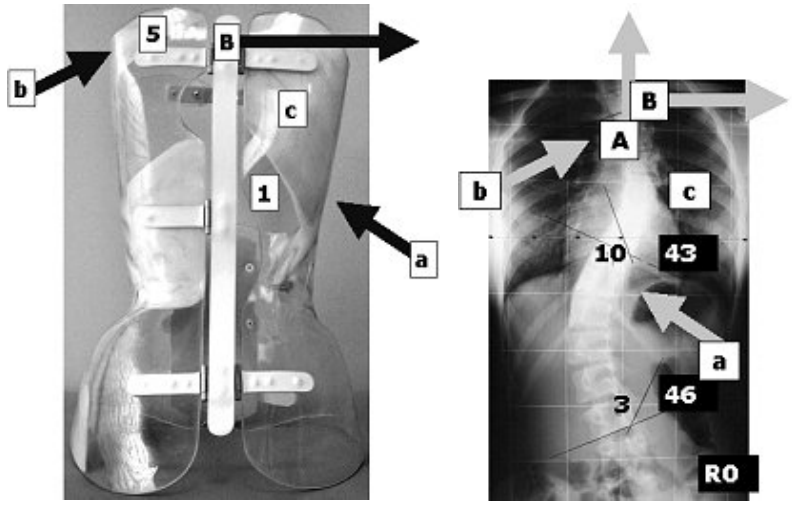


Fig. 41. Action of deflection according to SPoRT concept for thoracic scoliosis in the posterior-anterior and radiographic views. Pushes (lower-case letters), escapes (upper-case letters), drivers (numbers) and stops (numbers) are explained in the text. Black letters refer to pushes, drivers and stops on the surface considered, while white letters to controlateral surfaces: e.g. in the lateral view of the brace of next figure the push "a" and the stop "7" are on the right side of the brace (controlateral surface), while all the others are on the left side of it (surface represented).

– **Lateral proximal concave push** (b): This is obtained by maintaining the brace high under the axilla through brace modelling and a direct pad. Again, to avoid rib flexion and apply the push to the spine we need the **posterior** (5) and **anterior** (6) **superior concave drivers** as well as the counter-push of the **thoracic lateral stop** (7). The spine is driven to the **anterior-superior escape** (A) and also to the **convex-superior escape** (B);

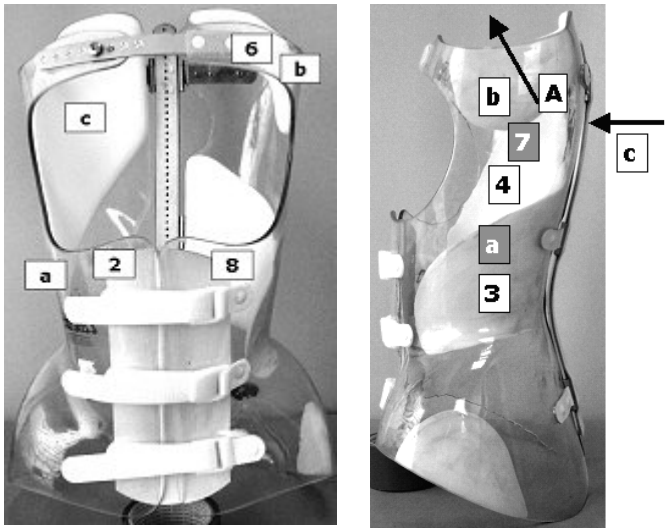


Fig. 42. Action of deflection according to SPoRT concept for thoracic scoliosis in the anterior-posterior and lateral views.

– **Posterior convex push** (c): The main action of this push is derotation, but it also becomes deflexion due to the **thoracic lateral stop** (7), which allows a straightening (flattening) of the ribs with no lateral space but only medial space; and the **anterior superior** (6) and **inferior** (8) **concave drivers,** which avoid an anterior escape. Again, in terms of deflection the spine is driven to the **anterior-superior escape** (A) through the **concave lateral driver** (4), which does not allow a direct lateral shift.

4.3.2.2 Action of derotation

The mechanisms needed to achieve derotation action are:

– **Posterior convex push** (a): This works through the **thoracic lateral stop** (1) and the **posterior** (5) and **anterior** (6) **superior concave drivers**, which really represent **stops** so as to avoid an anterior uncontrolled buckling of the spine (Fig. 43);

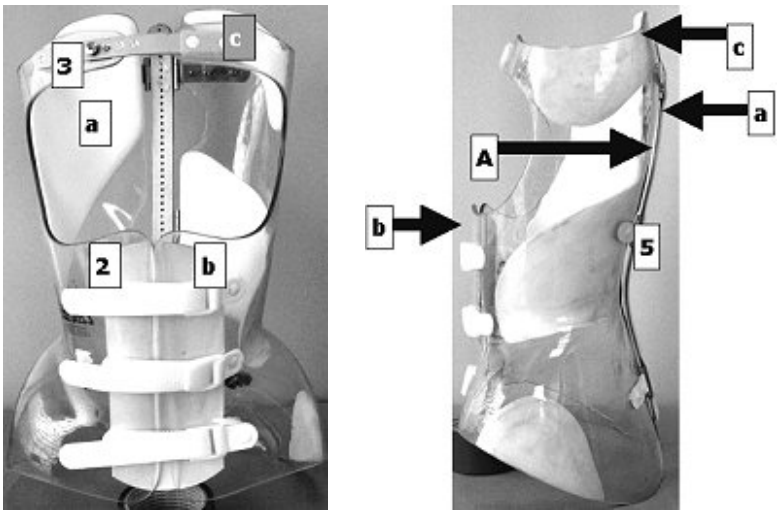


Fig. 43. Action of derotation according to SPoRT concept for thoracic scoliosis in the anterior-posterior and lateral views.

– **Anterior-inferior concave push** (b): It joins the posterior convex push in a couple of forces posteriorly transmitted through the **concave lateral driver** (4). The **lumbar posterior stop** (5) avoids a posterior buckle of the spine;
– **Posterior concave escape** (A): This is the only escape for this correction, even if it does not allow over-derotation due to the **posterior concave driver** (4) that, once reached, transforms the forces towards the anterior-superior escape considered in the deflexion action (Fig. 44);

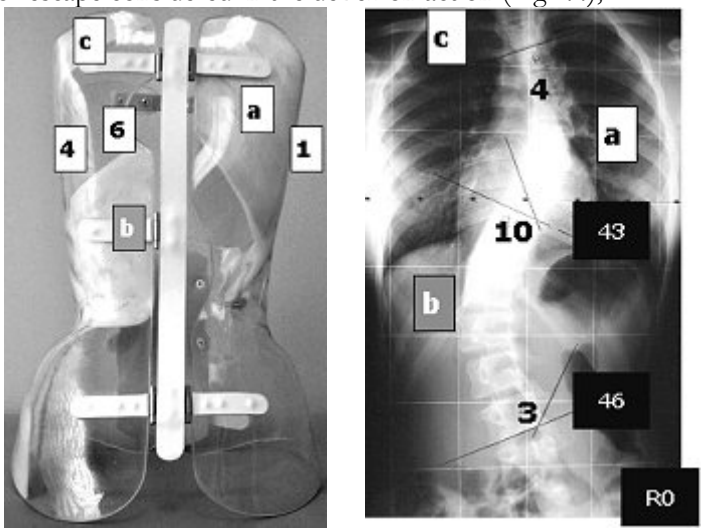


Fig. 44. Action of derotation according to SPoRT concept for thoracic scoliosis in the posterior-anterior and radiographic views.

– **Superior concave push** (c): The combined actions of previously reported forces almost always cause a contra-rotation of the upper girdle towards concavity, which must be controlled through this push (whose action is mainly towards kyphotisation) whenever necessary.

4.3.2.3 Action of kyphotisation

This is mainly realised through **brace construction**, but it is also achieved through other mechanisms as follows:

– **Anterior-inferior bilateral pushes** (a): They posteriorly decompensate the upper trunk, creating a lordosis through the **lumbar posterior bilateral stops** (1) but also facilitating the formation of kyphosis (Fig. 45);

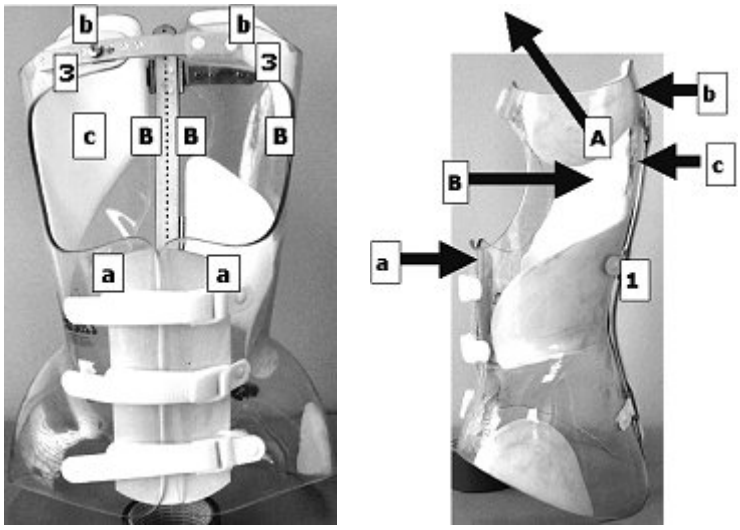


Fig. 45. Action of kyphotisation according to SPoRT concept for thoracic scoliosis in the anterior-posterior and lateral views.

– **Superior bilateral push** (c): Once posteriorly unbalanced, the spine must be superiorly flexed to create kyphosis. The combined actions of previously reported forces almost always cause a contra-rotation of the upper girdle towards concavity, which must be controlled through this push (whose action is anyway mainly towards kyphotisation) whenever necessary (Fig. 46);

– **Posterior convex push** (c): Again, the main action of this push is derotation, but it also becomes kyphotisation when it is allowed an adequate paravertebral escape to the medial side of the hump, together with the **thoracic lateral drivers** (2) that allow a straightening (flattening) of the ribs with no lateral space but only medial space; and the **anterior superior** (6) and **inferior** (8) **concave drivers**, which avoid an anterior

escape. Again, in terms of deflection the spine is driven to the **anterior-superior escape** (A) through the **concave lateral driver** (4), which does not allow a direct lateral shift.

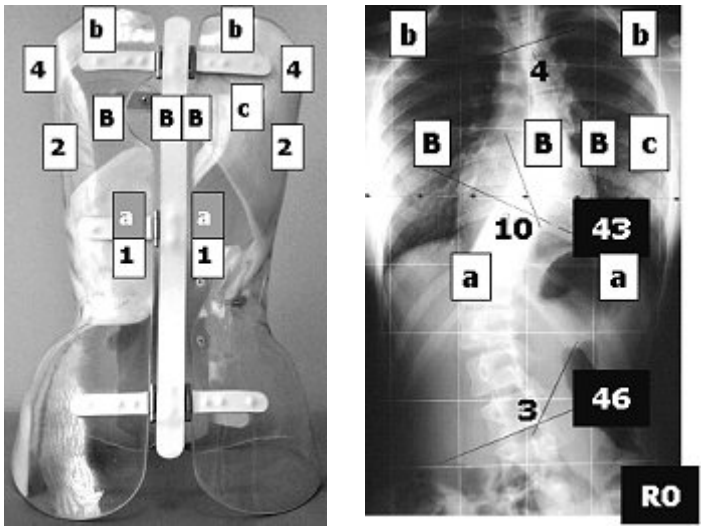


Fig. 46. Action of kyphotisation according to SPoRT concept for thoracic scoliosis in the posterior-anterior and radiographic views.

4.3.3 Correction of a thoracolumbar scoliosis

The **pushes** are:

- Posterior convex, with derotation and lordosis actions;
- Lateral distal convex, with deflection action;
- Lateral proximal concave, with deflection action;
- Anterior bilateral, with lordosis action.

The **escapes** include:

- Vertical, with deflection action;
- Posterior concave, with derotation action.

The **drivers** are:

- Lateral median-proximal convex;
- Lateral median-distal concave;
- Anterior submammary convex;
- Anterior bilateral;
- Posterior proximal concave;
- Posterior distal convex;
- Posterior convex (escape).

4.3.4 Correction of a lumbar scoliosis

The **pushes** are:
- Posterior paravertebral convex, with derotation and lordosis actions;
- Lateral over-iliac convex, with deflection action;
- Lateral proximal concave, with deflection action;
- Anterior proximal bilateral, with lordosis action.

The **escapes** include:
- Superior-posterior, with deflection and lordosis actions;
- Posterior concave, with derotation action;
- Lateral convex, with deflection action.

The **drivers** are:
- Lateral over-iliac concave;
- Anterior bilateral;
- Posterior concave (escape).

4.3.5 Correction of a high thoracic scoliosis

The **pushes** are:
- Posterior convex, with derotation and kyphosis actions;
- Lateral distal convex, with deflection action;
- Lateral proximal concave on C6-7 through a rigid hemi-collar;
- Anterior concave or convex, as needed.

4.4 Results

4.4.1 Scientific results

The results that are today available on the SPoRT concept relate to the Sforzesco brace and necessarily are short-term, because the first treated patients are now reaching the third-year follow-up examination and haven't yet completed their treatments. At an anecdotal level (not confirmed by formal studies), we can already state that results are at least maintained over time, according to what is reported below on the basis of preliminary results.

4.4.1.1 The Sforzesco brace is more effective than the Lyon brace after six months of treatment

We conducted a prospective cohort study[110,112] (Sforzesco brace, SPoRT correction concept) with a matched retrospective control group (Lyon brace, three-point correction concept) on thirty patients aged thirteen years and with curves of 38° Cobb. It was a study on the "best available practice," because 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, in the Sforzesco group 80% of patients improved and none worsened, while the Lyon group

had respective results of 53% and 13%. We did not notice a difference in regard to humps (Fig. 47).

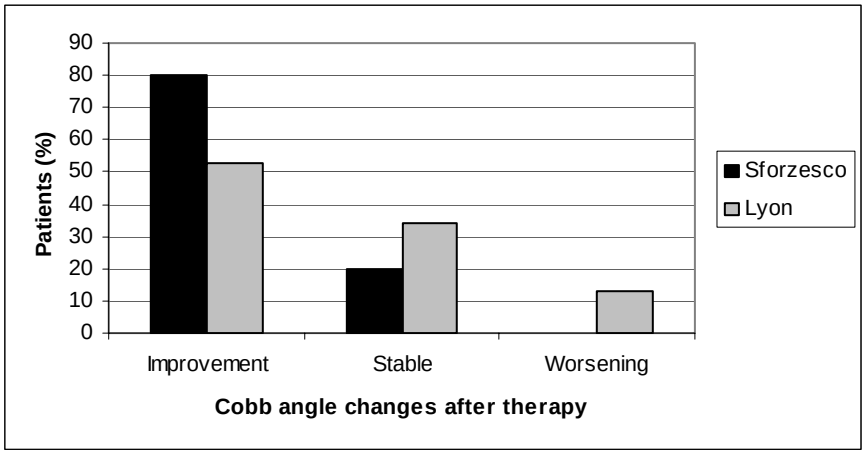


Fig. 47. The number of improved patient in terms of Cobb angle is significantly higher in the Sforzesco group than in the Lyon one[110,112]

4.4.1.2 Sforzesco brace equally effective as Risser plaster brace

Currently, the Risser plaster brace is also proposed by the Scoliosis Research Society (SRS) as the most effective tool for the conservative treatment of adolescent idiopathic scoliosis. We conducted a prospective cohort study[124] with a retrospective control group on forty-one patients aged four years and with curves of 40° Cobb. Eighteen were treated with the Risser plaster brace and thirty-three with the Sforzesco brace.

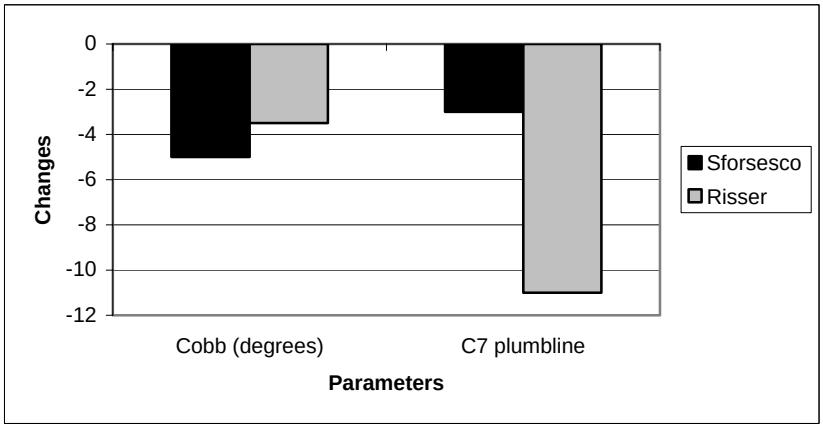


Fig. 48. The mean reduction of Cobb angle is higher in the Sforzesco group than in the Risser plaster brace one, even if not statistically significant, while the opposite happens for sagittal plane curves[124]

It was a study on the "best available practice," because until 2002 plaster had been our standard treatment for the largest curves, while since the midpoint of 2004 we have systematically used the Sforzesco brace.

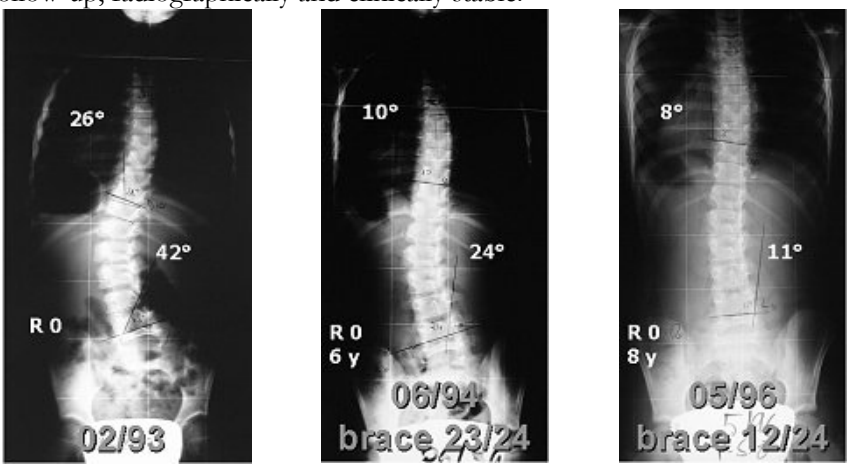
The verification was scheduled at eighteen months, when the corrective phase of the treatment has finished (twelve months) and the first follow-up examination is available with complete clinical and radiographic data. The Sforzesco was shown to be more effective at reducing the thoracic curve, and its 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 decrease of personal (quality of life) and social costs (outpatient treatment for brace, while plasters always require some kind of hospitalisation, at least in day-hospital), today we have a plastic brace that can take the place of the Risser plaster brace (Fig. 48).

4.4.2 Clinical results

We are perfectly aware that clinical cases are not comparable to scientific data, but they anyway have the benefit of the real life.

4.4.2.1 Maria C., juvenile idiopathic scoliosis

Maria (Fig. 49) has a juvenile idiopathic scoliosis discovered at the age of 5, with double curve of 26° and 42° (Fig. 49 A). She has been treated with a full time Chêneau brace 23 hours per day accompanied by SEAS exercises, with a first results without brace reported in Fig. 49 B. Gradually the brace was reduced (Fig. 49 C,D,E) until complete weaning at the age of 10, while she was still pre-menarchial, no signs of puberty. She continued with SEAS exercises alone to prevent progression until end of growth; she never required to be braced again, even if she had during puberty some progression (Fig. 49 F, G, H, I, J, K), controlled through SEAS exercises. Maria's final aesthetic appearance is shown in Fig. 49 L. Today she is at three years follow-up, radiographically and clinically stable.



A *B* *C*

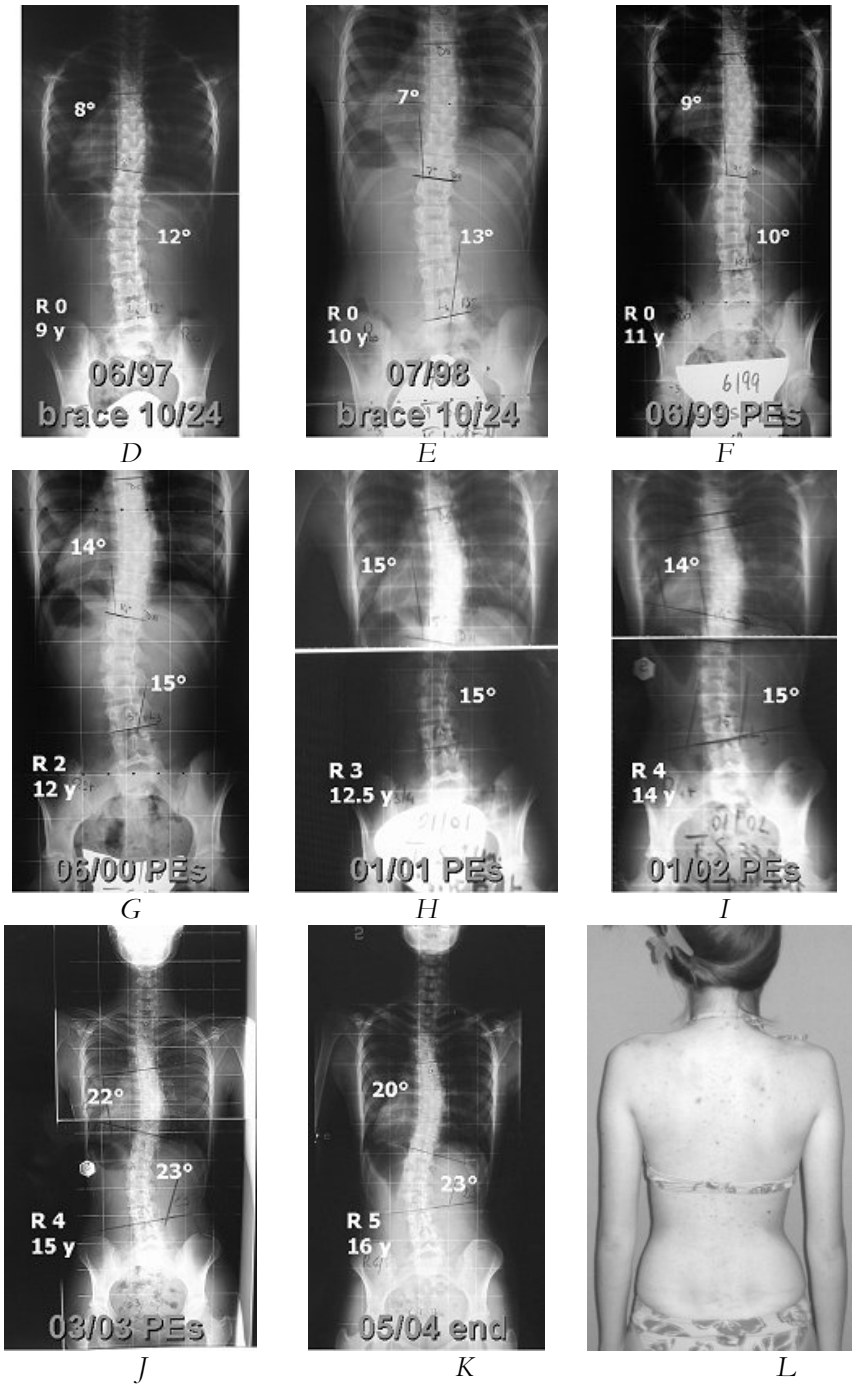
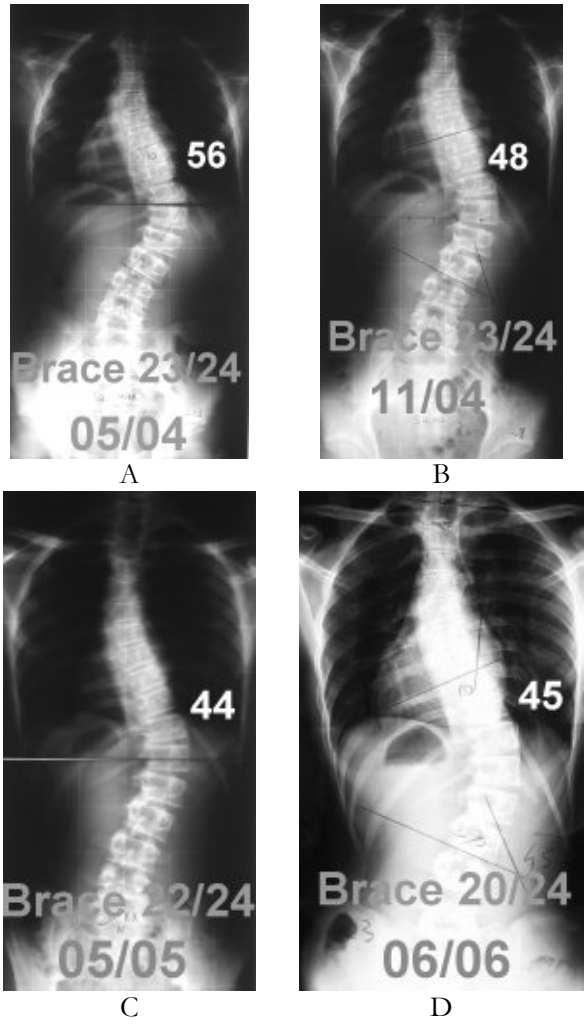


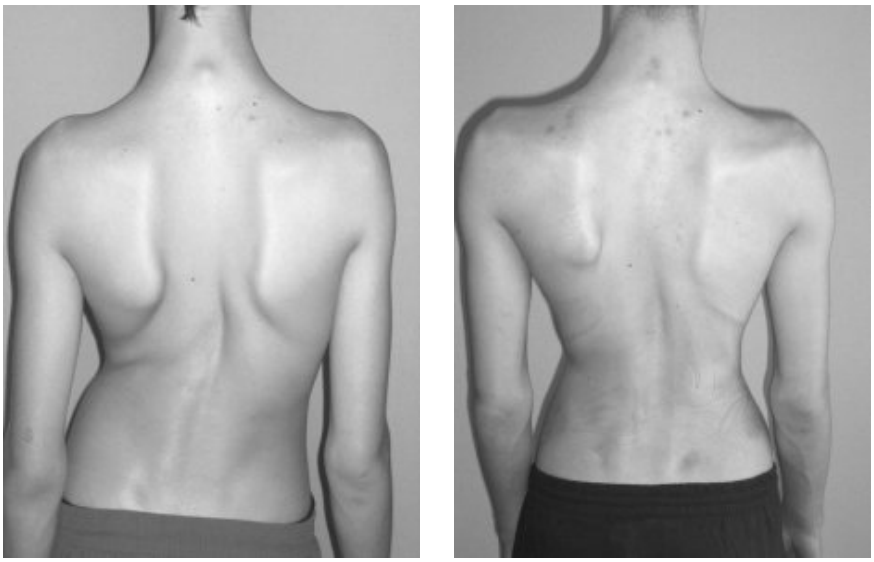
Fig. 49. Case history of Maria. In each radiograph month and year are represented, as well as Cobb degrees, Risser (R) stage and years (y). Bracing time is shown: 23/24 means 23 hours per day; PE: Physical Exercises treatment.

4.4.2.2 Simone S.: adolescent idiopathic scoliosis

Simone (Fig. 50) has a high degree adolescent idiopathic scoliosis, discovered at the age of 13.5, with a single thoracolumbar curve of 56° (Fig. 50 A); his aesthetic appearance is shown in Fig. 50 E. He (and his family) did not want to be operated on, and decided to try with bracing: he was then treated with a full time Sforzesco brace 23 hours per day, with first results without brace reported in Fig. 50 B. Gradually the brace has been reduced, with stable results in x-rays performed without the brace the same hours of weaning he had each day (Fig. 50 C,D), according to the "concertina effect" theory (Fig. 35). Today he is still wearing the brace 18 hours per day and his Risser stage is 4. Simone's today aesthetic appearance is shown in Fig. 50 F.



A B C D



E F

Fig. 50. Case history of Simone. In each radiograph month and year are represented, as well as Cobb degrees. Bracing time is shown: 23/24 means 23 hours per day.

5 Evidence-Based ISICO concepts in other spinal deformities

5.1 Sagittal plane deformities

5.1.1 Theoretical basis of sagittal plane deformities treatment

Spinal sagittal deformities are posterior (kyphosis) or anterior (lordosis) pathological deviations, irreducible to a variable extent, being caused by structural disco-legamentous modifications and vertebral bones changes of different aetiologies[12]. Because these deviations occur within the physiological curvatures of the spine, the latter can be excessively increased (thoracic hyperkyphosis or round back, lumbar hyper-lordosis), reduced (flat back, hollow back, hypo-lordosis, lumbar kyphosis) or modified in their normal distribution (kyphosis of the thoraco-lumbar junction, cervico-thoracic kyphosis)[47,106] (Fig. 51).

During growth, we must distinguish between structured and **functional hyperkyphosis**, the latter being of minor clinical importance, and entirely corrigible (round back or postural hyperkyphosis). All adult kyphoses are structured, being characterised by rigidity of the curve, which cannot be totally reverted. The maturation of the spine is a process that causes, at the end of adolescence (Risser stages 3 to 5) a progressive stiffening of kyphosis. With this normal mechanism, a pathological but still functional curve can become a **structured hyperkyphosis**[47]. In some cases, rigidity can also be found in children, while on film vertebral bodies have normal size profiles and show no sign of wedging or endplate irregularity. In this case, too, there is a structured hyperkyphosis.

Scheuermann's thoracic hyperkyphosis is the most frequent form of hyperkyphosis, having a mean estimated incidence of 1%-8% in the population.[76,182] This disorder is essentially caused by smaller height growth in the anterior region of vertebral bodies (wedge-shaped deformity) due to a transient histopathological modification of fertile cartilages, with a consequent irregularity of endplate profile and an inhibition of somato-vertebral growth correlating to secondary mechanical factors.[6,36,143] This deformity is often accompanied by a thoracic backache related to movement and posture (mechanical thoracic pain), which sometimes is the symptom that first brings the patient to the physician.

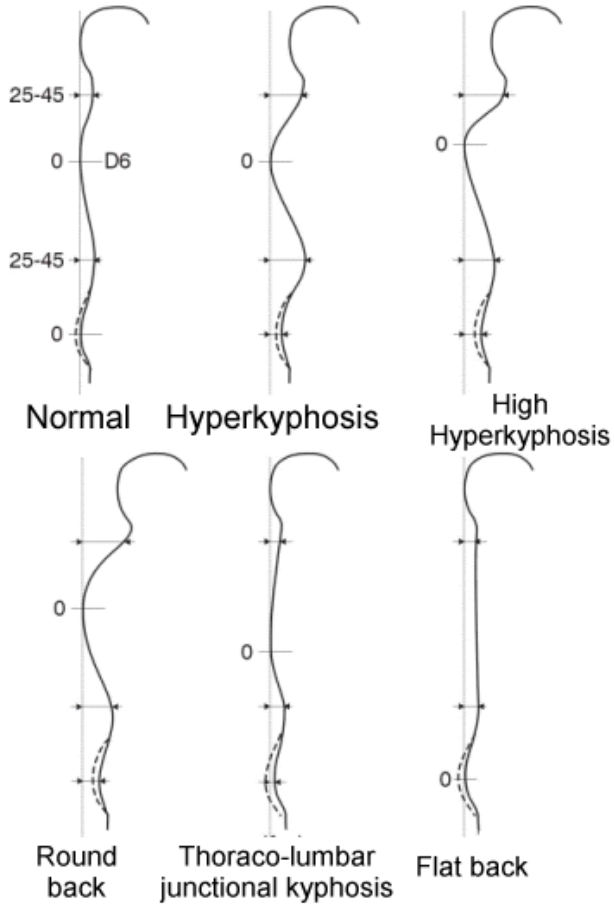


Fig. 51. Spinal sagittal deformities occur within the physiological curves of the spine, that can be excessively increased (thoracic hyperkyphosis or round back, lumbar hyper-lordosis), reduced (flat back, hollow back, hypo-lordosis, lumbar kyphosis) or modified in their normal distribution (kyphosis of the thoraco-lumbar junction, cervico-thoracic kyphosis).[47,106]

Thoraco-lumbar junctional kyphosis is a so-called "long" kyphosis because it descends below T12, i.e., it also includes L1 and L2 in the kyphotic tract (and sometimes other lumbar vertebrae). It can have a postural origin: uscle hyposthenia and poor back control drive the patient to "sit" on his/her back, with an inversion of physiological lordosis in the upper part.[47,106] Otherwise, it can be caused by an osteochondrosis localisation at the cranial lumbar vertebrae (type II Scheuermann's disease). Kyphosis is pathological solely on the basis of its positioning and the seriousness of somato-vertebral modifications, not for its angular value, which is generally limited to a few degrees. This condition predisposes the patient to backaches as soon as early adolescence and even more in

adulthood, given the degenerative nature of long-term outcomes. That is why it must be treated regardless of the angular value.

Lumbar lordosis rarely requires treatment. It is indeed a totally mobile spinal region, inserted between two stiff tracts (sacral and thoracic kyphosis), that is shaped according to postural needs due to fixed points: pelvic orientation and horizontality of the eyes. Therefore, a hyper-lordosis in upright posture is generally due to an increase of thoracic kyphosis and/or a pelvic antiversion.

5.1.2 Why and when to treat sagittal plane deformities

According to these premises, our treatment choices include the following:[47,106]

- **Observation**, in the case of functional hyperkyphosis of a low degree, asking parents to require their children to practice postural control;
- **Exercise treatment**, when we presume (because of its high degree) or have verified the impossibility of spontaneous correction of a functional kyphosis, in all cases of structured or junctional kyphosis that we think could be reverted without bracing (or we want to at least try because the spine is stiffening but is not too rigid yet), and if there is Scheuermann's disease without a pathological curvature;
- **Bracing**, only in the case of structured hyperkyphosis or junctional kyphosis that is no longer reversible through exercises because it is too rigid or because exercises have already proved insufficient; and in all cases of Scheuermann's disease with pathological curvature.

5.1.3 Practical application of sagittal plane deformities treatment

5.1.3.1 Patient's evaluation

The **patient's evaluation** allows us to achieve two essential goals: to adapt therapeutic modalities and evaluate treatment results. The examination regards the body as a whole. Therefore, it is necessary to have a global view of the subject, bare-chested, in any upright posture; and in the frontal, lateral and back views. In the **static examination,** we must highlight the following: feet equilibrium, lower limb alignment, sagittal and frontal pelvic balance, hip asymmetry, the abdomen, the spine as a whole, every possible morphological disharmony of the chest, and finally the shoulders and bearing of the head.

We **measure** sagittal posture through the distances from the plumb line in order to highlight the different forms of deviation and their magnitude (Fig. 52). We performed a study to compare various sagittal surface methods of measurement,[195] and today this classical one[150] is not significantly exceeded by any other. Regardless, in our opinion surface measurements are, in the case of sagittal spinal disease, the most important ones. In fact, Cobb degrees on radiographs are greatly impaired by the need for flexure of the shoulder so as to let the spine be visible, and this is known to greatly change sagittal posture. Radiographs are nevertheless very important because they allow us

to see the vertebrae and their deformation, but more generally for diagnostic purposes than follow-up.

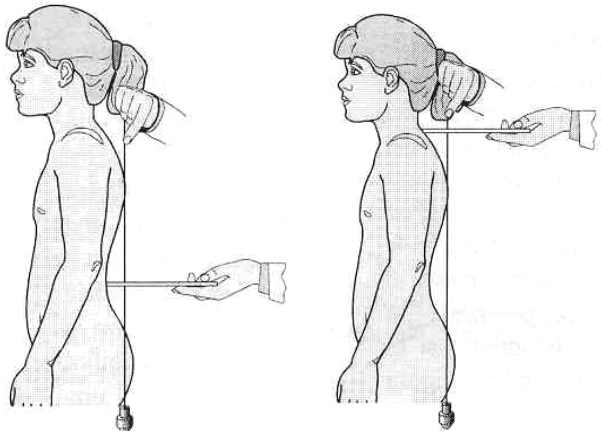


Fig. 52 – Measurement of sagittal distances from the plumb line at the level of C7 and L3, used to evaluate kyphosis and lordosis.[150,195]

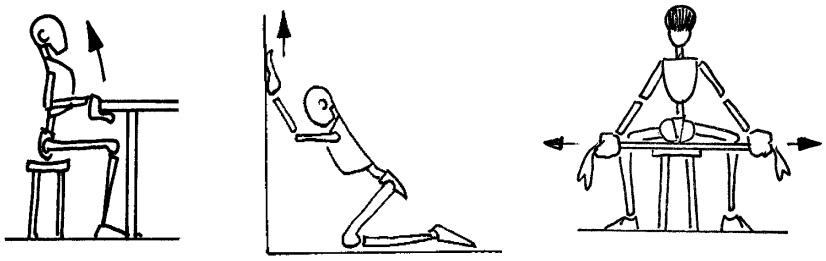
The evaluation of **joint mobility** in general and of the spine in particular, through axial auto-stretching, allows us to highlight stiff regions within the curvatures. We should be particularly careful during the evaluation of musculo-articular stiffness, particularly in regard to the stretching of certain muscular groups (pectoral muscles, upper recti, psoas, ischio-crural retraction) that have a negative influence on sagittal curves.
To complete the evaluation, we will proceed to the analysis of the **moving subject** given that the observation of coordination and balance can influence therapeutic choices. Equally important is the need to record possible aggravating factors such as visual disorders, excessive shyness, psychological disorders and so on, which can sometimes require the intervention of an expert in such problems.

5.1.3.2 SEAS exercises for sagittal plane deformities

Correction strategies through **SEAS exercises** are essentially based on a first moment of identification and mobilisation of the stiff muscles and regions, then on correct posture learning and stabilisation through muscular strengthening and cortical control of the spine. Whatever the hyperkyphosis aetiology, rehabilitation requires us to respect the following **phases** [17,21,90,103,132]:

- Becoming aware of the spine;
- Becoming aware of the correct posture;
- Mobilisation, stretching and breath training;
- Muscular strengthening and neuromotor integration;
- Ergonomy.

SEAS exercises are not meant to passively correct the spine but are mainly intended to **create all facilitating conditions**, both musculo-skeletal (harmony of structures, with sufficient elasticity of joints and muscles and muscular endurance) and neuro-motorial (knowledge of the correct spatial positioning), so as to allow **the patient to reach and maintain a** posture that is better than what was initially presented. Because posture is a matter of anatomy, functional requirements, psychological feelings, personal beliefs and self-knowledge, rehabilitation and exercises work on nearly all these points (even if differently on each). Nevertheless, achieving a "correct" sagittal posture is a personal task, but without good facilitation it would often be impossible.



A B C

Fig. 53. A - *Endurance strengthening of paravertebral muscles. Sitting with hands under the table who offers resistance: extend the spine.* B - *Mobilisation of the spine in extension. On the knees with the hands on the wall. Push up the hands and extend the spine pushing the chest to the wall. To add a strengthening element, it's possible to ask the patient to detach the hands from the wall, without loosing the acquired position.* C - *Endurance strengthening of antigravity muscles. Sitting with an elastic band behind the pelvis. Lengthen the band while extending the spine*

5.1.3.3 Bracing for sagittal plane deformities

Bracing is needed in the case of hyperkyphosis with a stiffness that does not allow a good therapeutic outcome on the basis of exercise alone. The "timing" of the start is decisive in obtaining the final outcome:[145] it is important not to arrive at an excessive degree of stiffness that would endanger the achievement of an adequate correction even if, in the first instance, it is nearly always better to implement exercise treatment, which is less invasive and thus a preferable first approach.

In the case of sagittal plane deformities, brace therapeutic goal is a **full correction**.[106] If the patient shows an adequate compliance, correction is complete for hyperkyphosis, very good for a thoracic Scheuermann's disease (mainly on the overall sagittal shape of the spine, and much less on the

deformity of the single metamers, which in part can recover) and good to moderate for a kyphosis of the thoraco-lumbar junction.
We apply the same **principles of bracing** that are proposed for scoliosis, including: active brace; mechanical efficacy, versatility and adaptability; teamwork; compliance; perfect body design and minimal visibility; maximal freedom in the ADL (Activities of Daily Life); assumption of responsibilities and cognitive-behavioural approach. The **mechanical efficacy of braces for hyperkyphosis** is based on a direct push on the kyphosis apex, which is the actual stiff zone to be corrected. Thrusts in other region of the spine must be avoided so as not to cause an excessive straightening in unaffected areas. The anterior thrust to the spine is obtained by directly acting on the clavicles so as to have an effective posterior push of the spine, in a place that is not highly sensitive and where dresses can succeed in masking the brace. Conversely, we don't use sternal pushes, which mostly cause a closure of the shoulders that drives towards kyphosis. Neither do we use acromial pushes, because they usually cause pain and excessively (and uselessly) limit the mobility of the shoulders.
Again, the **active bracing principle** as applied to scoliosis is also totally effective in hyperkyphosis, even if it is slightly modified. We teach the patient to escape from the clavicle pushes all day long in order to learn a new posture, strengthen useful muscles and progressively mobilize the rigid tract of the spine against the posterior apical push. This is much better achieved through **specific in-brace exercises**, as well as through a stabilizing one during the weaning period.

5.1.3.3.1 The Maguelone brace

The Maquelone brace is a custom-made, two-valve TLSO with posterior thoracic and sacral thrusts interconnected by three metal bars (Fig. 54) and one anterior plastic abdomen moulded in hypolordosis and connected with two stiff metal clavicle pushes. The name "Maguelone" is due to its origin from the kyphosis corrective principles described by Perdriolle, but it has been developed by Sibilla[147] et al. This brace is highly effective and very dedicated to the most frequent pure thoracic hyperkyphosis with apex from T5-6 to T8-9. However, because its structure is not very versatile it should not be used in other kyphoses, nor should it be used if there is an associated important scoliosis.

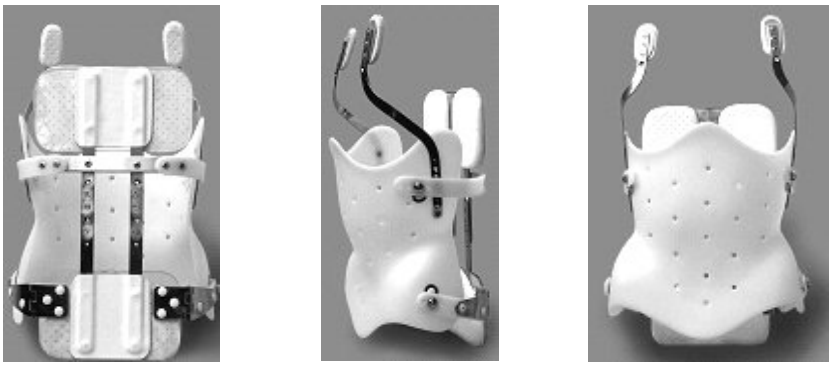


Fig. 54. The Maguelone brace has been developed by Sibilla et al.[147] from the kyphosis corrective principles described by Perdriolle

5.1.3.3.2 The Lapadula-Sibilla brace

The Lapadula-Sibilla brace is a one-valve, custom-made plastic LSO with a median frontal clasp that enwraps the chest from the submammary line to the groin, and posteriorly from T5 to the buttocks (Fig. 55). This brace, originally created for lumbar and thoraco-lumbar scoliosis, is versatile and allows the control of all situations in which kyphosis is not the typical thoracic one with a T8 apex. This is because it can also protect the frontal and horizontal planes while following the entire course of sagittal curvatures. Pushes are obtained through pads that are properly moulded and positioned, in symmetrical or asymmetrical ways, at the metameric level demanded by the specific clinical situation, as well as the escapes, which are usually obtained through posteriorly openable windows in the body of the brace. Maguelone clavicle pushes can be applied to the Lapadula-Sibilla brace as well, but their use must be avoided in lumbar and thoraco-lumbar diseases that involve a straightening of the upper thoracic spine.

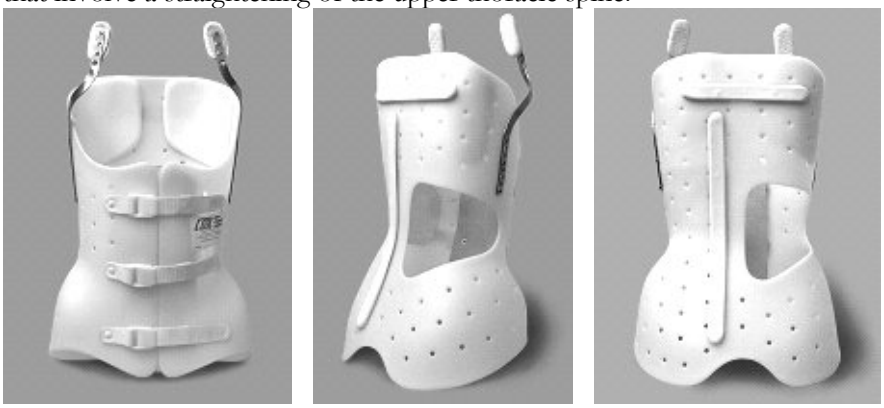


Fig. 55. The Lapadula-Sibilla brace for a thoracic hyperkyphosis with lumbar left scoliosis.

5.1.4 Results sagittal plane deformities treatment

We performed a study[140] in order to evaluate the efficacy of a one-year rehabilitation treatment based on SEAS.02 exercises in 85 patients. The first group (48 patients) used the SEAS protocol and was compared to classical exercises. According to what stated before, we did not use radiographs but C7, T12 and L3 plumb line distances as outcome measures, and they were considered changed when the difference exceeded 10 mm[195]. We found a statistically significant variation (0.0001) only for C7 in the whole sample: in the SEAS group we found a higher number of improved patients. In conclusion, exercises are an effective treatment for hyperkyphosis.

5.2 Spondylolisthesis

5.2.1 Theoretical basis of spondylolisthesis treatment

The term "**spondylolisthesis**" indicates the anterior subluxation of a vertebral body on the lower one[75,187,188] (Fig. 56). This phenomenon can occur at every spinal level, but in most cases it involves the fifth lumbar vertebra that moves anteriorly from the sacral base. Spondylolisthesis normally appears in association with a pre-existing **spondylolysis** (solution of continuity at isthmus level, i.e., the part of the vertebral arc comprised between the upper and the lower joint apophyses).

Fig. 56. The term "spondylolisthesis" indicates the anterior subluxation of a vertebral body on the lower one.

Its incidence has been estimated in 4%-6%[75,161,162], with some variations (sometimes remarkable) depending on race (Japanese 9%, Eskimo 27%).[192] Interestingly, although defects in the pars interarticularis are less common in girls than in boys, high grade shift is four times more frequent in girls.[75] The most known **classification** is Wiltse's,[187,188] in which six types are described:

– Type I, **dysplastic or congenital**: Congenital deficiency of facet joints

- Type II, **isthmic or spondylolytic**: Pars interarticularis lesion with three subtypes: lytic fracture of the pars; elongated but intact pars; acute fracture of the pars
- Type III, **degenerative**: Facets or intervertebral disc degeneration
- Type IV, **traumatic**: Acute fracture in a vertebral area other than the pars
- Type V, **pathological**: Pars or pedicle lesion caused by a general bone disease
- Type VI, **post-surgical**: Ablation of vertebral support structures after a decompressive osteotomy

The first two forms are characteristic of children: dysplasia normally includes more severe forms, while the isthmical one is far more frequent.[187,188] Taillard states that in children a localisation at L5 constitutes 86% of cases, at L4 10% and at L3 4%.[161,162] Exceptionally, cervical localisations have been described at the C6 level. No olisthesis has ever been found at the thoracic level.

Repeated micro-traumas and growth have been connected to spondylolysis and spondylolisthesis.[8,75,126,185,186] **Hyper-extensions**, in which the caudal margin of the L4 lower facet joint touches L5 pars interarticularis, are considered causative traumas. This is confirmed by the higher incidence of spondylolysis in those who participate in certain **sports**: female gymnasts, football players and weightlifters.[8] Spondylolysis is not reported in adults who have never walked. Even **growth** plays a definite role: defects do not appear in infants, reach a 4% prevalence at six years of age and equal adult prevalence at fourteen years of age.[75] The shift extent increases during the entire growth, with a **progression peak related to the pubertal growth spurt**. This progression generally stops or is minimised after skeletal maturity.[75] Females have a higher risk of progression to a higher shift grade.

5.2.2 Practical application of spondylolisthesis treatment

5.2.2.1 Patient evaluation

Lumbar pain is the main symptom of spondylolisthesis.[7,8,55,75,133] Sciatica is less frequently recorded. It is generally accepted that a certain number of spondylolistheses and an even higher number of spondylolyses are asymptomatic. The lumbosacral pain caused by spondylolisthesis seems to be correlated with an abnormal stimulation of posterior joints and ligaments. When present, manifestations of radicular suffering are ascribable to root compression or sprain within a conjugation channel that has been deformed and narrowed by the anterior shift of the arc portion that is united with subluxed vertebral body.[173]

At the first **evaluation** of a child, we always search for the so-called "**step sign**" or "bar sign," i.e., the abrupt depression of spinous processes line, which is perceivable with the fingertips at the shifted vertebra level. This sign has been proposed but never thoroughly studied, though in our experience it has both false positive and negative results. The finger-pressure searching for

the previous sign usually causes an elective pain increased by a hyperextension of the patient with the finger positioned on L5 (**Sibilla's sign**, which can be with or without reaction).

Spondylolysis diagnosis is **radiographic**[75] and often perceivable in the classical views, even if oblique ones are specific to study of the isthmus and apophyseal joints. To evaluate spondylolisthesis, we need a lateral view of the patient in upright posture. We must underline the criticality of radiographic centring at the lumbosacral joint level, with a radiographic field that includes the lumbosacral area but does not extend to the entire lumbar spine. Small variations can lead to a high bias rate. To document a **progression**, a 10%-15% or 4-5 mm shift variation is necessary.[188] It is always important to analyse a possible vertebral instability through dynamic radiographic exams.

On latero-lateral projections we can radiographically evaluate:

- Shift grade;
- The clear-cut reduction of intersomatic space;
- Trapezoidal deformation of vertebral body.

To measure vertebral shift we use a modified Taillard's method[161,162], tracing a perpendicular of the inferior endplate of the lysthesis vertebra to the superior endplate of the lower vertebra. In this way, we split in two the length of the lower vertebra endplate so as to identify a segment (the posterior one) that expresses the shift value. The shift extent will be expressed as a percentage on the basis of the following proportion: **shift value: length of lower vertebral endplate = X : 100.** The measurement of shift extent, indicated as a percentage, can be classified into four grades[125,187,188], as follows:

- **Grade I**: Equal to or less than 25%;
- **Grade II**: 26% - 50%;
- **Grade III**: 51% - 75%;
- **Grade IV**: More than 75%.

5.2.2.2 Treatment of spondylolisthesis

The shift extent, which correlates to symptom duration and severity as well as to the significance of radiographically detected morphological changes, will guide the therapeutic approach. Several studies have documented the efficacy of spondylolisthesis **conservative treatment**,[7,8,55,128,133] particularly with regard to grade I and II shifts. All treatments in the literature focus on symptoms, but we have developed a new approach to **reduce the extent of the shift itself** in Grade I and II spondylolisthesis. There is an expert consensus that says the greater the shift is the greater the problems will be, mainly in adulthood. On this basis, a treatment that during growth could stop shift progression, or even revert and reduce it if not eliminate the spondylolisthesis, should be of high importance.

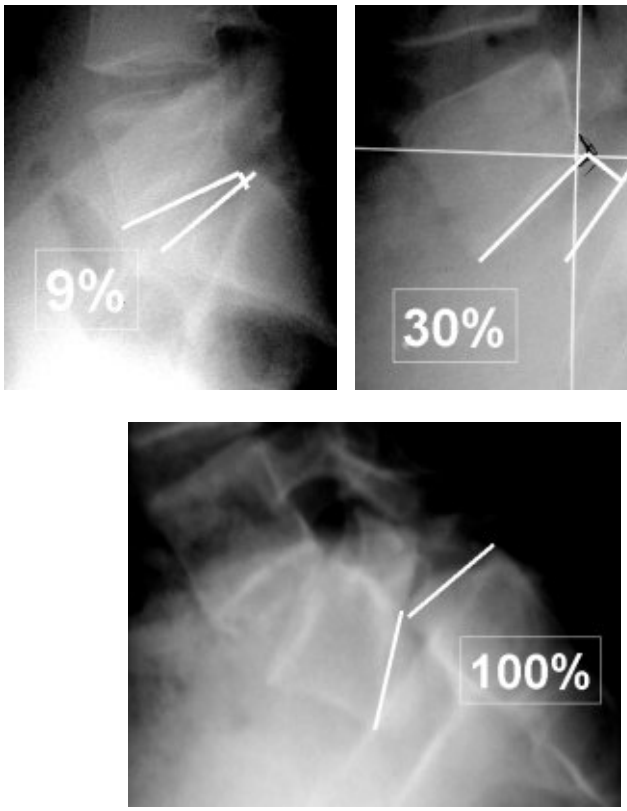


Fig. 57. Measurement of spondylolisthesis: grade I, II and IV (almost ptosis) examples.

Sibilla first developed such a treatment, and then we improved it.[113,123] This treatment is based on a modified **Lapadula-Sibilla brace** (Fig. 58), that pushes on the lowest abdomen and the sacrum while increasing the abdominal pressure. This way, we cause a vector from anterior inferior to posterior superior to the listhesis vertebra through the low abdomen thrust, while blocking the sacrum with a pad. Therefore it is no longer a simple antilordotic brace, as initially proposed by Sibilla. **Specific exercises** are extremely useful in order to eliminate pain,[55,75,128,133,173] and can help prevent shift progression, being effective alone when there is only a lysis or when spondylolisthesis is under 10%. Otherwise, the specific exercises work together with bracing.

5.2.3 Results of spondylolisthesis treatment

A retrospective study[113,123] that we preliminarily conducted confirms that by using a TLSO brace and an exercise program for lumbar stabilisation it is possible to block and reduce the shift extent in grade I and II spondylolisthesis. We studied nineteen consecutively recruited subjects (including six males) aged 13.5 years at the start of treatment and 16.8 at the end, with 20.0 ± 5.6% (range 15-30) isthmic spondylolisthesis.

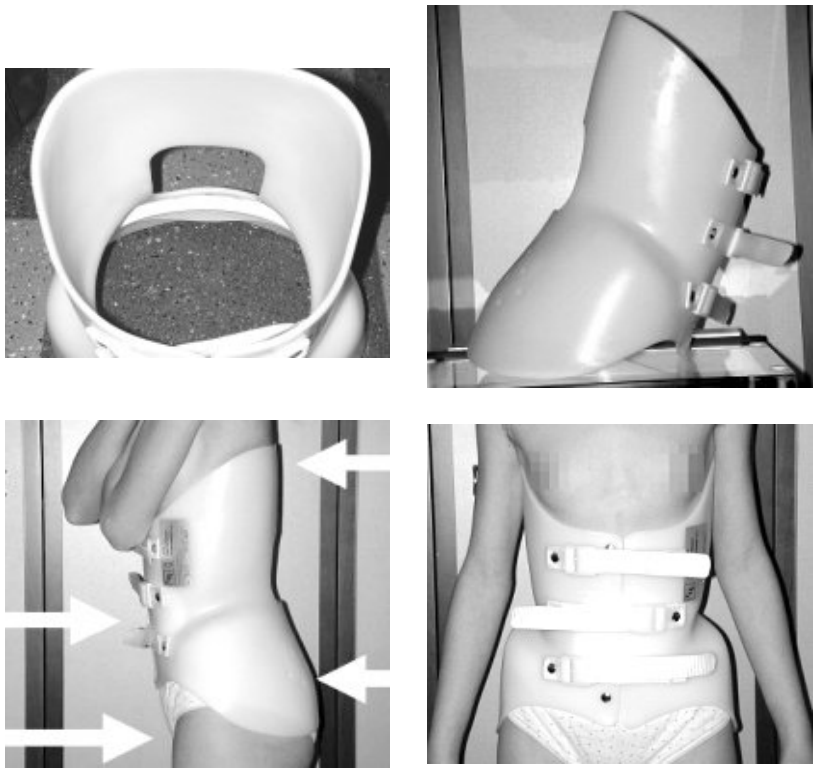


Fig. 58. The Lapadula-Sibilla brace for spondylolisthesis pushes on the lowest abdomen and the sacrum, while increasing the abdominal pressure. This way, we cause a vector from anterior inferior to posterior superior to the listhesis vertebra through the low abdomen thrust, while blocking the sacrum with a pad.

We used the full-time antilordotic Lapadula-Sibilla brace, progressively reduced according to bone age, and stabilizing physical exercises twice a week. Spondylolisthesis was reduced to 12.2 ± 8.4% according to radiographs after at least twelve hours without the brace (up to six months). Only one case progressed (from 15% to 22%) and one did not change, while nine improved by more than 50%, five by more than 90% and three reached 0% (complete reduction). All patients at the end of treatment were stable on dynamic radiographs. These results suggest the possible usefulness of braces for spondylolisthesis in adolescents, even if a controlled study is needed. We have recently confirmed these results in a case series of sixty-one patients aged 12.5 years, and followed up for a maximum of thirty months (seventeen cases), in which we had an average reduction of 5.2%.[104]

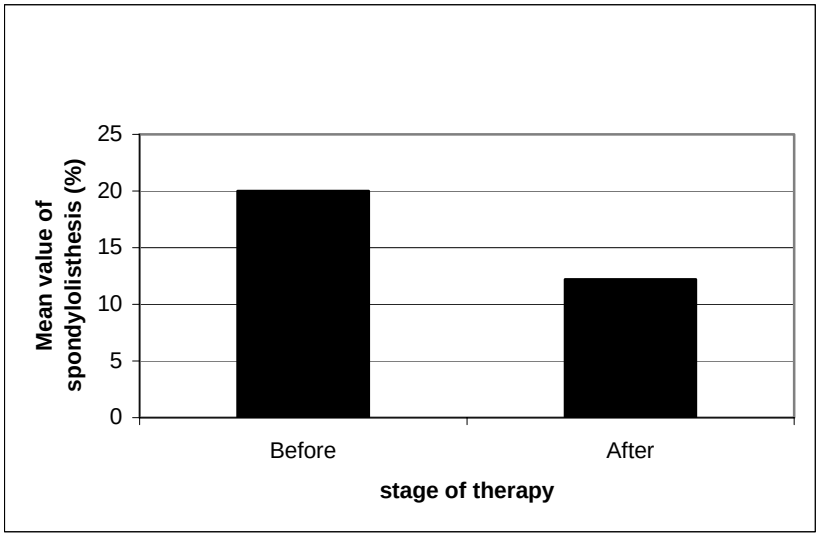


Fig. 59. Brace treatment in growth period reduces spondylolisthesis on average, with complete recovery in 17,5%.[104]

5.3 Adult spinal deformities

5.3.1 Why, when and how to treat adult scoliosis

The types of treatments that can be applied in adult scoliosis are comparable to those of the growth years, but they're dependent on the actual deformity and disability as well as the risks the patient would face. Excluding **surgery**, which must always be considered an option in high-degree scoliosis and/or curvatures that have progressed in adulthood, the possible treatments include:

- **Observation**: Due to the fact that all scoliosis can progress in adulthood,[3,45] over 20° of curvature at the end of growth observation should be considered even if with a long time span (five years), while this should be reduced and become regular over 30°. At the end of treatment during growth, in our view even an important scoliosis over 45° in a patient who does not want to be operated on should be only observed regularly so as to guarantee a period of "wash out," which is of high psychological importance. Sports activities must always be proposed as a way to maintain mobility, balance, strength, endurance and overall fitness while preventing pain: all activities can be used, the only limitation being high-intensity sports activities that increase the range of motion, and that could therefore destabilize the spine.[85,130]
- **SEAS stabilizing exercises**: Over 45° if the patient does not want to be operated on, and/or in cases of proven progression, exercises should be prescribed as the primary means to stop the evolution of the curve. These exercises are described later.

- **Cognitive-behavioural physical exercises approach to pain**: The treatment of back pain in scoliosis, even of a high degree, is not different from that in other patients.[4,31,32,59,109] In the case of scoliosis, the risk of chronic pain is increased,[93] and according to what we know of chronic back pain, the cognitive-behavioural approach gains high importance[127] from the beginning. We must pay attention to stabilizing the spine, though after recovering from pain and regaining functioning the treatment should focus on scoliosis. This approach is described later.
- **SPoRT (Sforzesco) bracing**: This can be applied only in the first years of adulthood (from skeletal maturity to an age ranging from twenty-five to thirty-five) in cases of proven progression of deformity, or in cases of high-degree curvature in patients not well treated before who do not want to be operated on, or when there is relevant subjective psychological impact of the aesthetic deformity. The protocol includes bracing full-time for six months, then rapidly decreased and weaned after twenty-four to thirty months. While bones are already formed, ligaments are still not completely rigid, and the bone and muscular mass are to be definitively acquired. In this period, the experience since the 1960s in Lyon by Stagnara[150] continued afterwards in Milan by Sibilla[144,145] have shown that aesthetic results can always be achieved, with a balanced posture that, together with some degree of rigidity due to the treatment, could prove to reduce the risk of progression (studies are underway in this respect).
- **Bracing in the elderly**: In our minds, this should be avoided as much as possible because it is rarely tolerated, while the efficacy is very low because there are no real mechanical means to recover a fixed deformity in flexion like that usually seen in the elderly. Obviously, these considerations relate to real bracing, not to supports that sometimes achieve a small reduction in pain.

5.3.2 Adult scoliosis

5.3.2.1 Theoretical basis

Structural vertebral deformity is a vertebral curvature involving loss of flexibility [62]. Vertebral deformities that are most frequently present in adults, namely scoliosis and hyperkyphosis, **slowly and insidiously evolve**, involving both the anatomical structure of the curve and the functional status of the patient. This worsening seems to be a **postural collapse** that at first is not a real deformity, because it is not structured. However, as time goes by the permanent asymmetric load tends to modify the vertebral structure and can no longer be recovered. Curvature development is accompanied in a linear way by an increase in **chronic pain and psychological suffering** -- in the most serious cases even by a reduction of cardio-pulmonary function.[49,60,62,74]

Among adults, the most disabling deformity of the spine is scoliosis, that can be idiopathic, degenerative ("de novo" scoliosis) or idiopathic with a superimposition of several degenerative changes [2]. In addition to the concern

for present disabilities, there is also the awareness of the high probability of a progressive and continuous worsening as time goes by. Furthermore, when the major curve is at the lumbar and thoraco-lumbar levels, besides the worsening of rotation and lateral curve there is the risk of a **collapse into kyphosis** (which is extremely disabling) and/or of a lateral drop.[52,57]

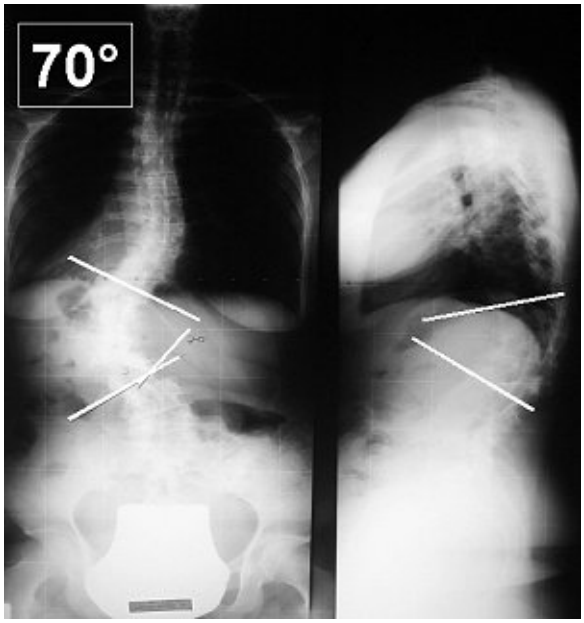


Fig. 60. When the major curve is at a lumbar and thoraco-lumbar level, besides the worsening of rotation and lateral curve, there is the risk of a collapse into kyphosis (which is extremely disabling).[52,57]

In the literature we find a growing number of data confirming the possibility that **exercise** alone can in some cases slow down the development of the scoliotic curve, not only in the child but also in the adult.[62] The reduction of scoliotic curve certainly does not indicate a reduction of deformity but a **recovery of the postural collapse,** which is present in upright posture. From a study by Torell and Nachemson, there is evidence that in adolescents, regardless of curve magnitude, the mean difference between a standing radiography and a supine one is 9° Cobb (Fig. 15).[164] There are no data in the literature to indicate precisely what this difference is (Duval-Beaupère called it "postural collapse" – Fig. 16)[44] in adult scoliotic patients. Probably the recovery of this collapse is the **key to avoid any worsening of adult curves**. On the other hand, the functional, cosmetic and psycho-social damages caused by scoliosis are directly proportional to curve magnitude,[49] so an initial improvement, followed by stability over time, must be considered a remarkable success in adult scoliosis therapy.

5.3.2.2 Practical application: SEAS in adults

5.3.2.2.1 Goals of adult scoliosis treatment

The goals at the neuromotor and biomechanical levels are the recovery of postural collapse, postural control and vertebral stability. Another paragraph describes what to do in the case of back pain.

5.3.2.2.2 Therapeutic modalities

- **Becoming aware** of pathology consequences and recovery possibilities for postural collapse;
- **Muscular strengthening and vertebral stabilisation**, always done in auto-correction, i.e., in the position of maximum postural collapse recovery (Fig. 61);

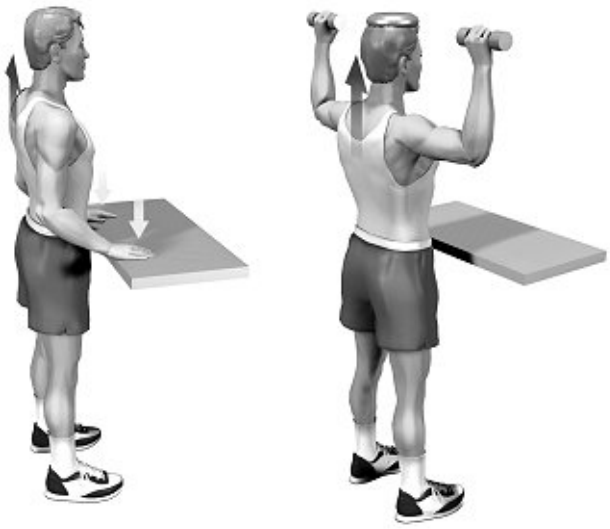


Fig. 61. Recovery of postural collapse and antigravity muscles endurance strengthening. A: the patient pushes hard against the table, heeping down his shoulders, to recover postural collapse. B: the patient liftes his hands holding auto-correction, with dumbbells and a weight on his head..

- **Global improvement of patient's function**, even with a partial recovery of possible deficits in joint range of motion and of muscular retractions, if present;
- Development of **balance**;
- **Postural integration**, which includes the neuromotor integration of correct postures and an ergonomic education program;
- **Functional improvement**, with aerobic and respiratory exercises in the case of cardio-pulmonary function reduction;
- **Cognitive-behavioural approach**, even in the absence of pain.

5.3.2.2.3 Organisation of the treatment plan

Therapy includes at least **two weekly exercise sessions** lasting forty-five minutes each, that the patient can freely do at home or at the Centre under the supervision of a qualified technician. The exercise plan differs every three months. During the **first year of treatment** we require greater diligence—on a daily basis in certain cases—so as to obtain a more rapid recovery from postural collapse.

5.3.2.3 Scientific results

ISICO is conducting a study on adult scoliotic patients. These patients have had curvatures of more than 30° Cobb on the first radiography done after the end of bone maturation. Preliminary data indicate that **in the years preceding** our examination, during a mean observation period of 5.81 years, scoliotic curves **worsened by an average 0.84 degrees per year**. These data are higher than the ones presented in the literature on natural history (yearly worsening 0.44°, with variations depending on initial severity and curve localisation),[170] but the sample is not representative of the general scoliotic population since it includes only those who have decided to be evaluated by ISICO physicians because they perceived a worsening of their pathology, had cosmetic concerns or experienced back pain. In a mean **therapy period** of 5.68 years, the **improvement** obtained with SEAS exercises is **0.47 degrees per year**. Particularly, there was a high improvement in Cobb degrees during the first years of therapy, followed by stability. As time goes by, this stability is very comforting and in striking contrast with the relatively rapid worsening noticed on the radiographies done during the years preceding therapy. Scoliotic curve reduction, obtained with exercises following the SEAS protocol (in one case 15° in one year), in our opinion certainly does not indicate a deformity reduction but a recovery of the postural collapse in upright posture.

5.3.2.4 Clinical results

We are perfectly aware that a clinical case is not comparable to scientific data, but they anyway have the benefit of the real life.

5.3.2.4.1 Anna G.: 24 years old when progressed

Anna (Fig. 62) had been treated during growth with bracing with the final result in May 2000 of a right thoracic T6-T12 curve of 28° and a left lumbar T12-L4 of 33°, reported in the Fig. 62 A. She was stable at 1 year follow-up (Fig. 62 B: T6-T12 26°, T12-L4 33°), but the 4 year follow-up did show a progression (Fig. 62 C: T6-T12 26°, T12-L4 37°): in the meantime she had continued swimming, that was her preferred sporting activity. Being results inside the possible measurement error, it was only suggested to repeat the exam in one year, while continuing normally activities of daily life. One year later, progression was definite (Fig. 62 D: T6-T12 33°, T12-L4 42°), and even increased; clinically Anna appeared to have a bad posture. SEAS exercises were started with the aim of avoiding surgery, and in one year she

recovered her posture, and according to radiographs she was even better than at the end of bracing treatment (Fig. 62 E: T6-T12 28°, T12-L4 27°).

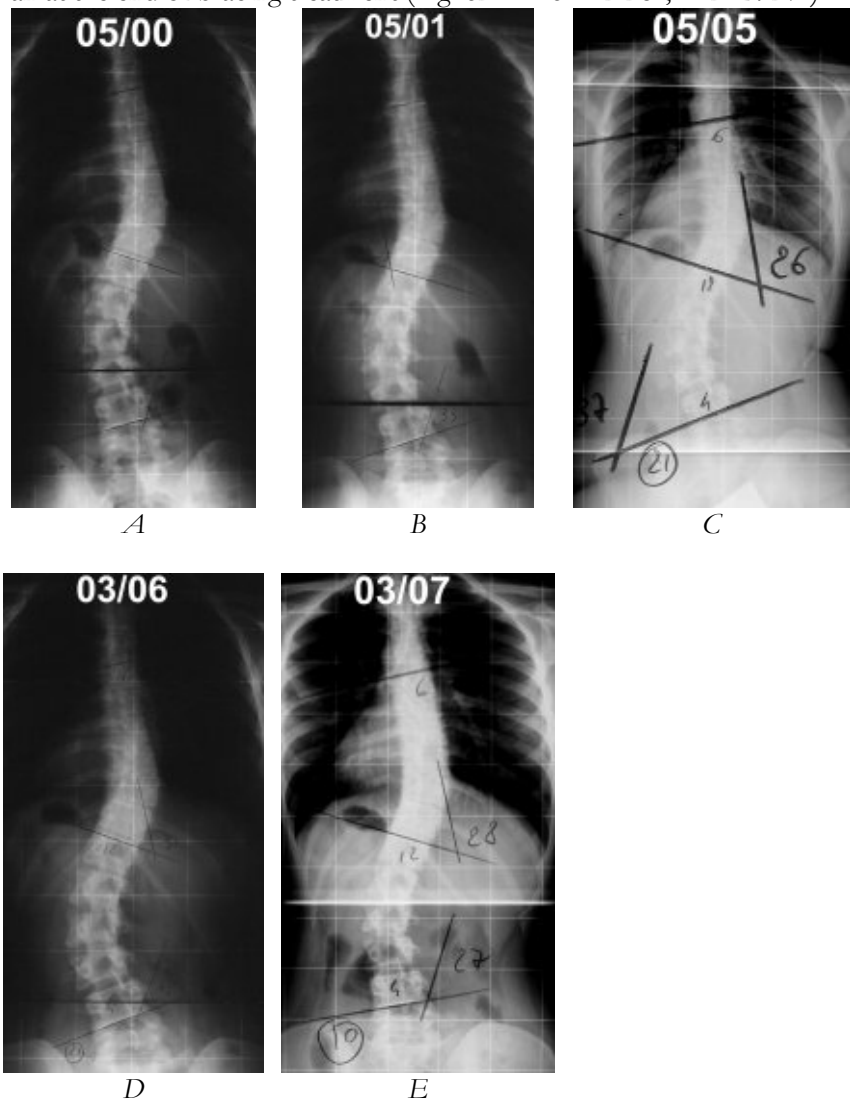


Fig. 62. Case history of Anna. In each radiograph month and year are represented, while Cobb degrees have been reported in the text.

5.3.2.4.2 Francesca F.: 41 years old when progressed

Francesca (Fig. 63) had never been treated during growth and, because of pain and perceived worsening of posture, she was radiographed in September 2004 (Fig. 63 A) and discovered a left thoracic T2-T6 curve of 31° and a right lumbar T6-T12 of 27°. She was then required to perform a specific technique of exercises: Postural Reeducation according to Souchard.

After 1 year (May 2005) there were no real changes (Fig. 63 B: T2-T6 30°, T6-T12 of 25°) but, because she perceived herself worsened, Francesca performed 9 months later new radiographs that demonstrated progression (Fig. 63 C: February 2006 T2-T6 33°, T6-T12 of 32°). Suggested that there could have been some mistakes in that exam, she repeated it with no real changes (Fig. 63 D: April 2006 T2-T6 33°, T6-T12 of 31°). She was proposed surgery, that she wanted to avoid. SEAS exercises were then started with this aim, and in one year (March 2007) according to x-rays exams she was even better than at start of her adult progression (Fig. 63 E T2-T6:27 T6-T11:23).

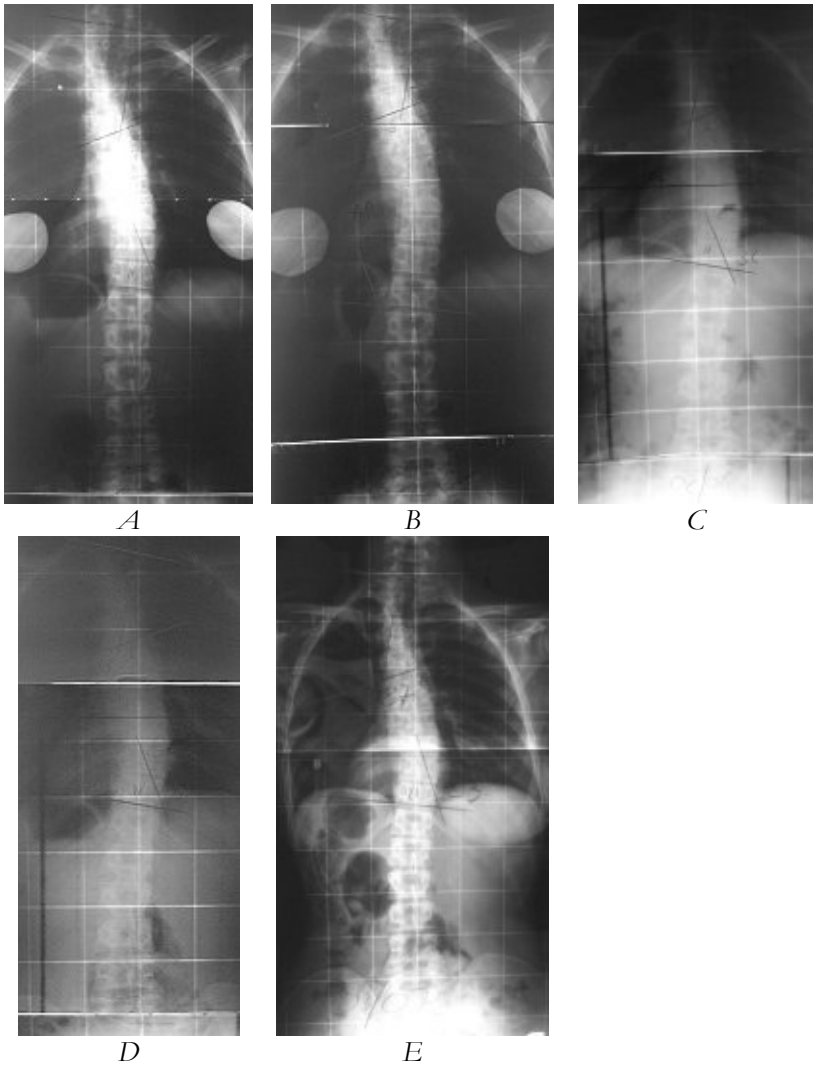


Fig. 63. Case history of Francesca. Month, year and Cobb degrees have been reported in the text.

5.3.3 Back pain and adult scoliosis

The literature on **spinal pain and scoliosis** in adults is fairly uniform: in adult scoliotic subjects, researchers found that the incidence of lumbar pain was similar to that of subjects without any vertebral deviation,[70] while prevalence was higher.[59-61,63] This pain seems to be more frequent in women after pregnancy or after a period of spinal mechanical overload[3], even if researchers did not find any risk of debilitating low back pain in adult patients with untreated lumbar scolioses. Moreover, there is a similar rate of surgery for lumbar pain in patients, with and without scoliosis.[93] Even if pain symptom is the main cause of surgical-treatment requests for stabilisation purposes, its extent cannot be connected with to magnitude of curvature.[148] Instead, there is a significant relationship between lumbar lordosis magnitude and pain: the increase of pain and reduction in quality of life are indeed directly proportional to the flattening of the lumbar curve.[142] For this reason, in the treatment of an adult patient with scoliosis and persistent lumbar pain, one of our goals is **to recover/maintain sagittal curves** with particular attention to the research of a good lumbar lordosis.
Strength-endurance training exercises toward extension of the spine, can be particularly useful. In any case, the three-dimensional nature of scoliotic deviation requires that we pay attention to the starting position, which should be chosen after doing several tests to find the one most appropriate for the patient (Fig. 64).

Fig. 64 – Example of extension exercise

Correcting the lateral or rotational misalignments by putting small shims under the pelvis allow us to identify the least painful position (Fig. 65).

Fig. 65 – Example of a support for the starting position

Like all subjects who report chronic pain, the scoliotic patient also tends to develop a progressive **fear-avoidance behaviour**, i.e., a growing reduction of his/her activities for the sake of avoiding pain. In the acute phase, this fear-avoidance behaviour, like rest, claudication or stick usage, has a protective effect against pain thanks to the reduced stress on the recovering structure. Consequently, this behaviour can persist in order to avoid pain, but can cause a progressive "**disuse syndrome**".[11] For that reason the treatment schedule for a patient who experiences chronic pain must be organised from the cognitive-behavioural perspective (Fig. 66).

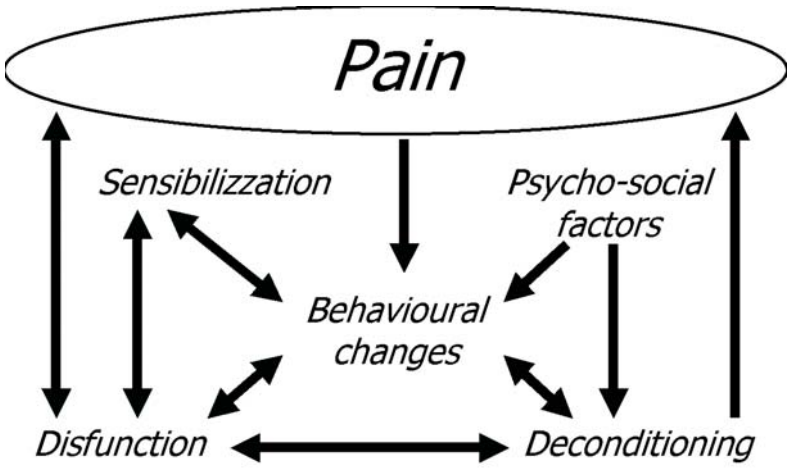


Fig. 66. A representation of some of the vicious cycles who lead to the development and then maintain chronic low back pain. Fear avoidance behaviours and progressive "disuse syndrome"[11] must be confronted in a cognitive-behavioural perspective.

Learning in order to change can be considered the treatment slogan that will have the following main goals:

- Clear the patient from wrong beliefs;
- Let him/her give up fear avoidance behaviors;
- Eradicate behaviours that increase risks;
- Seek good physical fitness.

One of the main weapons is an **effective educational program** ideated in such a way that it offers the patient every clarification useful for understanding his/her own problem. This is because the patient should be aware of the real extent of his/her problem and should not overestimate it, which often occurs when information is misinterpreted. We will stimulate thoughts about what endures and what, on the contrary, allows us **to manage pain**, underscoring how a different approach can have a decisive influence on pain perception and the status of disability it can achieve. We will pay considerable attention to avoiding the development of a "**catastophisation**" attitude, meaning the perception of pain as an extremely threatening element that will have irreparable consequences on one's future life. Because catastrophisation is influenced by patient-therapist interaction, the way that messages are transmitted is a fundamental element for goal achievement.

Cognitive-behavioural approach will be particularly effective if some **realistic goals** are established before treatment begins, and if auto-monitoring techniques are used in order to clear the patient from preconceived ideas and allow him/her to reach an awareness of his/her wrong behaviours and thus document his/her improvements.

We will emphasize **self-treatment and personal management** in order to ensure the conscientious involvement of the patient, who must become the main "actor" in the recovery process.

6 The rehabilitation ISICO approach to spinal deformities

ISICO was founded only recently, but since the beginning it has been planned to offer the best clinical answer to patients using the best possible tools, both clinical and organisational (Table 1). This gives rise to a **new approach** that fuses medical tradition with modern technologies both soft and hard, always from the clear perspective of Evidence-Based Medicine, as well as on the basis of research where we have no data on our traditional methods.

6.1 Complete multiprofessional evaluations on a scientific basis to treat and rehabilitate

A treatment without a careful evaluation should not be possible. Nevertheless, in the past this has been applied in rehabilitation, because of a lack of instruments needed to perform this careful evaluation. Today, this is no longer completely true in the field of scoliosis [106]. We have developed a complete and thorough **clinical evaluation of scoliosis patients both for physicians and physiotherapists**. This evaluation focuses on diagnosis and orthopaedic and rehabilitation treatment follow-up, and exercise planning and evaluation, respectively. We look at impairments along with disability and quality of life. In cases where clinical tools have not been previously validated, we have conducted specific research in order to identify their advantages and limits, as well as their normal parameters [56,92,115,193-195]. Moreover, we are very interested in new technologies that are useful in daily practice as a means to better understand the aspects of this pathology that aren't yet fully understood, such as three-dimensionality [98,99,116], body reactions to bracing[136], movement behaviour of scoliosis patients [137-139] and so on.

Today, standard clinical **measurements** performed by every **ISICO physician** include the following for all patients at every examination (or radiographic exam):

- Bunnell degrees and hump height[56]
- Distances from the plumb line[82,195]
- Aesthetic Index[194] evolved into the TRACE (Trunk Aesthetic Clinical Evaluation)[193] measurement
- ASIS, PSIS and iliac crest height
- Anthropometric parameters
- SRS-22[92]
- Cobb degrees

- Raimondi degrees for rotation[171]
- Lumbar take-off
- Risser sign
- Height differences between femoral heads

It is also possible, when necessary, to include measurements such as the Roland-Morris disability scale for pain or the EuroQol for quality of life. Moreover, at every examination some **non-numerical evaluations** are systematically performed: spine range of motion, rigidity of scoliosis curves and kyphosis, Romberg and Unterberger (Fukuda)[138,139] tests, strength and elasticity of the major muscle groups, and spine palpation.

Today, starting with the standard clinical measurements performed by physicians, each **ISICO physiotherapist** takes the following measurements in every patient at least twice a year (more often, if necessary):[137]

- Bunnell degrees;
- Distances from the plumb line;
- Anthropometric parameters;
- Trunk range of motion in all directions and planes;
- Range of motion in flexion of thoracic kyphosis;
- Endurance of trunk extensors, abdominals;
- Stretching of ileo-psoas, quadriceps and pectorals;
- Neuromotorial measurements[138,139]: Unterberger (Fukuda), Romberg (monopodalic, sensibilised), pendulum, oculo-manual control.

It is also possible, when needed, to include other measurements such as the Roland-Morris disability scale for pain or the EuroQol for quality of life. Moreover, at every examination some **non-numerical evaluations** are systematically performed, such as quality of Active Self-Correction and the districts involved in the limitation of trunk flexion.

We are working diligently through systematic research, from the physician and physios standpoints, to develop new evaluation tools and/or to refine existing ones.

6.2 Outpatient rehabilitation and consultation: how to reduce personal and social costs and achieve competence in the patient's home

One of the main problems of the field is the fact that scoliosis patients who could benefit from treatment account for roughly 2%-3% of the interested population, and together with the high competencies required to effectively treat them, this causes a dramatic **drop in treatment quality** for patients who have not the good fortune to live near a centre dedicated to the conservative treatment and rehabilitation of scoliosis. To improve this situation, there are two ways:

– Inpatient treatment one or two times a year, with high personal and social costs and the possible lack of compliance at home;
– A new model allowing local people to apply the same high-quality treatments as are available in super-specialised centres.

We chose the latter model, and today the protocols prepared and applied by ISICO are exclusively of an outpatient nature. Protocols are characterised, in addition to content updates according to the latest developments in the international scientific community, by an innovative layout that allows us to apply them even in **people who come from very far away**. Today, each year the Milan and Vigevano Centres only are reached by more than 2.000 patients coming from every region of Italy (and even from elsewhere in Europe). The Centres require a low attendance on the premises (from a minimum of two to a maximum of five), lasting 90 minutes each to give patients all the materials and competencies to be locally treated by their physios. Each patient receives his/her own personalised treatment program, his/her own scheme and his/her own DVD with exercises. This way, people perform exercises **at home or in a private or a national health service outpatient facility** near home, doing so in the best possible way, according to the highest competencies made possible by a **super-specialised centre**.

The healthcare field has for some years had a tendency to invest a lot on **domiciliary care** in order to optimise the costs and the use of healthcare structures: ISICO is not only following this path but goes beyond, favouring the auto-administration of domiciliary care without the absolute need for intervention by an external operator (though it is generally recommended for compliance reasons). This intervention modality offers the following benefits:

– For the patient: a reduced presence at the centres (less travel), with the implementation of therapy at home in the most appropriate ways and moments, according to family choice and preferences (and costs); there is a joint responsibility for therapy management of both the patient and the family; they can become autonomous and be free from "dependence" on the rehabilitator, which is often observed in cases of chronic pathology;
– For the therapeutic structure: a strong commitment in every single treatment, which must be adequately prepared and guaranteed by a trained staff operating as a team in order to provide the patient with every necessary competence.

Protocols that are organised in this way are coherent with ISICO's fundamental principles, particularly the following:

– Efficiency: With the same efficacy, efficient protocols, i.e., the less demanding ones in terms of time and cost;
– Acceptability: Protocols adaptable to the needs and preferences of the patient, who is not the object but the subject of treatments;
– Teamwork: All operators take part in the patient's treatment, working in close collaboration.

We are also working hard on the **brace construction side** to develop the means to prevent patients from having to travel around the country in order to reach the best orthotists, and the actual technical developments should allow us to reach the correct answers in a few months.

6.3 Cognitive-behavioural approach and counselling: compliance and acceptability through humanisation

Chronic pathology tends to cause a change in behaviour and relationships with the outer world[165]. Scoliosis can fall within the group of chronic pathologies because of the long time period required for its therapy, and due to the fact that treatment outcome will not be a complete patient recovery but the best possible control of the deviation[4]. The correct management of this disease is not always easy, because it usually appears in a frail period of life, i.e., the stage of pubertal growth spurt. When treatment includes a brace as well, the **young patient's reaction** is rarely good.[25,81] The brace causes a sudden shock and modifies the adolescent's human relationships during a period of dramatic physical change, when he/she is grappling with the acceptation of his/her rapidly changing body, this being the period involving the development of his/her personality and in which the young person is concentrated on weaving the first complex plot of relationships with the other sex. For the **parents,** it is also a difficult situation. Their natural ambition is to seek the utmost happiness for their children, but they are forced to struggle with the difficult problem of whether to ask the person they love most to make a big sacrifice that is necessary for the child's health, or to try and find a different path with a doubtful efficacy that could be dangerous and create even bigger problems.

In the treatment of **chronic pain**, the importance of formulating the treatment on the basis of a far less mechanistic nature than before is shared internationally[127]. Chronic back pain is described as a bio-psycho-social problem, i.e., a disorder that has a biologic origin, causes psychological implications of non-acceptance, growing fear and distrust towards problem resolution, until it finally results in depressive behaviours that eventually have repercussions even on relationship dynamics with the outer world. Thanks to this new awareness, we consider every facet of a condition that is much more complex than what we used to think.[168] This has suggested the use of **integrated treatment techniques** that draw on the experience of other medical disciplines as well. It is the case of cognitive-behavioural approach that originated from experiences developed in psychology field halfway through the past century.[18,48] **The transposition of a cognitive-behavioural approach to scoliosis treatment** is aimed at simplifying

treatment acceptance, reassurance, looking for a solution to practical problems and stimulating faith towards the outcome.[22]
The essential condition for an effective development of treatment is the definition of the **clear and effective two-way communication** necessary to win the trust of the patient[167] and family alike. This allows us to:

- Carefully **listen** to doubts and explanation requests;
- Let the patient/family **feel that we understand** his/her/their distress;
- **Solve** practical problems that might arise.

For the practical application of these principles, treatment protocols used at ISICO include a **family counselling meeting** to be held at the end of each session. This meeting sees the participation of the patient, his/her family, the ISICO rehabilitator who has taught the new exercise plan and, if present, the therapist who in practice follows the patient each time he/she does exercises. It is a moment of utmost importance to reach the described objectives, to regularly consolidate the "**therapeutic contract**" agreed upon with the patient and his/her family, and to cement the **"extended" therapeutic team**. It is an indispensable element for an optimal attainment of the final outcome.

6.4 The strength of a multidisciplinary rehabilitation team approach

We strongly believe in the importance of the **team in rehabilitation**. Our entire organisation and overall clinical work are strongly based on multidisciplinary patterns of rehabilitation. The "team approach" means that everyone speaks the same language, even if with different professional perspectives, thus making treatment a continuous path for the patient and family, without interruption. Moreover, in the team we include the patient and his/her parents. Our approach is focused on involving the entire family in the team. We believe that no treatment is possible without the participation of all needed actors, and the entire approach to therapy has been conceived around this idea.

6.5 High-tech to help clinicians, improve quality, perform research and implement innovation

The wide use of technology, which has characterised ISICO's organisation from the beginning, brings remarkable advantages in terms of **clinical activity support** and **simplification of managerial processes**.
In the first place, from the **clinical** point of view:

- The entire team uses **dedicated software** for medical and rehabilitation evaluations and treatments. The software creates a digital medical record, is able to communicate with a single central database via the Internet, and

allows us to overcome distances in time and space that often separate the physician's and rehabilitator's interventions;

- The adoption of **common standardised protocols** for clinical data gathering allows us to perform research and quantitative evaluations of treatments outcomes in order to begin the process of constant improvement and benchmarking among the different structures;
- The digital medical record, by accompanying the patient throughout the therapeutic process, provides a constant verification of **compliance** with defined protocols while permitting the room necessary for therapeutic process **customisation**, doing so by supporting all operators in the correct application of the shared diagnostic-therapeutic paths;
- All this allows a **strong centralisation of the technical decisional process** for the planning of single rehabilitative and treatment protocols, whose production constantly remains under the control of the central technical management;
- Data regarding research projects is available in real time, with an immediate transfer of outcomes to daily clinical practice.

From the **organisational** point of view, technology allows a high centralisation of every managerial process, realizing principles that today are often invoked but rarely accomplished in practice:

- The application of **Quality Management principles** to clinical-rehabilitative activity, with a constant monitoring of fundamental process indicators;
- The realisation of **excellence networks**, thanks not only to the establishment of a multicentric model but also to its progressive expansion to other field operators already present in the territory and who can fit into the pre-arranged informative-technological structure;
- The concrete application of **Knowledge Management principles**: The adopted methodology and technology provide a common base of information recording and management on which to insert every improvement proposed by internal research and international scientific knowledge, doing so by defining a qualitative standard with continuous growth characteristics.

7 Conclusion

Evidence-Based treatment (and in particular, for what is our interest, **rehabilitation and orthopaedic conservative treatment**) **for spinal deformities** already has some good bases,[72,95,105,106,122,179] even if not the scientifically strongest ones, that are universally defined as proofs coming from randomised controlled trials (RCTs), and subsequently from large observational studies regarding treatments based on the results of those RCTs.

The practice of medicine in these cases requires, as is done today (and presumably will be for a long time in the future due to the particularity of the field of growing age, which requires years to gather final data on treatments), that effort are based on EBM but also related to the preferences of patients, professionals and society where they live. This is perfectly in accordance with the definition of **Evidence-Based Clinical Practice** but also with what is happening in other fields, even where it is more a matter of molecule and chemistry than of human behaviors and child development.

ISICO was born:

- To **follow the EBM pathways** that will be traced by improvements in scientific knowledge;
- To **directly develop new evidence**, open new avenues to treatment, and shape the existing ones according to its ethical principles;
- To **spread this** knowledge (i.e., the approach), as much as possible, to professionals, industry, society and patients in Italy and abroad.

Where there will be people sharing the **same vision and philosophy** of life, this proliferation of knowledge could become a **collaboration** with which to pursue common ways of working and collecting data for research and other steps forward.

In this booklet readers have found the **concepts that ISICO applies**:

- One, called **SEAS (Scientific Exercises Approach to Scoliosis**), is old but continuously under development for nearly 30 years regarding exercises to prevent evolution and bracing, or to help orthosis work and avoid its side effects, thus increasing the overall quality of treatment;
- Another, called **SPoRT (Symmetric, Patient-oriented, Rigid Three-dimensional, active bracing**) is a new breakthrough that research has shown to be of interest;
- The others have no names, but they exist, together with the previous ones, within a unifying conceptual framework that is the **ISICO rehabilitation approach to spinal deformities**, fully based on our principles: efficacy, efficiency, research, innovation, acceptability, humanity, teamwork, transparency, organisation, appropriateness and reliability of treatments.

Today, we have new instruments such as **SOSORT**, the newly established international scientific **Society on Scoliosis Orthopaedic and Rehabilitation Treatment**, and its journal, **Scoliosis**: in recent years this has given rise to a sudden increase in research around the world, to which ISICO has given its full collaboration. Looking at all this, in our opinion the best conclusion of this booklet can be a simple statement:

EVEN IF TODAY WE ARE PERFORMING AT OUR BEST FOR OUR PATIENTS, WE ARE SURE THAT IN THE FUTURE WE WILL ACT DIFFERENTLY.
IN FACT, RESEARCH CONTINUOUSLY INCREASES SCIENTIFIC KNOWLEDGE, AND CLINICAL BEHAVIOURS MUST CHANGE ACCORDINGLY:
WE WILL CHANGE.

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9 Appendix

9.1 ISICO & . . . , or how ISICO can help you

9.1.1 Patients

ISICO operates within its own rehabilitation structures, ensuring the maximum synergy and a constant exchange involving daily **clinical experience, research and teaching activities**. Therapeutic and evaluation techniques and protocols are defined and adapted through an ongoing process of improvement, and are subject to verification and publication in the international scientific literature. On average, more than ten papers per year are published in the most important international journals.
The constant effort is to give a concrete application to the **principles** defined by ISICO as the basis of all its activities:

- **Efficacy**: Scientifically proven validity of used techniques, excluding alternative/traditional methods without evidence;
- **Efficiency**: With the same efficacy, efficient protocols, i.e., the least demanding ones in terms of time and cost;
- **Research**: Implemented on a daily basis during the clinical activity, as a guarantee of continuous improvement;
- **Innovation**: New effective and efficacious techniques should be acquired and transferred to clinical practice as soon as possible;
- **Acceptability**: Techniques that can be adapted to needs and preferences of the patient, who is not the object, but the subject of treatments;
- **Humanisation**: The single person is at the core of treatment, thanks to dialogue and psychological attention;
- **Teamwork**: All operators take part to the patient's treatment, in close collaboration;
- **Transparency**: Complete and accurate documentation of what we do, that is made available to the patient and the family practitioner;
- **Organisation**: The application of the right organisational principles allows us to favour processes of continuous improvement;
- **Services appropriateness and reliability**: They are a natural consequence of the application of principles described here. At ISICO Centres, we treat all spinal pathologies of non-surgical interest, from the child to the elderly individual.

Besides **medical evaluations** done by specialists with long-term, specialised experience in the field of spinal pathologies, we propose **treatments** characterised by therapeutic protocols that extremely up to date from the scientific point of view (e.g., the cognitive-behavioural approach for back pain), which allow us to also treat the patient coming from afar using a few

sessions at one of our centres. Patients coming from every region of Italy and from neighbouring countries access our structures.

9.1.2 Rehabilitation professionals

ISICO offers different means of collaboration for healthcare professionals. By proposing itself as a **highly specialised institute in the field of conservative treatment and rehabilitation for spinal diseases**, the main objective is to actively cooperate with other operators, to whom we give specialised support for the most complex cases in order to guarantee an adequate intensive intervention and lay the foundations for a subsequent management at the structures in the territory. That is why we want to establish **partnerships** and relationships with professionals (physicians and rehabilitators) who deal with spinal diseases and are interested in a high-level of scientific support.
For physicians (surgeons / physiatrists / other specialists / family practitioners / pediatricians) this support includes the following possible activities:

- Super-specialised counseling on specific diseases;
- Verification of possible alternatives to surgical treatment;
- Counseling for the definition of rehabilitation treatments;
- Possible direct conservative and/or rehabilitation therapy;
- Detailed presentation of outcomes;
- Guarantee of scientific and up-to-date answers.

For physiotherapists:

- Super-specialised medical examinations;
- Counseling for the definition of complex rehabilitation treatments and specific exercises;
- Deferring of the patient for the execution of his/her exercises on the territory;
- Detailed presentation of outcomes;
- Guarantee of scientific and up-to-date answers.

9.1.3 Rehabilitation facilities

For rehabilitation facilities on the territory, that deal with spinal diseases, ISICO proposes itself as a **potential partner** on several fronts:

- First of all, in terms of **clinical activity** we have established complex collaborations according to the methods indicated in the preceding paragraphs, with an intervention that goes from counseling for complex cases to specialised medical examinations and direct rehabilitation therapy;
- Another important mode of collaboration is **training**. ISICO is active in this area with the annual organisation of the R&R Congress--"Rachide & Riabilitazione Multidisciplinare" (Spine and Multidisciplinary

Rehabilitation)" (Fig. 67) -which includes refresher courses organised in collaboration with GSS (Gruppo di Studio Della Scoliosi e Delle Patologie Vertebrali - Study Group of Scoliosis and Vertebral Pathologies) and also the organisation of specific training projects addressing rehabilitation structures that seek to ensure timely updates for their operators in ISICO's field of specialisation;

Fig. 67. The logo of the National Congress yearly organized by ISICO: "R&R - Rachide & Riabilitazione multidisciplinare" (Spine and multidisciplinary rehabilitation).

– **ISICO Network** was born in 2006. It is a network promoted by ISICO in order to encourage the growth of adhering structures from the scientific perspective, and to give more visibility to these structures that show a certain commitment to achieve a higher qualitative standard. This network, which is still in the early stage of development, could eventually initiate communication and exchange channels aimed at spreading the culture of patient orientation, efficacy and efficiency, service improvement, scientific updating, research and evaluation of supplied services.

9.1.4 Orthotists

Orthopaedic technicians are a fundamental part of the team involved in conservative treatment of patients with vertebral deformities. That is why ISICO has always paid great attention to these healthcare professionals from the educational point of view, by guaranteeing specific competencies in their formative offer ambit, as well as from the technological and organisational perspectives in order to meet patient needs. Operating at a national level, it is difficult to guarantee an adequate and detailed answer encompassing the entire national territory in terms of the necessary competencies and professional experience. Therefore, patients are often compelled to travel even long distances to find adequate answers to their therapeutic needs. Some years ago, ISICO devoted itself to the fostering of experimentation and circulation of new technologies in this field, both as a means to propose specific research projects, and supporting with its own competencies the experiences started at the Italian level. As a result, ISICO has gathered a wealth of experience and wants to circulate it, so that we can encourage the professional growth of the most committed orthopaedic technicians and answer patients' needs to a greater extent than has been possible.

ISICO ACTIVITY AREAS

RESEARCH. Research is an established commitment for ISICO. It is performed in close cooperation with the main Italian research Institutes and with the most important Italian and foreign universities that operate in the sector of spinal pathologies. ISICO warrants active systematic participation in the world's most important sector conferences, as well as the promotion of excellent networks at the national and European levels. ISICO performs research and development activities too, in order to encourage immediate transfer, at the industrial level, of new results acquired through the international scientific ambit.

CLINIC. ISICO operates through its rehabilitative structures, in order to guarantee the maximum synergy and a continuous exchange between the daily clinical experience and the activities of research and education. The protocols and the therapeutic and evaluation techniques are adjusted and adapted through an ongoing process of improvement, in order to tangibly implement ISICO principles. At ISICO centres we treat all spinal pathologies of a non-surgical interest, from children to the elderly. We handle the most complex cases, and the adopted protocols are also ideal for those who must travel considerable distances.

EDUCATION. As everybody knows today, normally at least ten years will pass before the new knowledge acquired through research is progressively applied to daily clinical practice. ISICO has as its objective the reduction of this gap through powerful, broad-based education activity in accordance with the guidelines defined for CME (Continuing Medical Education), through the prompt updating of network-related structures in the territory, through the organisation of educational activity in cooperation with the main scientific sector-specific societies, and through the organisation of meetings at a national level designed to disseminate the results obtained in the research field.

COMMUNICATION. In the field of spinal pathologies it has been scientifically proved that correct educational health campaigns through mass media have a significant efficacy in reducing the extent of health and social problems. For that reason, ISICO is actively engaged in the production of popular publications, in the promotion of meetings with the population, of congresses and debates, and in participation through TV and radio programmes. We make the most of the Internet, given its great potential in this field. Furthermore, we propose a systematic cooperation with scientific societies in order to allow the maximum widespread diffusion of new knowledge.

PREVENTION. This is an ambit of elective work for ISICO. Its objective is to reduce the incidence of spinal disease problems in the population. In the child it is fundamental because vertebral pathologies, once established, are unlikely to be resolved fully. Moreover, their treatment involves prevention of the more important problems found in the adult age. In adults, the vast majority of problems are of a recurrent type, and in the elderly the process of aging makes it necessary to avoid aggravation over time. Therefore, prevention implemented in the daily and working ambit becomes a therapy as well.