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Physiotherapeutic scoliosis-specific exercises for adolescents with idiopathic scoliosis

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The use of exercises for the treatment of Adolescents with Idiopathic Scoliosis is controversial. Whilst exercises are routinely used in a number of central and southern European countries, most centres in the rest of the world (mainly in Anglo-Saxon countries), do not advocate its use. One of the reasons for this is that many health care professionals are usually not conversant with the differences between generalised physiotherapy exercises and physiotherapeutic scoliosis-specific exercises (PSSE): while the former are generic exercises usually consisting of low-impact stretching and strengthening activities like yoga, Pilates and the Alexander technique, PSSE consist of a program of curve-specific exercise protocols which are individually adapted to a patients' curve site, magnitude and clinical characteristics. PSSEs are performed with the therapeutic aim of reducing the deformity and preventing its progression. It also aims to stabilise the improvements achieved with the ultimate goal of limiting the need for corrective braces or the necessity of surgery. This paper introduces the different 'Schools' and approaches of PSSE currently practiced (Scientific Exercise Approach to Scoliosis - SEAS, Schroth, Barcelona Scoliosis Physical Therapy School - BSPTS, Dobomed, Side Shift, Functional Individual Therapy of Scoliosis - FITS and Lyon) and discusses their commonalities and differences.

KEY WORDS: Scoliosis - Exercise - Therapeutics.

Clinical features and epidemiology of adolescent idiopathic scoliosis

Scoliosis is a three-dimensional deformity of the spine.[1-3] In its most common form, idiopathic scoliosis (70% to 80% of cases), the causes are unknown.[1, 4] AIS is discovered at 10 years of age or older,[1] and is defined as a curve of at least 10°, measured on a standing radiograph using the Cobb technique.[5, 6] While the prevalence of adolescent idiopathic scoliosis (AIS) is around 3% in the general population, almost 10% of those diagnosed with AIS will require some form of treatment;[4] usually observation or PSSE for mild curves, braces for moderate curves and spinal surgery for severe curves (Cobb angle >50°). Up to 0.1% of the population is at risk of requiring surgery.[2, 7] A severe form of AIS is more commonly found in females.[4] Typically, AIS does not cause any health problems during growth (except for extreme cases).[1] 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.[8-10] 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

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reduction of the deformity is difficult.[7, 11] If scoliosis surpasses a critical threshold, usually considered to be 30° Cobb, at the end of growth, the risk of health and social problems in adulthood increases significantly.[7, 12] Problems include reduced quality of life, disability, pain, increased cosmetic deformity, functional limitations, sometimes pulmonary problems, and progression during adulthood.[11-18] Because of this, management of scoliosis also includes the prevention of secondary problems associated with the deformity.[19-21]

Current consensus and clinical practices

The level of evidence in the conservative management of AIS is not high. Treatments applied include surgery (instrumentation and fusion), bracing and/or exercises.[22, 23] In the past, electrical stimulation has also been used but without significant results;[24] other treatments not recommended by the current guidelines [22, 23, 25] include manipulations [26] and insoles. The existing evidence concerning these treatments, which is classified according to the Oxford Centre for Evidence Based Medicine,[27] can be summarized as follows: physiotherapeutic scoliosis-specific exercises (PSSE) can be recommended as a first step in the treatment of AIS to avoid and/or limit curve progression (grade B);[20, 22, 23, 28-31] bracing is recommended when PSSEs are unable to prevent progression (grade B);[20, 22-25, 32, 33] and fusion is the recommended treatment when AIS is either causing symptoms (rarely), conservative treatment has failed and a well-informed patient requests fusion (grade C recommendation).[1, 25, 34, 35]

Considering the evidence, the treatment approaches adopted by various orthopedic surgeons and physicians specialised in the field of conservative management of scoliosis are divided indicating a lack of clinical agreement across the professions and different countries. In general a first group regards the exercises as useless,[1, 36, 37] while the second group uses them and advocates their efficacy.[20, 23, 31, 38] These two conflicting views seem to prevail in two different regions of the world: while in Canada, the US and UK, the wait and see strategy prevails, in various parts of continental Europe, Eastern and Southern Europe, conservative treatment (PSSEs and bracing) is considered to be of benefit to the patient [31, 39] and is prescribed routinely by the large majority of scoliosis physicians and surgeons.

The conflicting approaches are also reflected in the guidelines put forth by the Society on scoliosis Orthopedic Rehabilitation and Treatment (SOSORT) [23] composed mainly of rehabilitation specialists and orthotists and the Scoliosis Research Society (SRS) which includes mostly surgeons. The SRS guidelines say the following about the use of PSSE:

"Alternative treatments to prevent curve progression … such as chiropractic medicine, physical therapy, yoga, etc. have not demonstrated any scientific value in the treatment of scoliosis. However, these and other methods can be utilized if they provide some physical benefit to the patient such as core strengthening, symptom relief, etc. These should not, however, be utilized to formally treat the curvature in hopes of improving the scoliosis."[25]

In contrast, in the recently published SOSORT guidelines,[23] PSSE are recommended as part of a range of interventions deemed appropriate depending on the patients' and therapist's willingness to consider more or less aggressive options given the perceived risk of progression determined based on patients age, skeletal maturity and curve severity. Exercises are suggested by SOSORT to pursue the following goals in skeletally immature patients (Risser sign of 3 or less) with curves between 11° and over 30° and in skeletally mature patients (Risser 4 or 5) with curves 11° to 45°: 1) to stop curve progression at puberty (or reduce it); 2) to prevent or treat respiratory dysfunction; 3) to prevent or treat spinal pain syndromes; and 4) to improve aesthetics via postural correction. Further, when patients are prescribed a rigid brace, SOSORT always recommends the associated use of PSSE.[23]

A possible reason for the negative beliefs towards PSSE within the clinical community in the Anglo-Saxon world is the lack of knowledge within the physical therapy community and associated clinical specialists. These scoliosis-specific exercises are not taught at either undergraduate or post-graduate level within the physiotherapy curriculum in the UK, Canada, and United States to name a few. Most clinicians (both physiotherapists and surgeons) in the these jurisdictions normally do not appreciate the difference between PSSE and general physiotherapy.

PSSEs consist of individually adapted exercises that are taught to patients in a centre that is often totally dedicated to scoliosis treatment. The patients

learn an exercise protocol that is personalized according to medical and physiotherapeutic evaluations of the individual's scoliosis curves characteristics. The principles of most PSSE are based on a specific form of auto-correction and exercise contraction, taught individually to each single patient, and then often inserted into stabilizing exercises that can include neuromotor control, proprioceptive training and balance depending on the specific PSSE school.[40] The exercises in many PSSE schools are also incorporated into activities of daily living and are practised at home, ideally under parental supervision. Routine 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 areas where PSSE are not widely used may be based on the effectiveness of generalised physiotherapy which has to date not been shown to be effective.[31]

Quantity and quality of the research studies to date and their limitations

Recent systematic reviews [28-31, 40] have shown the possible effects of PSSEs on scoliosis primarily in terms of Cobb angle, based on controlled studies which were mainly observational and partly prospective. A Cochrane Review [30] on the effectiveness of scoliosis-specific exercises for patients with idiopathic scoliosis 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 [41] to a protocol of electrostimulation, traction and postural training. This study provided very low quality evidence in favour of PSSEs *versus* the same protocol without exercises. More recently, a prospective controlled cohort study comparing the SEAS exercises versus usual physiotherapy,[42] 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. There are also on-going randomized controlled studies on PSSE being conducted by Parent *et al.* in Canada (NCT01610908) and Williams et al in the UK (ISRCTN90480705) and Abbot *et al.*[43] in Sweden (NCT01761305) with a focus on curves, quality of life and perceived appearance. Preliminary results from these studies show promising findings in the short term on the Cobb angle but also on postural measurements and perceived appearance.[44-46]

Further, one of the systematic review on the effectiveness of exercises that also included observational trials was conducted by Negrini *et al.* in 2008.[31] Nineteen studies were retrieved, including one RCT and eight controlled studies; 12 studies were prospective. The 19 included papers 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.[41] Apart from one old study (conducted in 1979 and of very low methodological quality using general physiotherapy (not PSSE),[47] all studies showed positive effects of PSSEs in reducing the progression rate (mainly in early puberty) and/or improving the Cobb angles (around the end of growth). PSSE were also shown to be effective at reducing brace prescription.[42] In contrast, general physiotherapy exercise cohort studies quantified the effect of trunk rotation strengthening exercises on Cobb angle and showed improved strength and no progression in the short term but no effect on curve progression during a longer follow-up.[48, 49]

If scoliosis does progress beyond a certain critical threshold (generally considered to be 30 degrees), bracing is generally recommended as the next step in the treatment with the aim of avoiding surgery.[23, 50] 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.[51-53] 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 [35, 54-56]. Hence, there is a promising role for therapeutic scoliosis-specific exercises, which does not have any unwanted psychological consequences. As stated above generalized physiotherapy (GPT) and PSSE differ significantly. The former type of exercises tends to be whole body physical activity

TABLE I.—*Key features of European physiotherapeutic scoliosis-specific exercise approaches.*

Physiotherapy school	Key features of Physiotherapeutic Scoliosis-Specific Exercise Approach
Scientific Exercise Approach to Scoliosis (SEAS) (SE) [40, 42, 57, 58] [40] (see Appendix 5 in citation for longer description and patients demonstrating exercises)	Improving the patient's awareness of their deformity to promote self-correction Autonomous 3D auto-correction Active Stabilization through intensive symmetrical activation of all stabilizing muscles Cognitive-behavioral approach to the patient and family to achieve maximum involvement and compliance Exercises to stimulate a balance reaction In-brace PSSE Improve spinal stability Home program
Schroth Method [40, 59] (SC) [60-69]	Improving the patient's awareness of their deformity to promote self-correction Repeated 3D asymmetrical spinal corrections exercises (consisting of elongation, pelvic alignment, side-shift of thorax, shoulder corrections, and derotation with breathing in lying, sitting and standing positions). Scoliosis-specific passive mobilization Active 3D stabilization Corrective breathing Repetition (proprioception) to correct body schema Integration of postural corrections within activities of daily living Easy and safe home exercise-program.
Barcelona Scoliosis Physical Therapy School (BSPTS) (BP) [70-72]	BSPTS follows the basic concepts from the Schroth Method: - 3D self-correction with the principles of correction provided by Barcelona School: Self-correction in 3D eventually with external assistance during the training process (self-elongation from a 3D corrected and stable pelvis and trunk + increase of de-rotation by asymmetrical sagittal straightening + increase of deflexion by creating vectors in the frontal plane + breathing mechanics) - Isometric muscle tension to stabilize the position - Repetition (proprioception) to correct body schema - Breathing mechanics to re-shape the trunk
Dobomed (DO) [40, 73-77] [40] (see Appendix 3 in citation)	Exercises in varied quadruped positions (on knees and hands) to increase kyphosis + activate asymmetrical corrections combined with breathing instructions Self-correction in 3D of the spine and ribcage in forward bending in different positions (closed kinematic chains fixing pelvic and shoulder girdle, upright under gravity) Help with breathing mechanics
Side Shift (SS) [40, 73, 74] [40] (see Appendix 4 in citation)	Improving the patient's awareness of their deformity to promote self-correction Self-correction in the frontal plane only Active stabilization through intensive symmetrical activation of all stabilizing muscles to locate the thoracic cage properly on the pelvis
Functional Individual Therapy for Scoliosis (FITS) (FI) [75, 76]	Improving the patient's awareness of their deformity to promote self-correction Relaxation of myofascial structures responsible for the limitation of corrective movements. 3D corrective movements using elastic resistance Improvement of spine stabilization Proprioception Corrective breathing In brace PSSE
The Lyon Approach (LY) [77, 78]	Improving postural balance: highlighting defects, learning correction and integration in the daily life activities Breathing control with use of expiratory reserve volume because the pelvis is fully stabilized. 3D mobilization of the spine Mobilization of the ilio-lumbar angle (lumbar scoliosis) Therapeutic patient education (food control to avoid cast syndrome, skin care...) Sitting position check Endurance of the deep paraspinal muscles is emphasized

(motor) treatments that are more generic and usually consist of low-impact stretching and strengthening activities like yoga and pilates. The second type of treatment activity consists of a protocol of exercises individually adapted and performed with the therapeutic aim of reducing the deformity and stabilising the improvements in order to limit the need of corrective braces or the necessity for surgery. The aim of this paper is to introduce the different Schools of PPSSE currently in existence, discussing their commonalities and differences.

Main schools of PSSE

The main schools or approaches to the Conservative Treatment of Scoliosis are based on physical exercises "born" in Europe and include: Scientific Exercise Approach to Scoliosis (SEAS), Schroth, Barcelona Scoliosis Physical Therapy School (BSPTS), Dobomed, Side Shift, Functional Individual Therapy of Scoliosis (FITS) and Lyon. All of them follow scoliosis specific criteria which include the four standard features described in the 2005 SOSORT Consensus paper:[21] patient and family education, 3D self-correction, stabilization in correction and training in activities of daily living. Key features of these specific schools can be seen in Table I.

Main technical characteristics and commonalities of the PSSE Schools

Self correction

Some elements are common to all PSSE approaches.[21, 79] The most important common feature is 3D Self-Correction, which means attaining the best possible correction through muscle contraction (all schools) with some schools (Schroth and BSPTS) using external aids. Self-Correction has been recognised by SOSORT experts as the most important component of PSSE.[21] Nearly all use side-shift of the torso towards the concavities (SEAS-Schroth-BSPTS-Side-shift-]Lyon) as well as isometric and stabilization-type contractions of the torso muscles in a corrected posture (SEAS-Schroth BSPTS-Lyon). Further, many approaches involve derotation (SEAS-Schroth-BSPTS-Dobomed) and kyphosing exercises (SEAS-Lyon-Dobomed). In addition, a number of Schools commonly use self-elongation (Schroth, BSPTS-Lyon) in conjunction with derotation of the torso and controlled breathing exercises (Schroth-BSPTS-Dobomed).

Physiotherapeutic scoliosis-specific exercises

The PSSE can be used in five main clinical conditions:[30]

1. sole use of exercise as the primary treatment of AIS for mild curves to limit and/or decrease progression and try to avoid the use of a brace;
2. before wearing a brace to improve the mobility, and the elasticity of the spine and the trunk to obtain a better correction by the pressures of the pads;
3. in conjunction with braces. In this case the aims are to reduce the side effects of wearing a brace (muscle weakness, rigidity, flat back), to improve the efficacy of internal brace pads and to avoid the loss of 3D correction during the weaning of the brace;
4. during adulthood if the scoliosis curves exceed certain thresholds. In this case, significant problems such as back pain, breathing dysfunction, contractures and progressive deformity may arise;
5. both before and after surgical correction. Before surgery the aim would be to maintain the mobility of the curve to help achieve maximal correction during surgery and post-surgery the aim of PSSEs would be to enhance the effects of surgery on back shape, balance and posture as and when needed in individual cases.[80, 81]

There is a wide range of exercise dosage used by the different schools going from intensive inpatient therapy to outpatient therapy combined with home programs. The differences in the dosage of exercises prescribed by the different physical therapy approaches are reported in Table II.

Additionally both clinicians with extensive experience in the conservative management of scoliosis patients as well as published trials suggest that a specialized multidisciplinary team working together has greater success in treating such patients than an isolated professional.[21] In fact, most of the European schools which have published their results follow this concept. This information raises the importance of such a team [82] in the management of patients with scoliosis. This team should be comprised of a physiatrist (a physician specialising in Physical Medicine and Rehabilitation) and/or a spinal surgeon specialized in this field, a physiotherapist and an orthotist with specialized knowledge, and all should be in

TABLE II.—*Differences in the dosage of exercises prescribed by the different School of Physiotherapeutic Scoliosis-Specific Exercises.*

School	Inpatient or outpatient	Treatment frequency	Home program	Country of origin
SEAS	Outpatient	1 individual session of 90 min for introducing the approach, and the teaching and the video recording of the exercises program every 3 months	Repetition of the exercises in a gym or at home with the assistance of a PT or a parent for 45 min 2-3 time a week + 5 min daily. The patient can choose to not perform the long session (45 min) and perform the program for 20 min daily instead.	Italy
SCHROTH	Inpatient	4-6 hours daily for 30 days in a specialist clinic.	The treatment includes 3-4 exercises at home for 30 minutes daily 5 times per week to maintain the improved postural balance.	Germany
	Outpatient	Two hours for two days per week with Certified Schroth therapists.		
BSPTS	Outpatient	BSPTS offers different frequencies and different modalities to treat patients: a) INDIVIDUAL LOCAL PATIENTS: 1 h session each week. Depending on the quality of the execution of the correction, the PT will space the sessions as needed. b) INDIVIDUAL FOREIGN PATIENTS: 2 h session; 10 consecutive days. To be complemented by 1 or 2 more weeks 3 to 6 months later depending on the level of knowledge acquired. c) INTENSIVE COURSE: 20 continuous days in group sessions of 3 h/ each. d) REGULAR COURSE: 30 sessions of 90 min in groups. Spread out after initial 8 sessions over a short period as the patient acquires the capability to perform the exercises properly independently.	For all: home exercises 5 days per week for 45-60 min./day	Spain
DOBOMED	Inpatient or outpatient	5 days/wk x 40 min over 3 weeks Or 60 min per week continuously Or Repeat stay as above.	??????	Poland
SIDESHIFT	Outpatient	1 individual session of 10 min for the preparation and the teaching of the exercises.	Home exercises daily for 10 min with or without assistance from parents	England
FITS	Inpatient	A 14-days inpatient program once a year.	For all: during exercises with PT the parent's presence is required. Daily home exercises for 20-30 min	Poland
	Outpatient	1 individual session (45-60 min) with PT 1-4 times per month) with frequency related to the Cobb angle, maturity, risk of progression and distance from clinic.		
LYON	Outpatient	Used during plaster cast or during 24 h bracing (1 to 4 months) 2 sessions/week with a PT After 4 months, 1 session/week	Daily exercises at home Sport without limitation	France

close collaboration with the patient and his/her family. The team may also include the collaboration of a psychologist with experience treating patients with a diagnosis of scoliosis, when required, and should follow evidence-based principles using the latest research available.

This is the main reason why the term "Physiotherapeutic" has been introduced before the term "Scoliosis-Specific Exercises" during the international Society on Scoliosis Orthopaedic and Rehabilitation Treatment (SOSORT) Guidelines development:[23] the term in this context is not related to any specific profession but to a comprehensive, overall team approach focused on the patient, which includes not only scoliosis-specific exercises, but the input from a multi-disciplinary team that includes all or most of the health care professions discussed above.

Current practice in Canada

The conservative treatment of scoliosis with the use of PSSE is not very common in Anglo-Saxon countries. In particular, a chart review study conducted in Alberta (Canada) [83] in a regional scoliosis clinics found that only 15% of patients were referred to physical therapy (mostly for general conditioning or to treat pain). The patients that were referred were 16 years old on average and their largest Cobb Angle was an average of 26° suggesting that referral patterns may not be consistent with SOSORT guidelines. Similary, a chart review study conducted in Montréal by Beauséjour *et al*.[84] of 636 consecutive patients referred for scoliosis evaluation over 1 year found that: 1) 42% of the suspected cases of AIS had no significant deformity (Cobb angle <10°=inappropriate referrals); 2) 32% of subjects with confirmed AIS were "late referrals" with regards to brace treatment indications [Skeletally immature (Risser ≤3) + Cobb angle ≥30°; or Cobb angle ≥40° (regardless of skeletal maturity)] and 3) 20% rather than <1% represented late referrals compared to a period when school screening was done.

Further, therapists in Anglo-Saxon regions possibly show low level of interest / experience with scoliosis. This hypothesis is supported by results from a survey of all 1599 registered physical therapists in Alberta which obtained a response rate of only 12%.[83] Among respondents only 69% had treated scoliosis patients in the past:

— pain represented the most frequently cited objective pursued (80%) followed respectively by stopping curve progression (57%), improving function (53%) and body image (45%);

— only general physiotherapy approaches were reportedly used with core stabilization exercises at (76%) as the most frequently used treatment technique followed by postural advice (73%), mobilizations (55%), and yoga stretches (32%);

— pain (75%) was the most frequently tracked outcome followed by subjective perception of posture improvements (73%), spinal range of motion (69%), and muscle strength (64%). (Not Cobb)

The survey results suggested that, in Canada, surgeons only refer a very small proportion of the whole population of adolescent patients with scoliosis to physical therapists. The sample of patients referred to physiotherapists may have a higher proportion of pain problems than the overall population of patients with scoliosis. This study should be replicated in other countries where PSSE are underused to clarify the generalizability of the findings.

Publications

All of the main schools of scoliosis conservative treatment have reported research studies where patient-centred outcomes have been improved albeit at a low level of evidence. Among the 19 studies reviewed by Negrini *et al*.[31] in 2008 on any type of exercises for scoliosis focused on the curve severity, most did not report on compliance, intention-to-treat analyses, or on recruitment strategies. Only one used random allocation; none blinded evaluators; only 13 were prospective; only seven detailed recruitment; and only one study statistically controlled for confounding variables. Only six exercise studies reported on compliance with only two studies with compliance report exceeding 75%. Given the early promising results but poor study quality, there is an urgent need for stronger study designs evaluating the effects of Schroth exercises and on scoliosis exercises in general. These results demonstrate the relevance of PSSE in the conservative treatment of IS. The main results of these papers show that PSSE can:

— decrease Cobb angle;[66, 76, 85]

— reduce (slow down) curve progression;[31, 86]

— decrease brace prescription;[31, 42, 86, 87]

— decrease loss of correction during brace weaning;[88]

— increase breathing function related to structural flat back;[62, 86]
— decrease back asymmetry;[46, 76, 89-91]
— improve muscular imbalance;[63]
— improve general exercise efficiency measured using ergospirometry;[86]
— decrease stress;[92]
— control curve progression in adult scoliosis;[93-95]
— decrease pain in adult scoliosis;[93-96]
— improve the posture in adult scoliosis.[94, 95]

Considering the quality of available studies, the final conclusion of the Cochrane review on the effect of exercises for scoliosis was that it is not possible to recommend the use of PSSE for AIS, according to the Cochrane criteria for the evaluation of the trials.[30] However, previous systematic reviews [40, 97] which included trial designs excluded by the Cochrane methodology reviewed a considerable number of trials of lower methodological quality. Although the quality of the included studies was low, results were consistent in favour of the efficacy of the exercises in reducing the progression rate (mainly in early puberty) and/or improving the Cobb angles (around the end of growth). Exercises were also shown to be effective in reducing brace prescription. Higher quality research is therefore needed to verify these promising findings.

The importance of education in disseminating the use of PSSE approaches

Currently to our knowledge there is no specialized training for physiotherapists or allied health professionals focused on the rehabilitation of patients with scoliosis at a university degree level. In fact, most physical therapists qualify with a minimal level of knowledge about spinal deformities. Further, training programmes for postgraduate non-surgical spinal researchers are too rare to allow building research capacity in this field. There is a demand for research expertise on conservative scoliosis treatment. There is also a clear need for the non-surgical management of idiopathic scoliosis to be recognised as a distinct and important specialisation. With greater recognition of the complications related to spinal surgery there is a strong potential for allied professions to become recognised specialities within inter-professional practices focused on scoliosis in the future. Such allied professions include: physiotherapists, exercise scientists, spinal orthotists, spinal nurses, certified osteopaths, biomedical engineers and IT technicians.

There is also an urgent need for increased research and clinical capacity in the non-surgical management of spinal deformities. Research is needed of high quality about the effectiveness of the approaches but also about the mechanisms of actions of the approaches in order to formulate recommendations about the most effective combinations of exercises to maximize the effects. The overwhelming majority of the published scoliosis research work is focused on surgery.[39] This is partly due to the lack of suitably qualified professional healthcare researchers, and the unavailability of specialized postgraduate non-surgical international training programmes in scoliosis and other spinal deformities, despite the potential to significantly increase the impact of non-surgical management on patient care. More specialist researchers in the field of scoliosis-specific exercises and of spinal bracing are needed. The majority of scoliosis research societies were founded mostly by surgeons and, consequently, tend to be very surgically focused. The Society of Scoliosis Orthopaedic and Rehabilitation Treatment concentrates solely on non-surgical management and works actively at developing the knowledge base supporting conservative interventions for scoliosis and at disseminating this knowledge by establishing links with other societies. The present paper summarized the exercise-relevant content presented as part of the half-day course at the latest Scoliosis Research Society meeting in Lyon in September 2013 and illustrates this Society's increased interest in conservative treatments for scoliosis.

Conclusions

According to current evidence, PSSE can be a useful aid in adolescent patients with idiopathic scoliosis. However, we need more evidence and are awaiting the results of ongoing randomized controlled trials with great anticipation. The different Schools presented in this paper are active at producing evidence by actively collaborating via SOSORT. Collaborative efforts have highlighted strong commonalities among the constituting elements of each exercise approach discussed. Continued discussion, education, comparisons and high quality research of the different approaches will lead to a better understanding of the effective elements of the 3D PSSE

with continued improvement of the clinical care offered to patients as seen in Table II.

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This paper summarizes 4 presentations offered during the Scoliosis Research Society Half-day Course on Non-Operative Spinal Deformity Treatment Techniques held in Lyon on September 19th 2013. The presentations were: European Schools of Physical Therapy for Scoliosis, Mónica Villagrasa-Escudero, PT, MSc, DO; Evidence Based Exercises for AIS-Cochrane Review; Michele Romano, PT; North American Perspective on Exercises for Scoliosis, Eric C. Parent, PhD, PT, MSc; Role of Education in Non-Operative Treatment, Josette A. Bettany-Saltikov, PhD, MSc, MCSP.

Conflicts of interest.—The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript. However, for full disclosure, the authors are listed hereafter with PSSE schools for which they have received certification: JBS (Schroth), EP (Schroth, BSPTS), MR (SEAS), MV (BSPTS), SN (SEAS).