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# Physical Therapy for Adolescents with Idiopathic Scoliosis

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## 1. Introduction

Scoliosis is a three-dimensional deformity of the spine. In its most common form, idiopathic scoliosis (70% to 80% of cases), the causes are unknown (Rowe 2003). AIS is discovered at 10 years of age or older, and is defined as a curve of at least 10°, measured on a standing radiograph using the Cobb technique (Parent et al, 2005). While the prevalence of AIS is around 3% in the general population, almost 10% of those diagnosed with AIS will require some form of treatment; usually observation or scoliosis-specific exercises (SSE) for mild curves, braces for moderate curves and spinal surgery for severe curves (Cobb angle >50⁰). Up to 0.1% of the population is at risk of requiring surgery (Lonstein, 2006). A severe form of AIS is more commonly found in females. Typically, AIS does not cause any health problems during growth (except for extreme cases). However, the resulting surface deformity frequently has a negative impact on adolescents` body-image and self-esteem that can give rise to quality of life (QoL) issues and in worst cases, psychological disturbances (Maclean et al, 1989). Adolescent patients are generally treated in an attempt to halt the progressive nature of the deformity. No treatments succeed in full correction to a normal spine, and even reduction of the deformity is difficult (Danielson and Nachemson, 2001). If scoliosis surpasses a critical threshold, usually considered to be 30º Cobb, at the end of growth, the risk of health and social problems in adulthood increases significantly (Negrini, 2005). Problems include reduced quality of life, disability, pain, increased cosmetic deformity, functional limitations, sometimes

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pulmonary problems, and progression during adulthood (Weinstein et al, 2003). Because of this, management of scoliosis also includes the prevention of secondary problems associated with the deformity.

### 1.1 Current consensus and clinical practices

The level of evidence in the conservative management of AIS is not high, whatever treatment is considered. Treatments applied in this field include surgery (fusion), bracing and/or exercises. In the past electrical stimulation has also been used but without significant results; other treatments not recommended by the current guidelines (Weiss et al, 2006) include manipulations and insoles. The existing evidence concerning these treatments, which is classified according to the Oxford Centre for Evidence Based Medicine (Philips et al, 2001), can be summarized as follows: scoliosis-specific exercises (SSE) can be recommended as a first step in the treatment of AIS to avoid and/or limit curve progression (grade A); bracing is recommended when SSE`s are unable to prevent progression (grade B); and surgical fusion is the unavoidable treatment when AIS is either causing symptoms (rarely), conservative treatment has failed or a well-informed patient requests fusion (grade C recommendation) (Weinstein et al,2008).

Considering the evidence, the treatment approaches adopted by various orthopaedic surgeons and physicians specialised in the field of conservative management of scoliosis are divided indicating a lack of clinical equipoise across the professions and different countries. In general these approaches can grossly be split into two opposing groups: the first group regard the exercises as useless, while the second group use them and advocate their efficacy (Negrini et al, 2005). Similarly, bracing has been abandoned by some (Dolan and Weinstein, 2007) while others support its use on the basis of the existing weak evidence about efficacy; fusion is generally considered to be necessary when AIS either exceeds a certain degree, previous treatments have failed or AIS causes symptoms, but indications vary widely according to the preference or not of the treating physician/surgeon for conservative management (Dolan and Weinstein, 2007). These two conflicting approaches seem to prevail in two different regions of the world: while in the US and UK, the wait and see strategy prevails, in various parts of continental Europe, Eastern and Southern Europe conservative treatment (SSE`s and bracing) is considered to be of benefit to the patient and used routinely by the large majority of scoliosis physicians and surgeons.

A possible reason for the negative beliefs towards SSE within the clinical community in the United Kingdom is the lack of knowledge within the physical therapy community and associated clinical specialists. These pathological condition-specific exercises are not taught at either undergraduate or post-graduate level within the physiotherapy curriculum in the UK. Most clinicians (both physiotherapists and surgeons) in the UK normally do not appreciate the difference between SSE and general physiotherapy. Scoliosis-specific exercises consist of individually adapted exercises that are taught to patients in a centre that is totally dedicated to scoliosis treatment. The patients learn an exercise protocol that is personalized according to medical and physiotherapeutic evaluations. Usual generalised physiotherapy (GPT), on the other hand, is more generic, usually consisting of low-impact stretching and strengthening activities like yoga, pilates or tai chi (taiji), but can include many different exercise protocols

according to the preferences of the therapist. The understanding within the generalised AIS treating community in the UK and USA may be based on the effectiveness of generalised physiotherapy which has not been shown to be effective.

### 1.2 Quantity and quality of the research to date and their limitations

Recent systematic reviews (Negrini et al, 2009) have shown the possible effects of SSE`s on scoliosis primarily in terms of Cobb angle, based on controlled studies, which were mainly observational and partly prospective. A Cochrane Review (Romano et al, 2009) (co-authored by 3 of the current authors: Bettany-Saltikov, Negrini and Romano) on the effectiveness of scoliosis-specific exercises for patients with idiopathic scoliosis (currently being peer-reviewed) found that, despite a comprehensive search of published and unpublished literature, only two studies met the stringent Cochrane methodological criteria. Of these only one was a randomised controlled trial; this trial compared a protocol of exercises, electrostimulation, traction and postural training (Wan et al, 2005) to a protocol of electrostimulation, traction and postural training. This study provided very low quality evidence in favour of SSE`s versus the same protocol without exercises. More recently, a prospective controlled cohort study comparing the SEAS exercises versus usual physiotherapy (Negrini et al, 2008b), also provided very low quality evidence in favour of SEAS exercises. The outcome most frequently used across previous studies was the Cobb angle; only Negrini's study considered the more patient-centred outcome of brace avoidance as a main outcome.

Further, another systematic review that also included observational trials was conducted by Negrini et al in 2008 as an update to a previous review conducted in 2003. This review was included in the DARE Cochrane Database (Negrini et al, 2003c). 19 studies were retrieved, including one RCT and eight controlled studies; 12 studies were prospective. In total the 19 papers included considered 1654 patients and 688 controls in all. The highest-quality study (RCT) compared two groups of 40 patients, showing an improvement of curvature in all patients in the intervention group after six months. Apart from one old study (conducted in 1979 and of very low methodological quality using general physiotherapy, not SSE), all studies confirmed the efficacy of scoliosis-specific exercises in reducing the progression rate (mainly in early puberty) and/or improving the Cobb angles (around the end of growth). SSE`s were also shown to be effective at reducing brace prescription. Although the authors of this review concluded that the current evidence on exercises for AIS is of level 1b, the only RCT reported within the review had a number of serious methodological issues. This raises the need for a well conducted RCT.

The aims of Scoliosis-Specific Exercises considered in various research protocols to date include: limiting or halting scoliosis progression, improving physical functioning and reducing scoliosis patients` disability and avoiding more invasive methods of treatment such as bracing. In the worst patients (fused, or elderly in a flexed posture) pulmonary rehabilitation has also been considered. If scoliosis does progress beyond a certain critical threshold (generally considered to be 30 degrees), bracing is generally considered (by physicians or surgeons who normally believe in bracing) to be the subsequent step of treatment with the aim of avoiding surgery. Nevertheless, it has been shown that braces have psychological consequences on adolescents during a crucial pubertal period of spinal growth when relationships with the opposite gender are generally initiated and body self-image and self-esteem develops (Falstrom et al,1986). Surgery has also been shown to have a

significant psychological impact, as well as causing considerable functional limitations due to the fusion of the spine (Hawes 2006b). Hence, there is a promising role for therapeutic scoliosis-specific exercises, that do not have any unwanted psychological consequences.

The International Scientific Society On Scoliosis Orthopaedic and Rehabilitation Treatment (SOSORT) has proposed and supports the use of SSEs and gives indications for their use (Weiss et al, 2006). Furthermore and most importantly, scoliosis-specific exercises based on specific auto-correction and stabilization are also supported by a recent consensus of specialists in the field of the conservative management of scoliosis (Weiss et al, 2006). Numerous scoliosis-specific exercise approaches to the treatment of mild to moderate scoliosis are available. The following SSE approaches that will be discussed in this chapter include; The Scientific Exercise Approach to Scoliosis (SEAS), written by M.Romano and S. Negrini; The Barcelona Scoliosis Physical Therapy approach (BSPTS), written by Dr. Manuel Rigo; The Lyon approach, written by Dr. Jean Claude De Mauroy; The Functional Individual Therapy for Scoliosis (FITS) approach, written by Andrejz Mhango and Marianna Bialek; The DoboMed approach, written by Prof. Jacek Durmala; and finally the SpineCor approach, written by Ana del Campo and Dr. C Coillard. Each approach will now be discussed in turn.

## 2. SEAS approach (Italy)

### 2.1 Introduction

SEAS is an acronym for "Scientific Exercise Approach to Scoliosis". The name indicates that this approach is based on scientific principles, which is a very important feature of this treatment approach. The continuous improvements and developments to the original method results from the constant introduction of new knowledge derived from the scientific literature.

### 2.2 History of the SEAS method

The SEAS method originates from the Lyon approach where a number of the basic characteristics to the approach had already been developed. This includes: improving the patient's awareness of their deformity, autonomous correction by the patient, the use of exercises to stimulate a balance reaction, as well as the performance of in-brace scoliosis specific exercises using the brace as a training tool (Romano et al, 2008).

### 2.3 Principles of the SEAS method

The difficulty with treating patients with idiopathic scoliosis is the impossibility of working directly on the cause of the deformity, which is still unclear. Each type of treatment whether surgery, bracing, or scoliosis-specific exercise (SSE), is aimed at minimizing the effects of the symptoms of the disease. In the SEAS approach the two main treatment objectives are active self-correction as well as the improvement of spinal stability. The self-correction component can be defined as the search for the best possible alignment within three dimensional spatial planes, that are obtained autonomously by the patient.

These are some assumptions the form the basis of the SEAS approach:

Conservative treatment of scoliosis has the aim of preventing the progressive deformation of the vertebrae, caused by the constant asymmetric pressure on them.

The self-correction obtained by the active movement of the patient lasts for the duration of this movement.

Even using very demanding treatment approaches that involve performing exercises for several hours a day it is not possible to maintain the correct position after the exercise sessions finishes.

The purpose of the SEAS exercises is therefore to find a strategy that helps the patient search for the position of self-correction, as they move throughout the day during their usual activities of daily living. In our concept, this can only be done by developing a specific reflex neuromotor spinal reaction, that when performing different destabilizing everyday activities drive the spine toward corrections instead of postural collapse.

For this reason, an essential aspect of self-correction, structured according to the SEAS approach, is that this movement has to be performed in a local `direct' manner: 'direct' means a self-correction performed by the patient focusing only on moving the spine, without any external aids (supports, specific body positions…) or movements of other body parts (limbs, head…).

According to the SEAS approach the execution of an "indirect" self-correction movement does not achieve the aim on which this concept is based, i.e. moving from the "search of the best passive alignment" to the "functional stimulation of the alignment reflex". In fact, neurophysiologically, an active self-performed movement can be integrated into motor behaviours ("alignment reflex") better then passive ones; moreover, as we will see below, an active self-correction can be "challenged" in many very different situations (exercises) simulating real everyday life ("functional stimulation") which is better than specific static positions requiring specific supports.

### 2.4 Description of the SEAS approach

During the execution of an "active" self-correction we can see:

Appreciable improvement of the aesthetic component of the trunk.
Improvement of the plumbline and the weight distribution (also of the peripheral joints).
Improvement of the postural component.



Fig. 1. Before Active Self Correction.



Fig. 2. After Active Self Correction.

The modifications are not only postural but also measurable on X-Ray. SEAS exercises focus on the three primary principles, listed below in relation to their importance.



Fig. 3. Before Active Self Correction.



Fig. 4. After Active Self Correction.

**Principle 1. The SSE exercises use an element of "distraction" for training the maintenance of self-correction**

If we define the term "scoliosis specific exercise" as a movement performed by a patient in order to counteract the pathology, in scoliosis, the specific exercises are structured to have a direct corrective effect on the curve. In the majority of corrective methods that are based on exercises, self-correction is already integrated into the movement performed by the patient. In the SEAS approach, these 2 elements (self-correction and exercise) are integrated but performed in succession. **Self-correction**, especially when performed in various directions, is the real movement against the misalignment. The "exercise" is added to the self-correction in order to train the response in the correct position in different situations of postural stress. Therefore the exercise is only an element of the complex activity performed by the patient in order to counteract the curve.

**Principle 2. The purpose of the SSE exercise is to improve the primary 'target function', i.e. the stability of the spine**

The **target functions** are those elements, which need to be improved with the treatment. The main function is the stability of the spine. The progression of an unstable scoliosis is always towards an aggravation. The scoliotic spine can hence be described as a structure whose constitutional elements are no more able to maintain the physiological alignment. The asymmetrical distribution of loads and the progressive deformation of the vertebrae increases the difficulty of the spine to preserve stability. For this reason one of the primary aims of the exercises in this approach, is the stimulation of the musculature with the greatest potential for stabilization. This aim is achieved by asking the patient to perform various actions which tend to destabilize the spine, for example, imbalance exercises, exercises with addition of loads and exercises with dynamic components; the patient must be able to maintain active self-correction and spine stability in spite of these destabilizations, training in this way the target function.

**Principle 3. The aim of the exercise is to improve the deficit found during the initial assessment (strength, muscular retractions, motor coordination …)**

The SEAS approach requires an accurate assessment of the patient prior to treatment. In addition to the normal measurements of the specific pathological assessment, (Cobb angle, Bunnell, plumbline, sagittal posture and aesthetic parameters), the patient performs a number of tests in order for the physiotherapist to evaluate the physical condition of the patient. These include testing the strength and elasticity of the muscle groups that mainly influence the posture of the pelvis and spine, and testing neuromotor development (balance, proprioception, hand-eye co-ordination etc…). The purpose is to obtain a reliable overall assessment of the patient`s abilities. The outcome of this assessment will be used to determine the choice of exercises that may improve the deficits discovered during the assessment, and to identify those exercises which are most suitable for the improvement of the stability of the spine. For example, if during the assessment, difficulties of balance are discovered, just those exercises which contain important elements of balance will be used in order to improve the stabilization of the spine.

In a word the fundamental principle on which the SEAS approach is based, is the word "control". The patient is asked to always verify, during the performance of the exercise, the correct maintenance of the selected self-correction. In order to facilitate this `control` the patient uses a series of standard questions that they ask themselves during treatment.

**The four questions**

**Question 1**: Whilst performing SEAS exercises, patients are always told to start from where the spine is in a position of basic support. This means that before performing any exercise the patient always needs to check that they are not in a position of uncontrolled relaxation. For this reason, the first question is: **Is my spine supported?** At this stage, the patient does not yet perform the correction. Regardless of the position (sitting, standing etc..) from which the patient starts performing the exercise, he is requested only to maintain the basic control of the spine, being aware that he is not relaxed. Once he/she is aware of this precondition the patient performs the self-correction chosen by the therapist on the basis of their curvature, imaging, aesthetics, and posture.

**Question 2:** To verify that they have successfully performed the self-correction, the patient asks themselves the second question: **Is my body now more symmetrical than before?** The first test is visual (**I see that my body is more symmetrical than before!**) because the patient performs the exercises in front of the mirror. But then over time (usually months) they will be more and more linked to somatosensory perceptions (**I feel** that my body is more symmetrical than before!) because the exercises will be carried out without the help of the mirror. The patient consequently will gradually, over time, perform exercises that will aim to make it increasingly more difficult to maintain the self-correction. The question that they will now ask themselves at this point will be:

**Question 3: Whilst doing the exercise am I able to maintain the correction?** Based on the reply of the patient the therapist will be able (beyond the simple observation) to understand whether the difficulty of the exercise is appropriate to the patient's ability to maintain self-correction during the execution of the exercise. In fact, if the patient replies "no" to this question the therapist will know that the patient should perform an exercise that is less difficult.

**Question 4:** The patient performs the exercise for about 10 seconds then slowly relaxes, returning from the self-correction to his/her normal position. The question that they ask themselves now will be: **Am I able to see that my body returns back to the original position it was in before performing the self-correction?** That means that the patient must be able to observe that the position of the trunk has changed from the position of correction to its usual position. This is probably the most important `control' performed by the patient to verify if the exercise has been carried out properly. The relaxation phase is the phase where movements of the body mass occur as a result of an elastic recoil and not as a consequence of active movement. If the patient answers "no" to this question the self-correction has been lost during the execution of the exercise and the exercise performed has lost its corrective specificity, becoming a mere gymnastic exercise. After this the patient is required to improve their perform of the exercise or, if this is not possible and the patient finds the exercise too difficult to maintain, then the main aim which is self-correction will need to be changed to a less demanding one.

**Application protocol of the SEAS exercises**

The typical application of the SEAS protocol consists of the teaching of an individual exercise program that is preceded by patient assessment and followed by family counselling. The SEAS approach attaches great importance to counselling because the patient's family is considered to be an important member of the therapeutic team, without

whose great support it is very difficult to obtain the compliance necessary to achieve the final result. The average session with a physiotherapist lasts approximately 1.5 hours and the sessions are performed every 3 months (3-4 times a year) by a skilled therapist. The patient is provided with a copy of the exercises on an appropriate format (DVD, USB Flash Drive) so that the patient can complete the program either at home or at a nearby gym with the help of a therapist, personal trainer or family member. The program includes 2-3 sessions a week lasting about 45 min, or a 15 min daily session, according to the preferences of the patient and the family.

**Strength of the SEAS approach**

One of the most important elements that distinguish this approach from other treatment methods is the absolute attention and consideration of the patient`s individual characteristics for the design of the treatment program. The three-dimensional self-correction is not only defined by the pattern of scoliotic deviation but also by the patient's ability to perform the exercises. Initially the direction of correction will be chosen from the simplest ones suited to the specific case and that the patient is able to follow correctly. Gradually, as the ability to execute and to control the correction becomes more refined, self-correction will become more complex up to the best execution. Even the choice of exercises follow the same path, whereby the level of difficulty should always take into account the patient's ability. The difficulty of the exercise should increase in parallel with the increase of the patient's ability. Another typical feature of the SEAS protocol is that the choice of exercise takes into consideration the eventual different stages of the treatment. For example, a patient with a prescription for bracing will make an initial treatment phase in which the objectives of the exercises will be focused on improving the mobility and the plasticity of the trunk and the spine to allow the brace to achieve the best possible corrective effect. Subsequently the exercises will change, and may try to take advantage of the forces of the brace as a useful tool to obtain a better modelling of the trunk. The ISICO clinic has a very useful tool that can be used to help develop an appropriate exercise program. This free software is available online at www.scoliosismanager.it

### 2.5 Research results

Over several years a set of essential outcomes of the SEAS approach, applied at different stages of treatment, have been published in articles that can be found on PubMed. SEAS exercises are effective in slowing down the progression of the curves and in reducing the rate of prescription of braces. The results of patient groups treated with SEAS exercises have been compared in several studies to patient groups that have performed other types of exercise (Negrini et al, 2006b). Even a worst-case analysis study has shown a statistically significant difference in treatment failure among patients treated with SEAS exercises compared to patients who have followed different exercise programs (Negrini et al, 2008a), with a particular emphasis on the possibility of reducing the rate for the need for surgery (Negrini et al, 2008b). As already mentioned patients who wear a brace have an initial program of intense mobilization to increase the corrective action of the brace. The group of patients treated with the SEAS protocol obtained better results than the control group who carried out various exercises (Negrini et al, 2006a). Other important effects of the SEAS exercises are their effectiveness in reducing the loss of correction due to the gradual weaning of the brace (Zaina et al, 2009) and the ability to control the progression of curves in adult patients (Negrini et al, 2008c).

## 3. Barcelona Scoliosis Physical Therapy School (BSPTS)

### 3.1 Introduction

The 'Barcelona Scoliosis Physical Therapy School' – BSPTS - is the physiotherapy method integrated into the rehabilitation approach used in the 'Elena Salvá Institut' in Barcelona, Spain. BSPTS is a physiotherapy method that can be defined as a therapy plan of cognitive, sensory-motor and kinaesthetic training which teaches the patient to improve her/his scoliosis posture and soft tissue imbalance, utilizing the assumption that scoliosis posture and soft tissue imbalance promote curve progression. The BSPTS recognises the importance of a multidisciplinary team approach to treating scoliosis which should include a medical doctor, physiotherapist, orthotist and psychologist.

### 3.2 History of the BSPTS method

The BSPTS was founded by Elena Salvá PT (1926-2007) circa 1968. It follows the Schroth principles, adapted from the original intensive-in-patient rehabilitation protocol used at the Katharina Schroth Clinic (Bad Sobernheim, Germany) to an equally intensive but out-patient regimen. The original Schroth principles were described by Katharina Schroth (Lehnert-Schroth, 2007). She opened her first clinic in Meissen in 1921. Katharina Schroth and her daughter Christa Lehnert-Schroth, also a physiotherapist, emigrated later to the former West Germany and opened a second clinic in Bad Sobernheim in 1961.

### 3.3 Principles of the BSPTS method

A paper describing the method from K.Schroth has recently been published by her grandson Hans Rudolf Weiss (Weiss, 2011). The primary principles can be briefly summarized in three points:

1. In idiopathic scoliosis, muscle imbalance is secondary to the deformity and its progression. Muscle imbalance can only be corrected by reaching the best possible three-dimensional 'self correction' before isometric muscle tension is used to stabilize this position.
2. Repetition of the best corrected posture, with the help of propioceptive and exteroceptive stimulation as well as visual control (mirror), is a useful mechanism to achieve a 'corrective body schema' to substitute for the 'scoliosis body schema'.
3. After the best possible 3D correction is achieved, specific breathing mechanics can be introduced to increase the corrective effect, whilst at the same time re-shaping the deformed trunk (this system was initially called 'orthopaedic breathing').

Secondary principles describe how to correct the postural component of the scoliosis in 3D according to a previously diagnosed curve pattern. Primary and secondary Schroth principles have been well described in numerous papers and books (Weiss, 2011).

The BSPTS, after closely following all of the newly acquired information on the three-dimensional nature of idiopathic scoliosis, has slightly but significantly modified the secondary principles. However, the primary principles are unchanged. In this section, the secondary principles about specific 3D correction according to the BSPTS are described.

For any physiotherapist interested in scoliosis treatment it is essential to understand the three-dimensional nature of idiopathic scoliosis. We have recently defined idiopathic scoliosis as a

multi-factorial three-dimensional deformity of the spine and the trunk, which appears and can progress during any of the rapid periods of growth in apparently healthy children. The aetiology is unknown but some models explain how idiopathic scoliosis develops and progresses (Burwell, 2009). The basic scoliosis deformity is classically described as a lateral deviation of the spine associated with axial rotation, however, it can be better defined as a combination of torsional regions separated by junctional zones, each region formed by a variable number of vertebrae in extension (or lordosis) deviated and rotated to the same side (Dubousset 1992). The scoliotic spine suffers a mechanical torsion, divided into inter-vertebral torsion and intra-vertebral torsion, the first being predominant close to the junctions and the second at the apical region. On the other hand, torsion produces a translation of the apical region. In a typical right thoracic scoliosis, translation follows an arch in a clockwise direction (Perdriolle & Vidal 1985). The vertebrae at the apical region present a typical morphological deformity: 1) Lateral wedging, from the lateral translation; 2) Dorsal wedging, from the ventral translation. Dorsal wedging is related to a relative anterior spinal overgrowth (RASO), due to eccentric growth caused secondarily by torsion.

From the physiotherapy perspective it is necessary to differentiate the structural component and the non-structural component. The structural component is related to bone deformity and does not occur in a specific moment but over time as a result of asymmetrical loading, according to the 'Vicious Cycle model' (Stokes et al, 2006). The non-structural component involves a purely postural component which can be reduced by self-correction in a moment, as well as a soft tissue component. The asymmetry of the soft tissues is partially fixed, but changable by a) exercises to increase flexibility and b) manual therapy intervention in a relatively short time of intensive physiotherapy. There is a relatively accepted dogma in scoliosis physiotherapy stating that idiopathic scoliosis is a flat back deformity or lordotic deformity and consequently there is a need to use exercises that increase kyohosis in the thoracic spine. Some schools recommend re-kyphosant exercises, which were generally performed by promoting trunk flexion in a single plane, the saggital plane. However, the geometry of the spine is not always hypokyphotic/hypolordotic, but highly variable (Legaye & Orban 1995), and the structural flat back is closely related to the torsional element.

### 3.4 Description of the BSPTS method

The BSPTS recommends looking at every patient to recognize the abnormal geometry of the spine and then, by using a general principle of correction called 'detorsion', try to attain the best correction until halted by the structural component. After attaining the best correction of the non-structural component, some degree of 3D deformity related to the structural component will still be noted. This may be minor or major depending on the severity of the treated scoliosis. At this point, the therapist can ask the patient to gently intensify the corrective forces. However, the patient must always use the combination of forces in the three planes rather than correcting in an isolated plane, as would be the case when using bending exercises in any single plane (frontal or sagittal), or by derotating one section of the body against an adjacent one. From the educational point of view, obviously the corrective forces and movements need to be decomposed plane by plane. The physiotherapist will train the patient to become familiar with all of the corrective forces and movements using 'plane by plane' singular, gentle corrections, whilst looking, from the very beginning, for a synchronic combination of all corrective forces and movements. The principles of three-dimensional correction according to the BSPTS can be briefly described as follow:

1. Self-elongation from a stable corrected pelvis. Self-elongation has a de-torsional correction effect by itself. Lateral deviation and rotation will decrease whilst the sagittal geometry of the spine will become flattened making the existing structural flat back more obvious. No matter what geometry is observed initially, after correcting lateral deviation and rotation by self-elongation, the geometry of the scoliotic spine will be flatter since the scoliotic spine is structurally flat, generally speaking. Afterwards the physiotherapist will teach the patient to fight against the structural flattening of the spine in order to re-create a more physiological kypho-lordotic profile. Self-elongation is an essential principle used to apply tension to all of the elastic structures that have to be stretched by de-collapsing all the concavities in the frontal and sagittal planes.
2. The combination of self-elongation with a corrective tension in any part of the ventral or dorsal trunk, consecutively from caudal to cranial is a correction principle called 'straightening'. The second correction principle is called 'asymmetrical sagittal straightening' which means that one hemi-body will be corrected in opposition with the other. Throughout 'asymmetrical sagittal straightening' the patient creates a 'pair of forces' for derotation at each desired plane or level. Thus, an additional derotation effect can be achieved by combining the first two corrective principles; 'self-elongation' and 'asymmetrical sagittal straightening'.
3. The third corrective principle is related to the frontal plane. Improvement of the correction in the frontal plane is then demanded from gentle movements and/or tensions performed in the frontal plane following the classical schema of blocks from Lehnert-Schroth. The schema of blocks differentiates two basic functional types called 'three' and 'four' curve patterns (Lehnert-Schroth 2007). The Schroth classification has been further re-defined to improve its reliability, by adding new radiological criteria (Rigo et al 2010). The BSPTS uses this classification to define specific corrections according to the observed functional curve pattern.
4. Breathing mechanics are then used to increase the de-torsional effect by creating an internal pair of forces for derotation, called Schroth rotational breathing. According to the BSPTS, asking the patient to increase, during inspiration, the sagittal diameter of the rib cage is a putative mechanism to fight against the thoracic structural flat back under the assumption that thoracic structural flat back reduces such a diameter. Deep abdominal muscle activation during correction will be used as a mechanism to prevent lumbar kyphosis, by maintaining a constant activation of the 'thoraco-lumbar fascia'. This is probably the part of the technique that requires more assistance from the physiotherapist.
5. Stabilization is achieved by muscle activation maintaining the best possible correction in expiration. Muscles in the concavities will be activated throughout eccentric isometric tension whilst the convex muscles will activate in concentrically (Figure 1).

The full description of the specific correction for each functional spine pattern as well as the description of any of the recommended exercises is beyond the objectives of this short brief. The principles of the BSPTS have previously been described in other publications (Rigo et al, 2008). Nevertheless, no matter how in-depth such a description can be made in a written publication, this will only be a supportive tool for therapists who have already been instructed during an extensive training course by the BSPTS. This is clearly a limitation and a weak point of this methodology. There is a relatively long learning curve for physiotherapists even after the successful completion of a theoretical-practical course, before clinical results can be achieved. Thus, physiotherapy for scoliosis should be considered a sub-specialty for devoted physiotherapists.



Fig. 5. A mature girl with a severe right thoracic/left thoracolumbar scoliosis (4 curves) performing an exercise in upright position with two poles and a resistant element on the left hip. She does maximum muscle activation by pushing down with the two poles, only after reaching the best 3D postural correction.

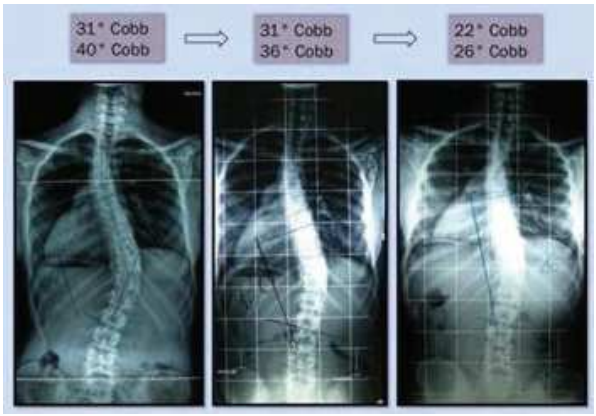



Fig. 6. The radiological evolution of a different girl with a right low-long thoracic curve combined with upper structural thoracic curve. The girl was almost mature when she started her exercise program (left X-ray). The Cobb angle was significantly reduced one year later (right), with an intermediate improvement (middle). Although all the Xrays were taken in an independent place, and the girl was instructed not to correct, some signs in the last X-ray – left ribs and shoulder – suggest that she was actively correcting herself. Thus this improvement should be interpreted with caution.

### 3.5 Research results

Results of the classical Schroth method have been widely published and summarized in several papers. Improvement of breathing function, pain, back asymmetry, posture, muscular imbalance and the Cobb angle in the short-term have been shown (Weiss, 2011). Specificity of the exercises has been shown by the BSPTS (Jelacic et al, 2011). However, no

research-based paper has shown that specific exercises following Schroth principles, or any other physiotherapy principle, can prevent curve progression in rapidly progressive scoliosis during the acceleration phase of the pubertal spurt, before the peak of growth and maintained through until reaching maturation. Thus, nobody can claim to halt curve progression in those cases, using the name of Schroth or the name of BSPTS or of any Schroth variant.

## 4. The DoboMed physical therapy approach (Poland)

### 4.1 Introduction

The Dobosiewicz's Method (DoboMed) is a conservative management approach for idiopathic scoliosis that addresses both the trunk deformity as well as respiratory function impairment. The DoboMed approach has incorporated both Klapp`s position for kyphotization of the thoracic spine as well as Lehnert-Schroth's approach for active asymmetrical breathing into its method.

### 4.2 History of the Dobomed method

The method was developed in 1979 by Prof. Dobosiewicz and has been used routinely in Poland since 1982. Initially it was tentatively trialed on an outpatient group and has since been continually improved and modified. It was later used (regularly since 2000) in the Department of Rehabilitation of the Medical University of Katowice, Poland, as an intensive in-patient rehabilitation approach for patients with scoliosis. From the start, this approach was used either as a sole physical therapy method or combined with bracing (Cheneau brace). Prof. Krystyna Dobosiewicz died in two thousand and seven. She was both a physiotherapist and a physician. Prof. Dobosiewicz was also very familiar with the Klapp's and Lehnert-Schroth's methods. It was from these beginnings that she started to create her own approach to the treatment of scoliosis.

### 4.3 Principles of the DoboMed method

The basic aim of this method is to prevent progression and/or decrease the curvature of scoliosis. The second aim is to improve respiratory function. Small, moderate and large curves (idiopathic scoliosis) can all be treated with DoboMed, however the effectiveness of the therapy depends on the curve flexibility and the patient's compliance. Active cooperation is the basic requirement for using DoboMed, therefore DoboMed is not recommended for small children.

### 4.4 Description of the Dobomed method

This Dobomed approach is a biodynamic method of 3-dimensional auto-correction of idiopathic scoliosis based on the pathomechanics of idiopathic scoliosis. The basic technique of active three-dimensional correction involves mobilization of the primary curve towards curve correction, with special emphasis on `kyphotization' of the thoracic spine and/or `lordotization' of the lumbar spine. This mobilization is performed in closed kinetic chains and developed upon a symmetrically positioned pelvis and shoulder girdle. The pelvis and

shoulders are positioned first and kept stable for the duration of the exercise and during the inspiration and expiration phases (Fig.7). For example, in primary thoracic curves the desired movement of the thoracic vertebrae is towards kyphosis, which is a backward displacement and axial derotation towards neutral. This is obtained partly by active movement of the thorax on a stable pelvis and shoulder girdle and partly by active 'asymmetrical' breathing. The frontal plane correction occurs automatically as the sagittal and axial planes are being corrected. Lateral flexion of the spine is not required in thoracic curves. Symmetrical positioning of the pelvis and the shoulder girdle is something that is unique to the DoboMed method.

The method consists of three parts. The first part to the approach is the main corrective technique and comprises of an active three-dimensional self-correction of the spine and rib-cage. The 3-D self-correction in forward bending is an original component to the DoboMed method. This basic technique is one of the key components of the DoboMed approach. The preparatory and final phases can be altered. Both basic and short exercises as well as combined exercises can be used in this phase. In the preparatory phase, non-specific physiotherapy may be used as a warm-up prior to the spine-specific exercises for each session. This position is thought to facilitate active correction between two symmetrical and stable zones, and helps to consolidate the correct postural habit beyond the therapeutic session. The exercises are designed in closed kinematic chains in order to enhance their effectiveness. This is obtained by the fixation of the pelvis and the shoulder girdle with the upper and lower limbs. At the beginning of the session, after warming up, exercises in low positions are performed (Fig.7). These positions free the back muscles from the influence of gravity. Probably because of that the largest correction of scoliosis is observed in these low positions. Maximum active kyphotization of the thoracic spine and lordotization of the lumbar spine with simultaneous 3D correction of the spinal deformation is performed in between performing the exercises in low positions (Fig 10, 11).

Next, active 3-dimensional auto-correction exercises are performed in upright positions with the spine positioned vertically with gravity fully affecting the back muscles. All exercise positions require strict symmetrical arrangement by fixation of the pelvis and the shoulder girdle with the upper and lower limbs during all phases of the respiratory cycle (Fig.7). The course of action focuses on the vicinity of the apical vertebra. On the concave side of the curvature a strong local pressure is applied (Fig 12), and on the convex side a subtle facilitation is applied (Fig 12). The correction and facilitation are 'phase-locked' with the particular phases of the respiratory cycle. A strong local pressure is applied on the concave side during inspiration, and a subtle facilitation is applied on the convex side during expiration. During expiration the achieved correction or hypercorrection is stabilized by an isometric contraction (Fig. 10-12).It is also important that when patients try and fix each position, the patient should have already corrected their pelvis position in 3 planes (frontal, sagittal and horizontal) (Fig.7).

As DoboMed may be considered as a difficult method, frequent checking of the patient by the physiotherapist is required. In our practice the best results were achieved by daily systematic exercises actively supervised by the parents, who were previously trained in the approach during the initial in-patient rehabilitation period.

The following are the principal distinctive features of the DoboMed approach:

1. Symmetrical positions for exercising;
2. Asymmetrical active movements to accomplish 3D scoliosis correction;
3. Thoracic spine mobilization to increase thoracic flexion;
4. Transverse plane derotation;
5. Specific treatment emphasis is focused on the area of the curve apex;
6. Concave rib mobilization to expand and derotate the ribs;
7. External facilitation;
8. Respiration-directed movements of the thorax and spine to improve respiratory function;
9. 3D displacement of vertebrae to obtain 3D scoliosis correction.

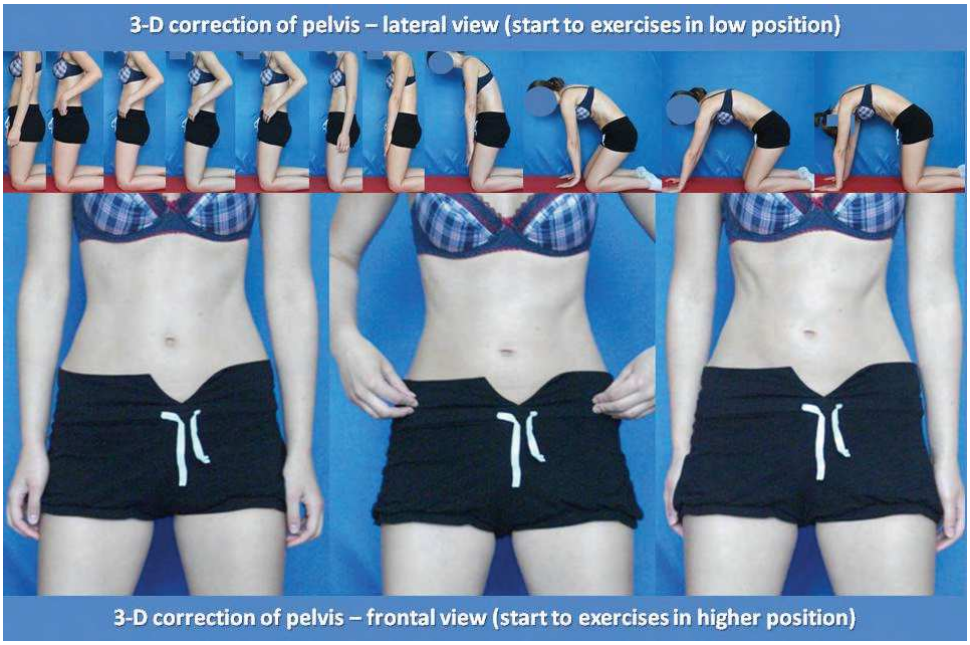



Fig. 7. 3D correction of the pelvis in the frontal and lateral view.

### 4.5 Research results

Results of therapy based on the DoboMed approach have been found to have an inhibitory effect on curve progression in idiopathic scoliosis. The radiological results were assessed on the basis of retrospective and prospective studies. They demonstrated that in most cases stabilization of curves in children with progressive idiopathic scoliosis treated occurred when using DoboMed (fig 8-9). The best effects of the treatment were observed in single scoliosis curves. The improvement of respiratory function, assessed by spirometry values (vital capacity, forced expiratory volume in one second), were also noted. The general exercise efficiency evaluated using ergospirometry was observed to increase significantly during physiotherapy with the DoboMed approach.

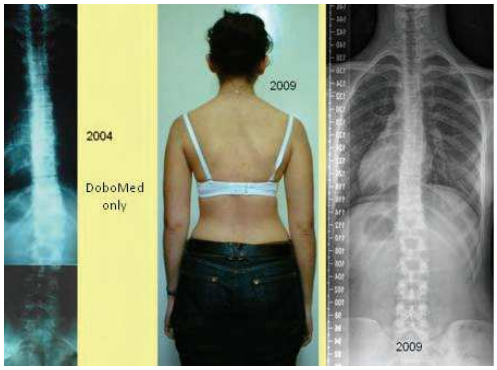



Fig. 8. Dobomed Exercise Case 1.

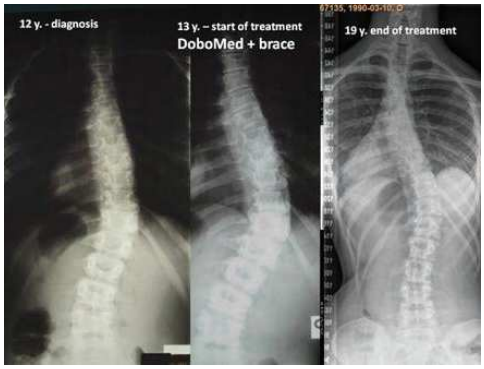



Fig. 9. Dobomed Exercise Case 2.

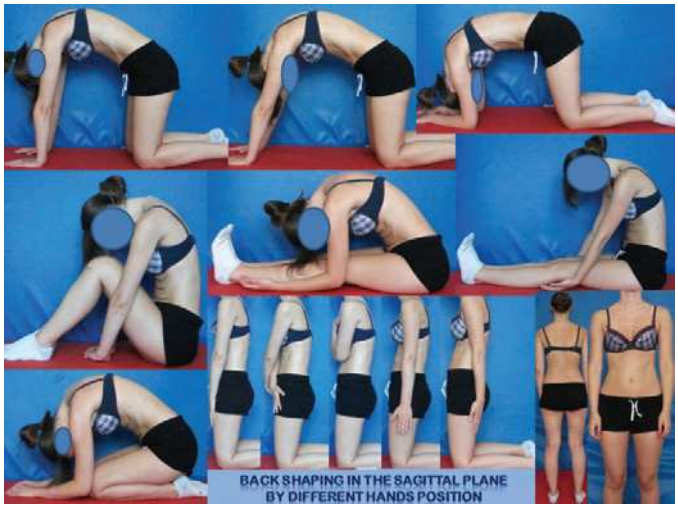



Fig. 10. "Shaping" the back by the use of different hand positions in the sagittal plane.

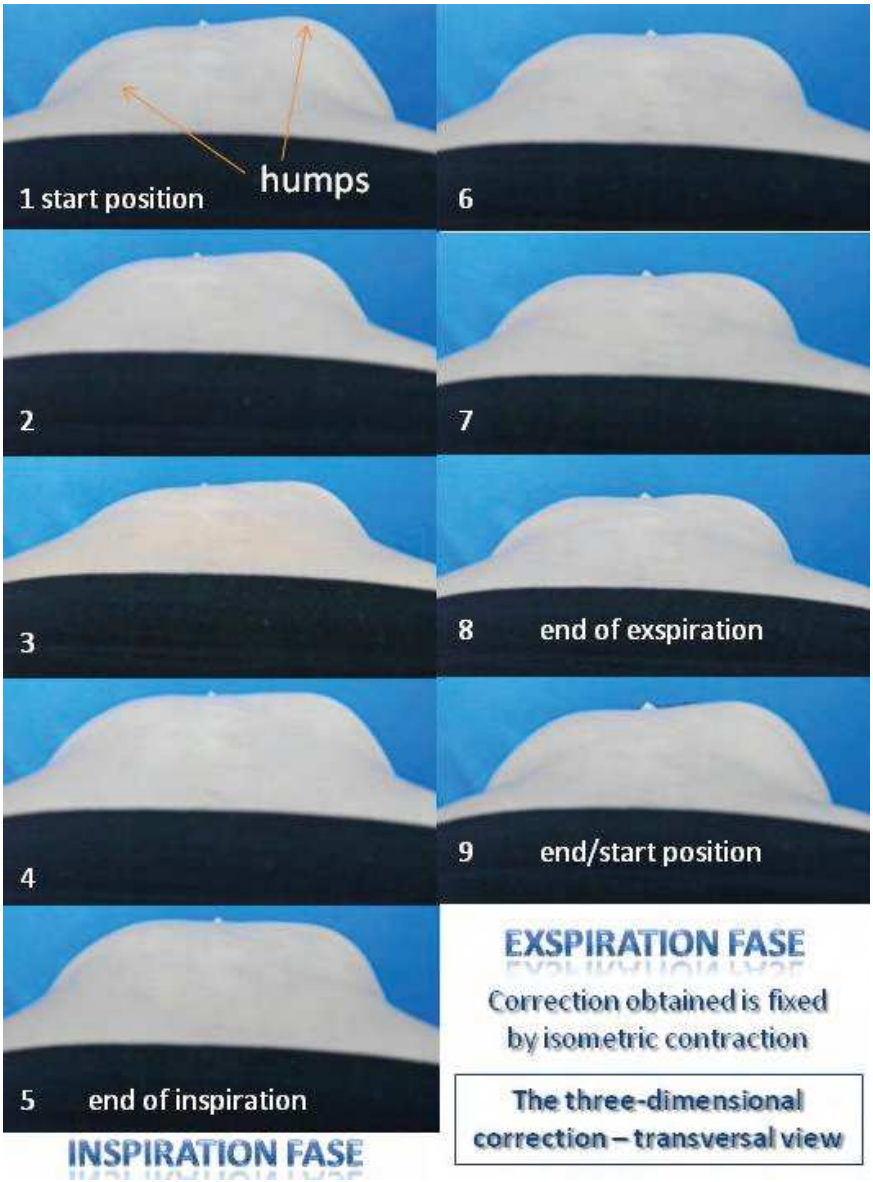



Fig. 11. The DoboMed may be considered to be a relatively difficult method; therefore, frequent checking of the patient to ensure they are practicing the exercise correctly is mandatory. The best effectiveness was achieved by daily exercises that were actively supervised by the parents, who had previously been educated in the DoboMed approach during the initial inpatient rehabilitation period.

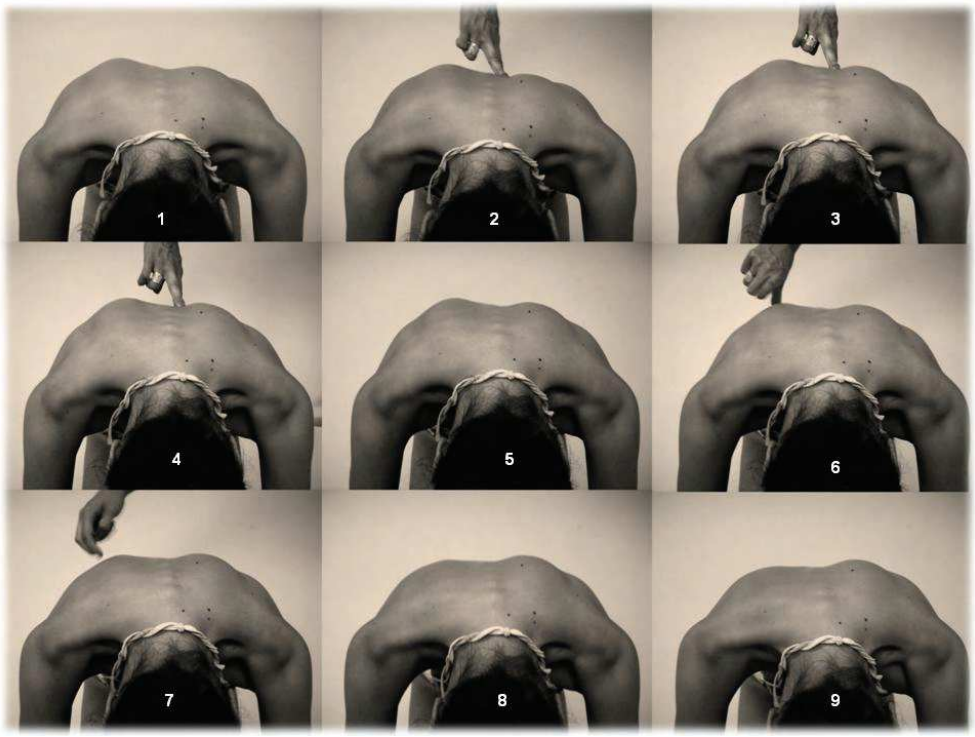



Fig. 12. The DoboMed approach to trunk derotation.

## 5. The Lyon approach (France)

### 5.1 Introduction

Physiotherapy is an integral part of the Lyon management for scoliosis together with the production of plaster cast before the Lyon brace.

### 5.2 History of the Lyon method

The Lyon method was developed 60 years ago by Pierre Stagnara together with the Lyon brace (Stagnara 1978 & Dubousset 1996). It has been tested by many physiotherapists including Georges Mollon (1986) and Paul Ducongé (2002). The Lyon method is not intended to provide the physiotherapist with an original technique and specific exercises, but rather it is intended to be a way of approaching and understanding scoliosis.

### 5.3 Principles of the Lyon method

**Stage I: Lyon approach to Assessment**

The Lyon approach considers that there are three elements that are important to guide therapy:

**1. The patient's age**

When the patient is less than 10 years old, it is usually an Early Onset Scoliosis (EOS). We know that there is a maturation delay in balance and posture. Physical therapy will be based on exercises favouring coordination and balance in a fun way, such as ball games. During puberty, growth occurs at the bone level and is inhibited by the paravertebral and myofascial structures. The readjustment of myofascial tension occurs globally by symmetrical range of motion exercises. The hypotonia of the musculature is also a characteristic of this period. We must insist on the maintenance of muscle tone over time by endurance exercises in aerobic metabolism.

**2. Postural Imbalance**

Multiple postural defects may be associated with scoliosis. The problem is that it is very difficult to determine what is a defect or compensation. If in doubt, examine the child walking; if the head is projected at the support polygon of the feet, there is no need to act on the segmental pelvic or scapular girdle correction. Similarly, if one leg is shorter on the side of the rib hump, it is likely that compensation by heel lift will increase the rib hump and in this case we will not use the shoe lift.

**3. Cobb angle**

- Below 25 °, it is impossible to predict the evolution of scoliosis and it behaves like a chaotic system described by de Mauroy (2008). It is essential to explain to parents that physical therapy cannot prevent the scoliotic earthquake, but scoliosis-specific exercises can produce an earthquake-resistant construction that will limit the damage.
- Above 25 °, the linear mechanism with a vicious circle of evolution has been described by Stokes: the asymmetric pressure on the vertebral body and disc modifies the growth of the vertebral body with accentuation of the deformity. The distance of the apical vertebral body from the line of gravity further increases the asymmetry of pressure. This pressure needs to be reduced by exercising, sitting position and sport.

**Stage II: Awareness of trunk deformity**

As the child has never seen his back, we must therefore make them aware of the corrective possibilities while also avoiding a dramatizing of the situation. Scoliosis is not a disease, but is an adaptation of the spine. This correction will be made by the orthopaedic mirror or using a camcorder and a screen. The feedback from the squared mirror is very useful during exercises of auto-elongation or walking with a small sand bag on the head. We must stimulate the perception of horizontality and verticality.

At this stage, we must also check and change the sitting position. It's the writing position that will focus our efforts. The feet are placed behind the chair; the buttocks in front of the seat, the anterior thorax just touch the front edge of the table and both forearms lie on the horizontal work plan. This position reduces stress on the disks and prevents excessive flexion of the spine. (fig 13)

**Stage III: What to do: Example exercises**

Gymnastic exercises **avoiding spinal extension** are the basis of the Lyon method of physiotherapy. They must be simple in order to be repeated every day at home. The

exercises are symmetrical, mainly made in the supine position; indeed, the radiological scoliotic angle is higher in the standing position than in the lying down position. The standing exercise called the "grand porter" consists of walking on tiptoes with a sandbag on the head. The child tries to stretch the spine along the vertebral axis while controlling balance by looking at the feedback mirror (fig 14). During therapy the exercises will be gradually adapted by changing various parameters such as pace, intensity, duration.

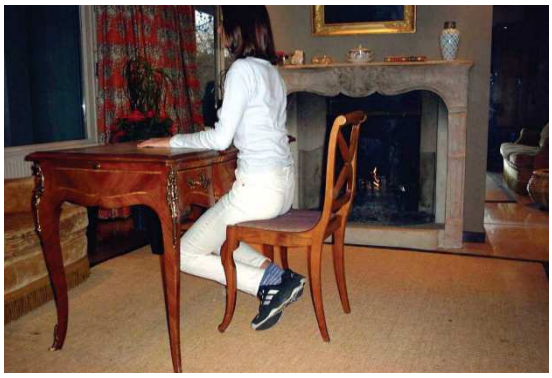


Fig. 13. Usual sitting position for writing and using the computer.



Fig. 14. “Grand porter”.

**Stage IV: What not to do and why?**

Much more important and rarely described are exercises and postures to avoid in scoliosis.

1. The functional plane is the sagittal spine. In this plane the extreme magnitudes should be avoided. By extension the flat back is accentuated, and by flexion, the disc pressure is increased. Furthermore, especially beyond a 25 ° degree rotation, the apical vertebra tends to further increase the existing rotation due to the paraspinal muscles lever arm and the position of the Instantaneous Centre of Rotation. Spinal muscles of the concave and convex side become agonist exerting an auto deforming action. (fig 15)
2. The deep breathing favours the rotation of the apical vertebra, therefore, avoid shortness of breath.

3. The modelling of the rib hump in the sagittal plane favours a flat back. For a true derotation in the prone position, place a cushion under the opposite anterior chondrocostal prominence and press the inner slope of the rib hump. (fig 16)
4. Strengthening the superficial body building type of muscles is useless, we must work on endurance on the deep paraspinal muscles.

**Stage V: Sport or only physiotherapy**

Many physiotherapists ask their patients to stop practicing sport. The Lyon method allows the pursuit of sport in so far as the contraindications of step 4 are met. So it's more how to practice the sport rather than the sport itself that matters. Our best results were obtained in the Lyon brace in the group of children who performed more than 5 hours of sport a week. The best sports for scoliosis are combat sports; the worst, rock climbing, as it promotes too much extension of the spine. We must adapt the sport to the age of the child. Before puberty, sports of balance and coordination are preferred. Swimming is excellent during the pubertal growth phase. After the age of 15 years the axial impact sports promotes calcium fixation to the bone and improve bone mass.

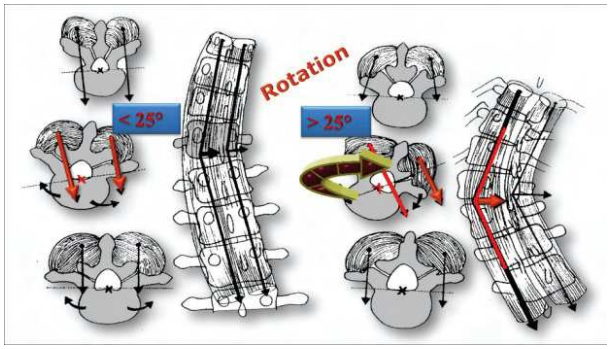



Fig. 15. Increasing rotation during trunk flexion for a scoliosis of more than 25°.



Fig. 16. Biomechanical basis of apical vertebral derotation.

### 5.4 Description of the Lyon method

When scoliosis is evolving, i.e. moves from a chaotic phase to a linear phase, the Lyon method combines physiotherapy and the Lyon brace. The Lyon brace is always preceded by a plaster cast that allows a real lengthening of the concavity beyond simple mobilization (de Mauroy 2011). Physiotherapy is greatly facilitated by the plaster cast. This is a true three-dimensional correction. During the time in a plaster cast (one to four months),

physiotherapy is intensified with at least two sessions a week supervised by the physiotherapist. The work plan includes:

- Breathing control with use of expiratory reserve volume because the pelvis is fully stabilized.
- 3D mobilization of the spine (fig 17)
- Mobilization of the ilio-lumbar angle (lumbar scoliosis)
- Therapeutic patient education (food control to avoid cast syndrome, skin care ...)
- Sitting position check



Fig. 17. Auto-3D correction of scoliosis with Lyon plaster cast.

The advantage of the plaster cast for scoliosis under 30 degrees is that the brace is worn only during the night. Physical therapy will continue at least once a week. When the scoliosis curve exceeds 30°, the brace must be worn during part of the day. The physiotherapist will perform physical therapy with or without brace. (fig 18)

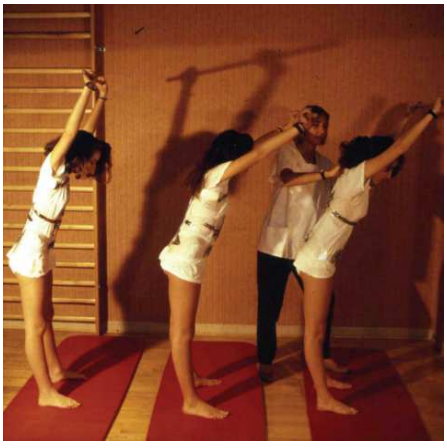


Fig. 18. Group physiotherapy in Lyon brace.

### 5.5 Research results

Psychologically physiotherapy in a group is better because the child feels less alone in their treatment. Unfortunately, the Lyon physiotherapy method for scoliosis does not follow a universal standardised protocol, but has to adapt to each child and develop during growth. It is therefore very difficult to quantify results in terms of angular correction for scoliosis, considered to be but it is essential when the Lyon brace is prescribed.

## 6. FITS (Poland)

### 6.1 Introduction

Functional Individual Therapy of Scoliosis (FITS) treatment is based upon the inclusion of many elements selected from a variety of other therapeutic approaches that have been adapted to form a different treatment concept.

### 6.2 History of the FITS method

In 2003 Bialek and M'hango decided to create their own program of therapy to improve postural problems and scoliosis. Many new ideas were developed during rehabilitation camps since the camps hosted many scientific studies. This was done in cooperation with Dr Wieslaw Chwala of the Department of Biokinetics at AWF Cracow, who was carrying out EMG examination and 3D gait analysis using the Vicon system. Moreover, Spirometry and Moire projection examinations were also conducted. As a result of these studies a new program for diagnosing and treating postural problems and scoliosis was created, which the authors started implementing in their practice by the end of 2003. Having observed positive effects of their work with scoliosis M. Bialek and A. M'hango decided to draw up a Physical Therapy course program of scoliosis diagnosis and therapy for physiotherapists and physicians. This resulted in the 'Functional Individual Therapy of Scoliosis' (FITS) concept being created, and in 2004 the first course based on the FITS concept was held. It received PTF (Polish Society of Physiotherapy) accreditation in 2005 (www.fits.pl). In 2006 cooperation with the orthopedist Dr Tomasz Kotwicki from Poznan began, which triggered further evolution of the FITS concept. On average three new groups, totaling about 70 trainees, attend our course and over a hundred children go to FITS rehabilitation camps every year. To date almost 450 trainees have completed our course and 700 children have been to FITS rehabilitation camps.

### 6.3 Principles of the FITS method

FITS is a method of diagnosis and therapy for idiopathic scoliosis. It may be used as a separate system for scoliosis correction, a supportive therapy to bracing, preparation of children for surgery, or for the correction of the shoulder and pelvic girdles after surgical intervention. Different techniques have been used from a variety of therapeutic methods in search of the most effective means of clinical and structural scoliosis correction. These techniques had proven themselves to be significantly effective in a short period of time. They were then modified and systematized, which was the starting point for the FITS concept.

FITS is a complex, asymmetrical and individual therapy, which can be used in a child of any age regardless of the Cobb angle. It requires the child to take an active part in the therapy

process, which is guided by an experienced and specialist therapist. FITS therapy is conducted in an out-patient clinic or as an in-patient by means of a 1 or 2 week course of treatment. It is recommended that the therapy is delivered by a physiotherapist together with an orthopedist and a psychologist.

The main objectives of the concept can be listed as follows:

To make a child aware of the existing deformation of their spine and trunk, and to indicate the direction of scoliosis correction.
To release myofascial structures which limit the three-plane corrective movement.
To increase thoracic kyphosis through myofascial release and articular mobilisation.
To teach correct foot loading; which will improve the position of the pelvis and realign the scoliosis.
To improve the lumbo-pelvis stabilization.
To release the myofascial tension between the apex of the scoliosis and the iliac crest (which limits spine shift towards scoliosis correction).
To teach the correct shift of the spine in the frontal plane in order to correct the primary curve whilst stabilizing, or maintaining in correction, the secondary curve.
To facilitate the right three-plane corrective breathing in functional positions (breathing with concavities).
To indicate the right patterns of scoliosis correction and any secondary trunk deformation related to curvature (asymmetry of head position, asymmetry of the lines of shoulders, shoulder blades, waist triangles and pelvis).
To teach balance exercises and improvement of neuro-muscular coordination with scoliosis correction.
To teach correct pelvis weight bearing in a sedentary position and to correct other spine segments in gait and activities of daily living (Bialek M.,M'hango A., 2010).

### 6.4 Description of the FITS method

There are three stages of the FITS concept:

**Stage 1: Examination of the patient**

Examination of the patient using a classical clinical assessment and a FITS specific assessment. Classical assessment includes: history, course of treatment, X-ray analysis and examination of a patient in three different planes.

FITS specific clinical assessment involves examination of the distance from the plumb line to the following: anal cleft, the apex of the primary and secondary curve, the edge of the scapula as well as checking the position of both scapulas. What has also been included is the observation of the type and location of compensation, position of the pelvis and measurement of ATR using the Bunnell's scoliometer. In addition, the assessment of lower extremity alignment in a standing position and gait is also conducted. Furthermore, the length of muscles in the lower limbs, pelvic girdle, shoulder girdle and trunk are checked for any indications of asymmetry. Finally the assessment of the possibility for scoliosis correction in standing and sitting positions is performed (Bialek M.,M'hango A., 2010).

**Stage 2: Preparation for 3D correction: detection and elimination of the myofascial restrictions which limit a three-plane corrective movement by using different techniques of myofascial relaxation**

The authors of this concept emphasize the importance of a child's awareness of the type of scoliosis and the trunk deformation caused by scoliosis. We analyzed X-ray pictures of the child, the three-dimensional position of scoliosis on a model of the spine, and we show the direction of correction. In our opinion, making a child a partner and not the subject of therapy significantly increases motivation to exercise and improves the effects of therapy at the same time (Bialek M.,M'hango A;2008, 2010). Many years of work experience with scoliosis has shown significant myofascial limitations in the area of many muscle chains (Myers, 2009). The limitations are particularly visible whilst attempting to perform passive corrective movement in functional positions. In order to specify the direction of therapy and effectiveness of therapeutic procedures we use an examination of corrective movement as a test during each session. Corrective movement at the beginning of therapy can be done only in one plane – shift, rotation, or flexion/extension. In further stages of therapy three-dimensional corrective movements also need to be included (Bialek M.,M'hango A., 2010). When a patient has been fully examined we move on to relaxation of structures restricting correction by using techniques such as; contract-relax technique, myofascial release (Chaitow, 1996, 2002), trigger point therapy (Travell & Simons, 1992), joint mobilization (Bialek, 1997; Colot & Verheyen, 2002; Kaltenborn, 1998; Lewit, 2001) and neuromobilisation. These techniques are often used in the area of myofascial bands according to Myers; SBL (superficial back line), DFL (deep front line), LL (lateral muscle line), SL (spiral muscle line), SFL (superficial front line) (Myers, 2009).

**Stage 3: Three-dimensional correction: building and stabilisation of new corrective posture patterns in functional positions**

We start building and stabilising new corrective patterns of posture in functional positions by teaching correct foot loading with the use of sensory motor balance training according to Greenman (Greenman, 2003). By observing children with scoliosis we notice unsettled stabilization of the lower part of trunk, especially during everyday activities (Lee, 2001; Richardson et al., 2004). Stabilization exercises of the lower part of the trunk have to be done before starting the teaching of corrective patterns of the upper part of trunk and shoulder girdle.

Facilitation of the right three-plane corrective breathing should be done after diaphragm release and restoration of the best possible joint mobility in the thoracic spine and thorax. The aim of our therapy is the facilitation of breathing movements towards the concavities which can be achieved by a 'derotative' breathing exercise (Dobosiewicz et al., 2005). The effectiveness of these exercises can be improved by adding elongation of the scoliosis concavity by using upper and lower limb patterns. In every case, attention should be paid to the correct position in the sagittal plane. Teaching patterns that correct scoliosis, and other trunk deformations that are associated with curvatures, is done in open and closed kinematic chains with the use of TheraBand (Ellenbecker & Davies, 2001). Each 'limb pattern' consists of a correction in the sagittal, frontal and transverse planes. The choice of each element of every corrective pattern depends on Cobb angle, size and direction of trunk rotation, position of the spine in the sagittal plane, and location of functional compensation

(Bialek, 2001). In scoliosis treatment it is most desirable to correct the primary structural curve in three planes. However, in many cases this might be too difficult, due to a considerable degree of curvature or insufficient 'correctivity' of curvature. In these cases we believe that creating and developing functional compensatory curves above and below the primary curve is beneficial

By functional compensation we mean creating a rotation which is directed in the opposite direction to the rotation found in the primary scoliosis, not creating a structural curvature. The compensation relates only to soft tissues and not the structures seen in X-ray photos. This counter-rotation should not exceed 3-4 degrees ATR.




Fig. 19. Before and after therapy pictures of Marta, our 10-year-old patient

Once the functional compensation has been achieved, our continued work focuses on decreasing the primary curvature by continuation of only elongation and shift. In a scoliosis with a small Cobb angle, which is more likely to be corrected, we can achieve a balanced posture and a good clinical effect by creating a functional compensation (Bialek et al., 2007). It is very important to be able to establish at which level the compensation is most desirable and where the compensation should be increased, decreased, or where there should be none. The type and size of functional compensation can be evaluated by measuring trunk rotation using Bunnell's scoliometer (Bunnell, 1984).



Fig. 20. Exercise in pattern correction.

**Strengths of the FITS method**

Individual approach to children.
Awakening patients' awareness, making them partners not subjects.
Examination of spinal flexibility and of active and passive correctional movement capability.
Removal of any myofascial limitations which restrict correct movement before educating the child of the correct patterns and proper postural reeducation for their specific curvature.
A comprehensive approach to patients and 3D scoliosis correction.
Teaching daily functional activities in scoliosis autocorrection.
Selection of movement patterns according to the change of the patient's clinical state

**Limitations of the FITS method**

The method is complex and requires utmost accuracy.
Strict cooperation of therapists and parents in the therapeutic process of a child is required.
Long duration of the therapy, until completion of bone maturity.

### 6.5 Research results

**Study design.** Retrospective study according to SOSORT and SRS criteria.

**Materials**

Three-hundred and seventy four patients received conservative treatment for idiopathic scoliosis according to the FITS concept between 2005 and 2010. One-hundred and fifteen of them were included in this study because they were conducted according to the SRS criteria of the initial Cobb angle and Risser sign. Patients were analyzed separately in two groups:

**Group A –** 68 girls and 10 boys, who received the FITS therapy without bracing. The group comprised children older than 10, with a Cobb angle between $10^{o}$ and $25^{o}$ and a Risser sign between 0 and 2. The children were classified into two subgroups:

Subgroup A1 – single thoracic (Th) or thoracolumbar (Th/L) or lumbar curve (L) (52 children).
Subgroup A2 – double scoliosis - thoracic (Th) and thoracolumbar (Th/L) or lumbar (L) curves (26 children).

**Group B** – 34 girls and 3 boys who received the FITS therapy combined with bracing. The group was comprised of children older than 10, with a Cobb angle between $26^{o}$ and $40^{o}$ and a Risser sign between 0 and 2. The children were classified into two subgroups:

Subgroup B1 – single thoracic (Th) or thoracolumbar (Th/L), (5 children).
Subgroup B2– double scoliosis - thoracic (Th) and thoracolumbar (Th/L) or lumbar (L) curves (32 children).

**Method**

The Cobb angle and Risser sign were analyzed at the initial stage and at the 2.8 year follow-up. The percentage of patients who improved (defined as a decrease of Cobb angle of more than $5^{o}$), were stable ($\pm 5^{o}$), or progressed (increase of Cobb angle of more than $5^{o}$) was calculated. The clinical assessment comprised: the initial and follow-up Angle of Trunk Rotation (ATR), the plumb line imbalance, the scapulas level, and the distance from the apex of the primary curve to the plumb line.

| Subgroup | Improvement | Stabilization | Progression |
|---|---|---|---|
| A1 | 50.0% | 46,2% | 3,8% |
| A2 | 50.0% | 30.8% | 19.2% |
| B1 | 20.0% | 80.0% | 0.0% |
| B2 | 28.1% | 46.9% | 25.0% |

Table 1. Percentage values of scoliosis improvement, stabilization and progression

| Subgroup | N pts in each group | N pts with pro-gression | % pro-gression in either curve | N pts with pro-gression in Th curve | % pro-gression in Th curve | N pts with pro-gression in Th/L curve | % pro-gression in TH/L curve | N pts with pro-gression on both curves | % pro-gression in both curves |
|---|---|---|---|---|---|---|---|---|---|
| A1 | 52 | 2 | 3,8% | 0 | 0% | 2 | 3,8% | - | - |
| A2 | 26 | 5 | 19,2% | 4 | 15,4% | 4 | 15,4% | 3 | 11,5% |
| B1 | 5 | 0 | 0 | 0 | 0% | 0 | 0% | - | - |
| B2 | 32 | 8 | 25% | 6 | 18.7% | 3 | 9,4% | 1 | 3,1% |

Table 2. Percentage of progression of more than 5° divided into Th and Th/L or L curve.

**Results**

In Group A1 in single structural scoliosis, 50.0% of patients improved, 46.2% were stable and 3.8% progressed. In Group A2 in double scoliosis, 50.0% of patients improved, 30.8% were stable and 19.2% progressed. In Group B1 in single scoliosis, 20.0% of patients improved, 80.0% were stable and no patient progressed. In Group B2 in double scoliosis, 28.1% of patients improved, 46.9% were stable and 25.0% progressed (Table 1).

Progression of scoliosis more than 5° was highest in the thoracic scoliosis in group B2 (18.7%). This was slightly less in Th and Th/L or L component of double scoliosis in group A2 (15.4%). Progression in both curves was greater in group A2 (11.5%) than in group B2 (3.1%)(Table 2).

## 7. The SpineCor method

### 7.1 Introduction

The SpineCor physiotherapy method is a postural re-education method that involves a combination of three-dimensional Corrective Movements and global muscle rebalance exercises.

### 7.2 History of the SpineCor method

In the early 1990's a group of researchers from Sainte-Justine University Hospital (Montreal, Canada) led by Professor Charles H. Rivard and Dr. Christine Coillard began investigating the etiology and pathogenesis of Idiopathic Scoliosis. The purpose of this research was to gain a better understanding of the causes of scoliosis and the factors that determine its progression, which in turn would lead to more effective treatment. Whilst a full understanding of the etiopathogenesis of Idiopathic Scoliosis may still be many years away, this research provided the group with the relevant information to better manage the

scoliosis progression with conservative treatment. The research concluded that idiopathic scoliosis should be described as a **neuro-musculo-skeletal pathology** since there is clear evidence of abnormality in all three areas in advanced cases. It was found that the initiating factor of Idiopathic Scoliosis is genetic, however the pathogenesis involves a sequence of critical events resulting in scoliosis which is defined not only as a 3-dimensional deformation of the spine, but also as a pathology involving a specific postural disorganization and a neuromuscular dysfunction (Coillard et al, 2001).

### 7.3 Principles of the SpineCor method

The understanding of scoliosis as a neuro-musculo-skeletal pathology made Dr. Coillard and the team of researchers at Sainte-Justine Hospital realise that in order to treat scoliosis effectively it was necessary to develop a new therapeutic approach which treats the muscular, neurological and osseous elements of scoliosis at the same time. The result was the SpineCor 3-dimensional approach to scoliosis which is based upon the use of dynamic forces by the application of a curve specific **Corrective Movement.**

The Corrective Movement provides a dynamic opening of the scoliosis curve with the ultimate objective of decreasing the spinal deformation. This is possible by the alternation of compression and distraction forces on the vertebral growth plates, whilst at the same time obtaining progressive correction of the postural disorganization and the muscular asymmetry. Over time this will result in neuromuscular integration of the new movement strategy. The integration of the Corrective Movement into the patient's brain provides sustainable long term improvement of curves and permanent stable changes to patients` postures.

The SpineCor dynamic brace was developed as a tool which is used to maintain the Corrective Movement the necessary length of time to get its integration into the patient. The SpineCor brace may be considered as a postural re-education tool rather than a brace. It provides low impact rehabilitation exercises 10's of thousands of times per day that have a positive effect on the spinal abnormal loading, as well as providing neuromuscular re-education with the final objective of neuro-muscular integration.

After years of positive outcomes with SpineCor Brace treatment the SpineCor research team thought that specific exercises that supported the Corrective Movement Principle would also have a positive effect on the treatment of Idiopathic Scoliosis. The SpineCor Physiotherapy Method was then developed, initially designed to complement the SpineCor bracing, however in some circumstances it can be used as a 'stand alone' treatment. The SpineCor physiotherapy program involves curve specific postural re-education and muscular re-balance exercises that comply with the Corrective Movement Principle.

A good understanding of the Corrective Movement Principle is a fundamental requirement to learning and correctly applying the SpineCor Physiotherapy Method. The Corrective Movements have been designed based upon the regional kinematics of the spine. In scoliosis the spinal deformation, the postural changes and the muscular imbalance affect the normal movements of the spine. The research carried out at Sainte Justine Hospital found that in scoliosis patients the movement patterns are maintained but the movement amplitude is unbalanced in opposite directions. As movement patterns in scoliosis patients are maintained and the spinal deformation and the postural disorganization are linked, the Corrective Movements should be performed in the same plane of maximum movement amplitude of a specific spinal segment but in the opposite direction correcting the specific postural disorganization. In simple terms, the Corrective Movements were designed to

overcorrect the specific postural disorganization. The postural overcorrection will open the scoliosis curve to decrease the spine deformation and at the same time allow for progressive correction of the muscular asymmetry. Individual or combined regional Corrective Movements of the spine create the overall Corrective Movement Position. A single curve with its apex at T12 or L1 will have a different Corrective Movement than a curve with its apex at L2 or L3 simply because the kinematics in these two regions is different. This makes each Corrective Movement specific for each type of scoliosis curve.

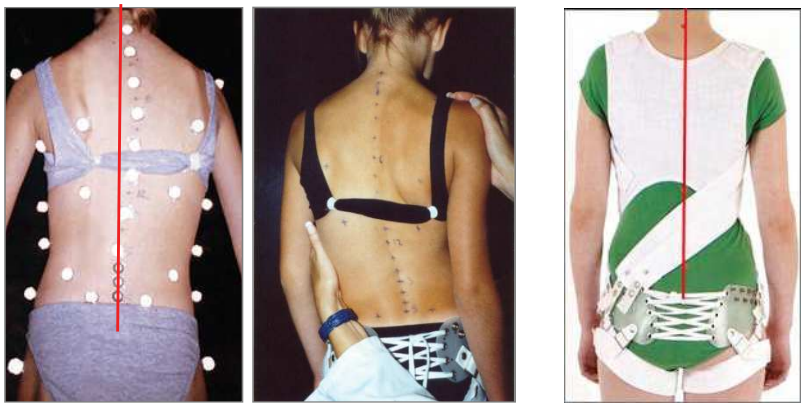


Fig. 21. Corrective Movement and fitting of the SpineCor brace for a Right Thoracic Type 1 curve. The moderate tension in the elastic bands allows the repetition and amplification of the Corrective Movement.

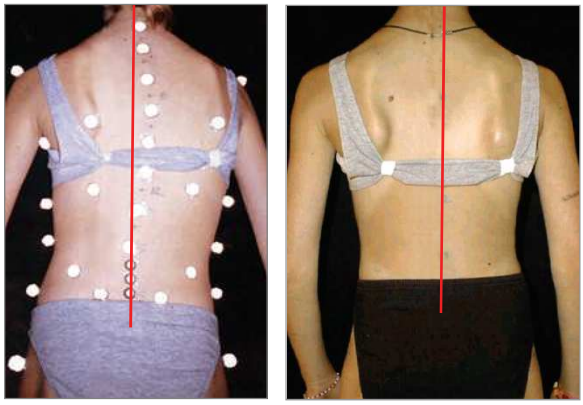


Fig. 22. The same patient is shown here before (left) and after treatment (right) with the SpineCor brace. The Corrective Movement has been integrated providing permanent stable changes to the patient's posture.

### 7.4 Description of the SpineCor method

The main goal of the SpineCor physiotherapy exercises is to provide further repetition and amplification of the Corrective Movements in order to help the consolidation of the

progressive curve reduction and to reinforce neuro-muscular integration and postural reorganization. When physiotherapy is used in conjunction with SpineCor bracing it complements the action of the brace. This differentiates this method from the exercises programs associated with rigid braces, where exercises are frequently performed in order to compensate for the collateral effects of the brace. As the SpineCor brace has no side effects, the brace and physiotherapy work with the same treatment principles to reach the same objectives. On the occasions that the curve has a Cobb angle that is too small for bracing (under 20 degrees), physiotherapy may be used on its own. On these occasions the goals would be to gain muscular balance, improve posture, reduce pain, and prepare the patient for bracing in those cases where it seems certain that this will be required.

**Postural Re-education Exercises**

The SpineCor Physiotherapy Method program addresses postural re-education exercises as the first step. No scoliosis patient feels crooked despite the fact that they have abnormal posture and movements, since scoliosis develops gradually and the motor control centers have time to adapt to the information received from the peripheral receptors and accept that information as being valid. It is essential then to teach patients an awareness of their own postural disorganization and how to mobilize the different postural levels (shoulders, thorax, pelvis), before patients are taught their specific Corrective Movement position.

Postural re-education exercises involve an **active self-correction** where patients learn to reproduce the Corrective Movement position without external aids. The position of the entire body is controlled and patients are taught to reproduce each of the different components of the Corrective Movement in the 3 planes of deformation (fig 23). Once patients are capable of controlling their posture and maintaining the Corrective Movement position in the 3 planes of the space, they are taught to amplify this position working with the breathing cycles. To help the neuromuscular integration of the correction the program also includes exercises to develop balance reactions on exercise balls and unstable surfaces. Patients are also taught to keep the Corrective Movement position while walking and performing daily living activities.

**Muscular Re-balance Exercises**

The SpineCor Method program addresses muscular rebalance exercises in the second step.

These exercises are curve specific and they are always performed from the Corrective Movement position learnt in the previous stage. This position by itself automatically provides a 3-dimensional correction of the postural disorganisation as well as the correction of the muscular imbalance. Muscular re-balance exercises seek to obtain a progressive correction of the muscular imbalance through **global asymmetrical muscular work**. From the Corrective Movement Position patients are taught specific isolated movements against resistance looking for postural overcorrection of each component of the Corrective Movement independently (fig 23). The position of the segments of the body that do not take part in the exercise is facilitated for a better postural control.

### 7.5 Research results

The effectiveness of the Corrective Movement principle in the treatment of Idiopathic Scoliosis through its application by the SpineCor brace has been demonstrated by the

treatment results within studies published by the Sainte-Justine research team (Coillard et al, 2003, 2007, 2008, Vachon et al, 2006), and by independent centres from different countries (Potackzek et al, 2008; Szwed et al, 2009; Vera, 2009; Tsakiri et al, 2009).



Fig. 23. Corrective Movement position achieved by the patient (left) and global asymmetrical muscular work on latissimus dorsi muscles (right) for a Right Thoracic Type 1 curve.

Our experience has shown that the reinforcement of the Corrective Movement principle by means of a scoliosis class specific Physical Therapy exercise program has a positive effect on its neuromuscular integration (del Campo, 2010). However at this present time there have been no comparison studies where the effectiveness of the SpineCor Physiotherapy Program has been evaluated against the Natural History of Idiopathic Scoliosis in pre-bracing groups of patients, or where the effectiveness of the SpineCor Physiotherapy Program on its own has been evaluated against the combined use of the SpineCor Brace and the Physiotherapy program. These studies will take place in the future when a significant number of patient results for both treatment groups in each case are collected.

## 8. Overall conclusions

In conclusion this chapter has reviewed six different scoliosis-specific exercise approaches to the treatment of adolescent idiopathic scoliosis that are currently used within different European countries. While the approaches differ, the overall aims are the same whatever method is used, which is to realign the spine, rib-cage and pelvis to the `normal` anatomical postures. Furthermore although research advances have been made to demonstrate the effectiveness of some of these approaches many more high quality research studies such as randomised controlled studies are urgently needed, as well as studies comparing the effectiveness of the different exercise approaches.

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