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Italian guidelines on rehabilitation treatment of adolescents with scoliosis or other spinal deformities

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Premise

Mandate

As mandated by the Italian Ministry of Health, the Italian Society of Physical Medicine and Rehabilitation (Società Italiana Medicina Fisica e Riabilitazione, SIMFER) appointed a Commission composed of SIMFER members to draw up guidelines for the rehabilitation treatment of adolescents with spinal deformities. Other medical organizations contributing to the redaction of the final guidelines version were the Italian Society of Orthopedics and Traumatology (Società Italiana di Ortopedia e Traumatologia, SIOT), the Italian Society of Trau-matology and Pediatric Orthopedics (Società Italiana di Traumatologia e Ortopedia Pediatrica, SITOP), the Italian Study Group on Scoliosis and Spinal Diseases (Gruppo Italiano di studio della Scoliosi e delle patologie vertebrali, GIS), the Study Group on Scoliosis and Spinal Diseases (Gruppo di Studio della Scoliosi e delle patologie vertebrali, GSS), which collaborated through society members nominated by the organizations' executive boards. The final document was also approved by the Italian Federation of Orthotics (Federazione Italiana Operatori nella Tecnica Ortopedica, FIOTO), the Italian Federation of Sports Medicine (Federazione Medico Sportiva Italiana, FMSI), the Italian Society of Medical Gymnastics, Physical Medicine, Physical Education and Rehabilitation (Società Italiana di Ginnastica Medica, Medicina Fisica, Scienze Motorie e Riabilitative, SIGM), the Italian Society of General Medicine (Società Italiana di Medicina Generale, SIMG), the Italian Society of Radiology (Società Italiana di Radiologia Medica, SIRM) and the National Union of Kinesiologists (Unione Nazionale Chinesiologi, UNC).

Commission

The names of guidelines Commission members, their role and affiliation are listed in Table I.

*) These guidelines have been prepared on behalf of: Società Italiana Medicina Fisica e Riabilitazione (SIMFER); Società Italiana di Ortopedia e Traumatologia (SIOT); Gruppo Italiano di studio della Scoliosi e delle patologie vertebrali (GIS); Gruppo di Studio della Scoliosi e patologie vertebrali (GSS). These guidelines have been approved by Federazione Italiana Operatori nella Tecnica Ortopedica (FIOTO); Federazione Medico Sportiva Italiana (FMSI); Società Italiana di Ginnastica Medica, Medicina Fisica, Scienze Motorie e Riabilitative (SIGM); Società Italiana di Medicina Generale (SIMG); Società Italiana di Radiologia Medica (SIRM); Unione Nazionale Chinesiologi (UNC).

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TABLE I.—*Commission members.*

Representant	Society	Role within the Commission	Institute
S. Negrini	SIMFER - GSS	Coordinator	Italian Scientific Spine Institute (ISICO), Milan Don Gnocchi Foundation ONLUS - IRCCS, Milan
L. Aulisa	SIOT, SITOP, GIS	Permanent Member	Department of Orthopedic, Catholic University, Rome
C. Ferraro	SIMFER	Permanent Member	Department of Orthopedic Rehabilitation, University of Padua
P. Fraschini	SIMFER	Permanent Member	Institute Eugenio Medea IRCCS La Nostra Famiglia, Bosisio Parini (Co)
S. Masiero	SIMFER	Permanent Member	Department of Orthopedic, Rehabilitation, University of Padua
P. Simonazzi	SIMFER	Permanent Member	Santa Maria Hospital, Reggio Emilia
C. Tedeschi	SIMFER	Permanent Member	Santa Maria Hospital, Reggio Emilia
A. Venturin	SIMFER	Permanent Member	Department of Orthopedic Rehabilitation, University of Padua
C. Guerra	SIMFER	Member	Institute Eugenio Medea IRCCS La Nostra Famiglia, Bosisio Parini (Co)
V. Pirola	SIMFER	Member	Salvini Hospital, Garbagnate Milanese
S. Pochintesta	SIMFER	Member	Institute Eugenio Medea IRCCS La Nostra Famiglia, Bosisio Parini (Co)
U. Selleri	SIMFER	Member	Bufalini Hospital, Cesena
D. Bianchini	SIMFER	External Collaborator	Santa Maria Hospital, Reggio Emilia
W. Bilotta	SIMFER	External Collaborator	Rizzoli Orthopedic Institute IRCCS, Bologna
I. Fusaro	SIMFER	External Collaborator	Rizzoli Orthopedic Institute IRCCS, Bologna
M. Monticone	SIMFER	External Collaborator	Italian Scientific Spine Institute (ISICO), Milan
S. Minozzi		Reviewer	Epidemiologist Italian Cochrane Center, Milan

TABLE II.—*Scientific evidence and available studies.*

Scientific evidence	Available studies
A) Very strong	More than 1 randomized controlled study with comparable results
B) Strong	At least 1 randomized controlled study with results comparable with other published studies
C) Fair	No randomized studies but various controlled studies with comparable results
D) Poor	1 controlled nonrandomized study or various studies with divergent results
E1) Strong scientific consensus	General consensus on a procedure or treatment
E2) Fair scientific consensus	Prevalent but not general consensus on the procedure or treatment
E3) Commission opinion	Opinion of the Commission where a general consensus was absent

Content

These guidelines concern the treatment of:
— idiopathic scoliosis;
— sagittal plane spinal deformities.

Methodology

The guidelines were drawn up using the following methodology:

— all available references were collected, including: indexed literature obtained from Medline search; existing guidelines obtained from internet sources; non-indexed literature gathered by targeted hand searching and from direct knowledge of Commission members; telephone contacts with experts known to the Commission; bibliographies of indexed and unavailable studies;

— the strength of scientific evidence for treatment was then classified according to the following criteria (Table II):

This classification was structured on the basis of conventional indications for establishing guidelines set up. Since this area of medicine is characterized by a wealth of descriptive studies and practices chiefly based on consensus rather than on scientific evidence, the Commission thought it useful to expand the E class of the guidelines by subdividing it into 3 graded levels of scientific consensus.

These guidelines are the result of a series of processes:

— SIMFER Commission members and other individuals wishing to contribute their work prepared a document for 1 or more guidelines; at least 2 documents were prepared for each guideline;

— the documents were distributed to all SIMFER Commission members who then reviewed and suggested revision of the documents as appropriate;

— three full-day SIMFER consensus conferences were held at the Don Gnocchi Foundation, Milan, to draw up the final version of the guidelines;

— the first version of the guidelines (version 1) was sent for revision of the methodology to Dr. S. Minozzi, an expert in guideline methodology and collaborator at the Cochrane Institute;

— on the occasion of the Congress of GIS the main association of orthopedic spine surgeons, a satellite symposium was held to begin work on external review;

— two consensus conferences involving SIMFER Commission members led to a preliminary version of the guidelines, which in the meantime has been updated with the most recent indications reported in the literature;

— the resulting guidelines (version 2) were made available to the public (health care professionals, patients, administrators) through posting at various websites (*www.simfer.it, www.gss.it, www.dongnocchi.it, www.ediermes.it*) in order to solicit written response;

— the guidelines were then sent to pertinent scientific societies with the request to have them published on the associations' websites. To ensure the maximum representation of all health care professionals, the societies listed in alphabetical order below were contacted:

— *AIFI* – Associazione Italiana Fisioterapisti (Italian Society of Physiotherapists);
— *AITO* – Associazione Italiana Terapia Occupazionale (Italian Society of Occupational Therapists);
— *FIOTO* – Federazione Italiana Operatori nella Tecnica Ortopedica (Italian Federation of Orthotics);
— *FMSI* – Federazione Medico Sportiva Italiana (Italian Federation of Sports Medicine);
— *GIS* – Gruppo Italiano di studio della scoliosi e delle patologie vertebrali (Italian Study Group on Scoliosis and Spinal Diseases);
— *GSS* – Gruppo di Studio della scoliosi e patologie vertebrali (Study Group on Scoliosis and Spinal Diseases);
— *SIGM* – Società Italiana di Ginnastica Medica, Medicina Fisica, Scienze Motorie e Riabilitative (Italian Society of Medical Gymnastics, Physical Medicine, Physical Education and Rehabilitation);
— *SIMG* – Società Italiana di Medicina Generale (Italian Society of General Medicine);
— *SIOT* – Società Italiana di Ortopedia e Traumatologia (Italian Society of Orthopedics and Traumatology);
— *SIP* – Società Italiana Pediatria (Italian Society of Pediatrics);
— *SIRM* – Società Italiana di Radiologia Medica (Italian Society of Radiology);
— *SITOP* – Società Italiana di Traumatologia ed Ortopedia Pediatrica (Italian Society of Traumatology and Pediatric Orthopedics);
— *UNC* – Unione Nazionale Chinesiologi (National Union of Kinesiologists)

— in addition to the members of the above listed societies, the representatives of local and regional health boards were contacted by mail;

— at a national consensus conference held on 14 June 2002, over 300 participants made additional proposals for guideline modifications;

— at another consensus conference involving SIMFER Commission members, final changes to the guidelines were defined and the most recent publications in the literature reviewed; this produced the third version of the guidelines (version 3);

— the resulting document was then sent to 4 organizations (SIOT, SITOP, GIS and GSS) which worked internally and with their Commission members to propose and make appropriate changes for drawing up the final version of the guidelines (version 4);

— the final document was approved by all Commission members, scientific societies and executive boards of the participating scientific organizations.

Presentation of results and recommendations

The guidelines document is structured in 3 parts:

Definition: changes in health to which the subsequent results and recommendation refer;

Results: presentation of published studies, assessment of methodology and discussion of content;

Recommendations: 1 or more recommendations followed by a note on the strength of evidence for such recommendations as based on available published studies and classified according to the scheme described above.

The related references on which the results and recommendations are based are published at the end of the paper.

Targets and area of application

The guidelines are addressed to all health care operators working in rehabilitation and conservative treatment of spinal deformities; the guidelines are applicable to patients affected with spinal deformities who may receive benefit from rehabilitation and conservative treatment for these conditions.

Idiopathic scoliosis

Definition

Scoliosis is a complex structural deformity of the spine, in which there is an abnormal curvature of the vertebral column on all 3 spatial axes. The condition manifests with a lateral curvature on the frontal plane, an alteration of the curvature often causing inversion on the sagittal plane and vertebral rotation on the axial plane.[1-3] By definition, idiopathic scoliosis is of unknown origin and is probably due to several causes. Etiopathogenetically, the spinal deformity caused by idiopathic scoliosis may be defined as a sign of a complex syndrome with a multifactorial etiology.[4, 5] Nearly always, the syndrome manifests as a solitary deformity but is not identical with it since further investigation may reveal other significant subclinical signs.[3, 5-7]

The classical definition of scoliosis according to the Scoliosis Research Society [1, 8] is a curvature with a Cobb angle >10° on the frontal plane, without taking into account the lateral plane, whose changes significantly impact on the evolution of the scoliosis and may require brace treatment. Based on this assumption, many published studies on the efficacy of conservative treatment for scoliosis (physiotherapy, plaster braces, braces) use as the sole assessment parameter the change in Cobb degrees. This practice is likely to come under review as radiographic and clinical evaluation of vertebral rotation becomes more refined.

The classification of idiopathic scoliosis may vary with the initial site of the deformity [1, 8] (thoracic, thoracolumbar, lumbar, double-curve scoliosis) and age at onset (infantile, juvenile and adolescent scoliosis). Based on the standard indications of the International Classification of Impairments, Disabilities and Handicaps (ICIDH) issued by the World Health Organization (WHO),[9] patients may be grouped according to the aspect of the disease (etiopathogenetic process), impairment (damage to body function or structure), and disability (consequence of the relationship between health status and personal and environmental factors). The WHO has recently updated these terms in a new International Classification of Functioning, Disability and Health [10] and recast them as impairment, reduction of activity and limitation of participation, which may also be applied to patients with idiopathic scoliosis.

Research has defined a series of elements of disease,[3] with a possible etiopathogenetic role, which may be classified as: factors originating from the central nervous system, biomechanical factors and factors related to connective tissue. The impairment caused by idiopathic scoliosis may be classified according to whether it affects [3, 11] neuromotor, biomechanical or cardiorespiratory function or cosmesis. The problems related to limitation of activity (disability according to the previous classification scheme) chiefly concern adult patients. Aspects such as pain, for example, or a significant reduction in strength or in activities of daily living or in productive life are features not considered in young patients. However, 2 elements typical of adolescence that have repercussions later in life are limitation of activity (disability) due to psychological causes and others that may be defined as iatrogenic, where a young person with idiopathic scoliosis is not respected as an individual struck at a doubly delicate moment in life, when he or she must come to terms with changes related to growth and pubertal development and deal with conflicts in self-image that are the consequences of a disease that is undermining the body's carrying structure - the vertebral column, wherein "column" bears significant metaphoric meaning. All these elements need to be evaluated on the basis of the severity of the scoliotic curve, where the limitations of activity nearly never manifest in curves with a Cobb angle <20° but increase as the disease progresses.

Scoliosis treatment comprises all the typical phases of prevention.[3] In mild disease, treatment consists of preventing the progression of scoliosis. This therapeutic phase is traditionally defined as "free treatment" (exercise program with regular medical checkups) and concerns so-called minor scoliosis (normally Cobb angle <20°). Prevention later becomes therapy because, as with treatment of hypercholesterolemia to prevent myocardial infarction, here too an important risk factor is treated since minor scoliosis may progress to major scoliosis.[12, 13] The chief form of prevention is a specific exercise program and kinesitherapy. The goal is to improve neuromotor ability in accordance with the features of the scoliosis and the characteristics of the patient. Programs are designed to enhance the individual's specific abilities (balance, coordination, eye-hand control) within the context of biomechanical equilibrium (movement on 3 spatial planes).

Another aspect is secondary prevention, *i.e.* treatment to prevent damage subsequent to the presence of an advanced stage of disease. The limits may overlap where the stage of the disease requires intervention with brace treatment. The primary objective in this phase is to prevent worsening of the scoliosis, hence, treatment of the disease along with the often forgotten need to treat impairment, to prevent limitation of activity (disability) and participation (handicap). Therefore, if the principal element is a brace, treatment of impairment and disability are the typical components of rehabilitation intervention, whether by kinesitherapy with specific exercises or by psychological support or education. Of course, this type of intervention is interdisciplinary in nature and involves various members of the rehabilitation team: physiatrician, orthopedist, physiotherapist, orthotist, motor science health professional, patient and his or her family.

Tertiary prevention is often understood as rehabilitation in the true sense. This phase is typical of post-intervention recovery and/or overcoming iatrogenic injury in adolescence.

Nonstructural scoliotic curvature, or paramorphism or scoliotic attitude, is not a pathologic condition and so is not covered by these guidelines.

Assessment

Results

There is insufficient scientific evidence for recommending or not recommending preventive school screening for idiopathic scoliosis in asymptomatic adolescents by.[14-17] However, because the positive efficacy of conservative brace treatment on the natural history of idiopathic scoliosis has been confirmed by controlled prospective studies,[18-21] we can only conclude that early detection may lead to conservative brace treatment. Alongside the concepts of efficacy and effectiveness, the notion of treatment acceptability should be introduced, which is particularly important in an area where definitive scientific evidence is lacking. Screening as an element upon which future intervention can be based is preferred by 95% of families.[22] In addition, positive outcome with screening has also been reported for Italy.[16, 17, 23, 24]

The principal evaluation test in the clinical examination of patients with scoliosis is the Adam's forward bend test. A positive result to the test is pathognomic for scoliosis.[25] The test's positive predictive value varies since it is proportional to the degree of curvature and depends on operator experience.[14]

The Scoliometer [26] is an evaluation tool that has proven highly useful in screening programs in recent years. The Scoliometer measures the angle of trunk inclination (ATI) and has a high interobserver reproducibility, which permits the determination of cut-off points above which radiographic study is indicated. It has a sensitivity of about 100% and a specificity of about 47% when an ATI angle of 5° is chosen. At an ATI angle of 7° sensitivity drops to 83% but specificity rises to 86%.[27-29]

The hump-meter (level protractor) is another instrument that can provide a further parameter of evaluation and differs from the Scoliometer in that it measures the height of the difference between curve concavity and convexity.[30] In Italian studies,[31-33] a cut-off point of 5 mm has been defined as significant for measuring back hump. A recent study showed that the reliability of this measurement is greater than previously reported.[34] A new instrument demonstrating high reproducibility [35] has also been recently tested.

Radiographic examination remains the reference standard for assessing the sensitivity and specificity of screening tests,[14] but cosmetic evaluation cannot be neglected either.[36, 37] In addition, it is important to use one of the clinical cut-off points mentioned above (ATI or hump), according to the clinician's discretion, before ordering radiographic study. Cobb angle measurement on radiographic films had an intra- and interobserver variability of 3-5° and 6-7°, respectively.[14, 38] Radiographic measurement of the vertebral rotation using Perdriolle's torsionmeter has been shown to be reproducible.[39] Based on the same principle, use of tables or Raimondi's ruler makes measurement easier and slightly more reproducible.[40-42]

The Risser sign constitutes a further parameter for radiographic evaluation and is useful in indicating the patient's growth status, since Risser grading can be done using the same radiographic film to evaluate the scoliosis.[43] Other essential parameters to be considered are radiographic maturity of the ring apophyses (ringapophysis), appearance of menarche in girls and Tanner staging.

Recommendations

— School screening programs for the early diagnosis of idiopathic scoliosis should be conducted (E2).

— During general physical examination, pediatricians, internal physicians and sports physicians should perform the Adam's test on children aged from 8 to 15 years (E2).

— The Adam's test should be conducted under a physician's guidance (E1).

— Assessment of scoliotic patients should be carried out by a physician specialized in spinal deformities (E1).

— Patients with idiopathic scoliosis should always be examined by the same physician. When this is not possible, then validated assessment methods and standard clinical data collection forms should be used (E2).

— A clinical diagnosis of scoliosis should be established, and the assessment of patients with idiopathic scoliosis should be comprehensive, including clinical and radiographic information (E1).

— Assessment of patients with idiopathic scoliosis should comprise pathologic, cosmetic, psychological, functional and family aspects (E2).

— History taking should be performed during physical examination (E2).

— During examination, sagittal alignment of the spine should be evaluated. (E2).

— Bunnel's Scoliometer should be used (E1).

— When the Scoliometer is used, the cut-off point should be 5° (E2).

— The back hump should be measured using a hump-meter or level protractor or other instrument in the clinical evaluation of the patient during specialist examination (E3).

— Clinical evaluation should be accurate; radiographic study of leg length discrepancy should be performed only when needed (E3).

— Sequential collection of clinical and diagnostic data should be recorded on specific forms (E2).

— Clinical follow-up examinations should be performed twice yearly in patients with idiopathic scoliosis or more often in patients at risk (E3).

— Radiographic studies should not be ordered when the Adam's test is negative (E3).

— An ATI angle 5° or 5 mm of back hump should be taken as the significant cut-off points for ordering a radiographic study at initial examination (E3).

— The decision whether to perform a radiographic study should be made by a specialist (E3).

— Radiographic studies should be made using centimetered films with a ratio of 1:1 in relation to real dimensions (even when digital), including visualization of the femoral heads and protection of the gonads, in any standing position without the use of support aids or indication of correct posture (E1).

— Curve magnitude should be measured using the Cobb method on the radiographic film (E1).

— Vertebral rotation should be measured using Raimondi tables or ruler or a Perdriolle torsionmeter on the radiographic film (E2).

— The first radiographic evaluation should include a lateral view (E2).

— On radiographic lateral projection, the patient's upper extremities should be placed in a 45° angle to the shoulder, elbows extended and hands resting on a support to preserve the sagittal curvature of the spine (E1).

— To reduce the invasiveness of follow-up, no more than 1 radiographic study per year should be performed or as decided by a clinician specialized in spinal diseases (E3).

— The least number of projections should be made on radiographic study (E1).

— In daily clinical routine, complex and costly studies should not be ordered, unless otherwise justified in the opinion of a clinician specialized in spinal diseases (E1).

Treatment with specific exercises

Specific exercise and specific exercises

Results

A recent systematic review has exhaustively evaluated studies on the efficacy of specific exercise programs in reducing the probability of progression of idiopathic scoliosis.[12] The review found that the general methodology used in studies published so far has generally been of poor quality, even though, except for 1 study, all study results indicate that treatment is useful. The authors of the review article concluded that as far as we know today specific exercises may be proposed to patients.

A 1979 study by Stone [44] found no significant difference between a prospective group treated for 1 year with home exercises and a retrospective control group. The exercise program had a very mechanistic concept that excluded the fundamental aspect of neuromotor integration. Poor efficacy was noted in a study by Farady,[45] although the study also underlined the benefits exercises performed without a brace can have for brace wearers in improving joint range of motion and muscle strength. This permits the rib cage to achieve adequate mobility and correct posture.

Other studies tended to show the efficacy of exercise programs, including observational studies with control groups,[46-50] comparative studies between rehabilitation techniques that showed an effect on spinal flexibility and biomechanics,[51] simple case studies,[52, 53] studies based on etiopathogenetic hypotheses.[2, 3, 11, 54-58] Many studies addressed the issue of type of exercise.[3, 11, 46, 54, 58-63]

A major drawback, however, is the unevenness of information about the natural progression of the scoliosis.[49, 64, 65] Several authors did not even consider the possibility of having patients perform specific exercises nor did they support this exclusion with any biographic reference.[20, 66-68] Hungerford does not support the exclusion of an exercise program with bibliographic references but considers those exercises valid that eliminate brace-induced stiffness.[69]

In a 1989 article, Focarile *et al.*[70] described a lack of studies on the efficacy of exercises performed alone, although several studies on brace treatment found the combination of some types of exercises effective.

Dickson [20, 71] questions the efficacy of conservative treatment, stating that the instable nature of rotation makes bracing ineffective. In addition, only 10% of diagnosed curves tend to worsen, particularly in young women with a right thoracic curve. Basing his opinion on Stone's study,[44] Dickson found specific exercises inefficacious, while recognizing the effectiveness an exercise program may have in limiting brace-induced stiffness. Only in a minority of the identified curves was a marked progression of the deformity found to occur.

The probability that the curve will worsen depends on patient age at diagnosis, type and severity of curve, sex and skeletal maturity.[49, 64, 72, 73] From 25% to 75% of curves found at screening may remain unchanged, whereas from 3% to 12% of curves may improve.[49, 64, 74] Weinstein [8] concludes that treatment decisions should be individualized, considering the probability of curve progression, based on curve magnitude, skeletal maturity, patient age and sexual maturity. A study by Lantz [75] showed that manipulation is ineffective in correcting minor scoliosis with a Cobb angle <20°.

In conclusion, there is no currently available evidence sufficient for or against recommending the use of specific exercise and specific exercises.[49] Moreover, when the acceptability of therapy was added to the concepts of efficacy and effectiveness, families preferred the use of specific exercises for prevention while awaiting a possible progression of the deformity to be later treated with a brace.[76] The review of the literature suggested that exercise programs may be efficacious in slowing the progression of the deformity in patients with mild curvature in idiopathic scoliosis.[46-48, 51]

There are no rigorous scientific studies on the therapeutic efficacy of the use of manipulation, plantar insets (not lifts), bytes, conventional and homeopathic medicines, acupuncture or specific dietary regimens for the correction of idiopathic scoliosis in adolescence.

Recommendations

— The choice of therapeutic options should be made by a clinician specialized in spinal diseases on the basis of information from history taking, objective and diagnostic procedures (E1).

— A nonstructural scoliotic curve and scoliosis with a Cobb angle <10±5° should not be treated specifically, unless otherwise justified in the opinion of a clinician specialized in spinal diseases (E1).

— Scoliosis with a Cobb angle <10±5° and a prominent nonstructural scoliotic curve should be regularly examined until the pubertal growth spurt, unless otherwise justified in the opinion of a clinician specialized in spinal diseases (E2).

— In treating minor curves, specific exercises should be initiated as a first step in the approach to treating idiopathic scoliosis to prevent progression of the deformity (C).

— Specific treatment teams (not necessarily working directly together) should be constituted, with close cooperation between the physician and the rehabilitationist (E3).

— Exercise programs should be designed and carried out by a specifically trained rehabilitation therapist experienced in scoliosis treatment (E2).

— Exercises should be performed individually or, even better, in small groups according to a personalized exercise program (E3).

— Exercises should be performed regularly until the end of treatment (E2).

— Exercises should be customized to the patient's needs (E2).

— The goals of an exercise program should be to improve neuromotor and postural control of the spine, balance and proprioception and to strengthen thoracic muscle tone (E2).

— Exercises should not increase joint freedom or spinal mobility, except in the preparatory phase for brace treatment (E2).

— In specific exercise, the use of single methods, none of which is adapted to all therapeutic phases, should be avoided in children with idiopathic scoliosis (E2).

— In each treatment phase, the best methods, techniques and exercises should be employed to achieve the treatment objectives established for the patient (E2).

— Manual mobilization and manipulation should be avoided, except in the preparatory phase for brace treatment (D).

— Correction of leg length discrepancy, if needed, should never be total and should be decided by a clinician specialized in spinal diseases (E3).

— Plantar insets (not lifts), bytes, conventional and homeopathic medicines, acupuncture, or specific dietary regimens should not be used to correct a spinal deformity (E1).

SPECIFIC EXERCISE AND RESPIRATORY EXERCISES

Results

Study opinions differ; some authors [77, 78] conclude that exercises are ineffective, while one [79] cites an increase in vital capacity and in chest wall expansion that would allow treatment of associated restrictive ventilatory disease. It is unlikely that scoliosis in puberty will lead to cardiorespiratory failure or clinically relevant pulmonary deficit, whereas scoliosis with an onset at age 5 may do so, with a reduction in vital capacity of over 50%.[80-83]

Mankin *et al.*[84] underlined that also in mild and moderate scoliosis pulmonary function deficit is appreciable, with a reduction in lung volume and vital capacity associated with a reduced flexibility of the spine and the vertebral rib joints, resulting in diminished rib excursion during respiration.

Other studies [85, 86] showed a reduction in total lung volume, vital capacity, O_2 tension and ventilatory response to CO_2, even in scoliosis with a Cobb angle >30°. Jones *et al.* found a reduced capacity of ribcage excursion in scoliosis affecting that part of the trunk.86 Smith *et al.*[87] reported that respiratory function in moderate idiopathic scoliosis with a Cobb angle <35° can be improved and that strengthening of respiratory muscles is an important contributing factor to this improvement. Pehrsson *et al.*[88] showed that cardiorespiratory failure occurs only in cases of severe scoliosis that had their onset in prepuberty and with a strong tendency to progression, wherein vital capacity was the strongest indicator for possible respiratory failure. Bjure *et al.*[89] found a correlation between an increase in the degree of scoliosis and a reduction in all pulmonary function values, whereas Caro *et al.*[90] underlined that rib cage stiffness increases with advancing age. Cooper *et al.*[91] postulated that low lung volumes in adolescents with moderate or medium scoliosis are caused by a mechanical deficit in the interaction between inspiratory muscles and the thoracic wall. Thulbourne *et al.*[92] found a marked decrease in rib depression on the concave side of the curve subsequent to active exercises performed in brace. Aulisa *et al.*[93] showed that vital capacity and total pulmonary capacity are negatively influenced by angulation of the scoliotic curve, vertebral rotation and hump size. Correction and surgical stabilization of the curve led to only a slight improvement in these indices.

Other studies [94-96] evaluated pulmonary ventilation using radioaerosol scintigraphy. Tracer distribution was less homogeneous in the lung located in the concavity of the curve and was associated with reduced hemidiaphragm mobility. In these studies, the authors cite the utility of specific exercise in brace and of respiratory training techniques to improve the mechanical function of the respiratory system.

Recommendations

— Where needed, exercises to improve respiratory function are recommended in patients with idiopathic scoliosis (D).

— Training in regional respiratory strategies is recommended to promote the expansion and ventilation of a specific lung compartment (E2).

— Exercises performed in brace or assisted pushing on the back hump are recommended to promote chest expansion of the concave side of the thorax (E2).

Specific exercise and specific exercises during brace treatment and surgical therapy

Results

A controlled randomized study on a small study population showed that in adolescents wearing a brace exercises are more effective than traction in improving curvature on lateral bending.[97] Another noncontrolled case series study concluded that some brace wearers had reduced vertebral rotation and thoracic curvature after completing forward bending exercises.[98] Carman *et al.*,[99] in a study on 24 patients, of which half performed exercises, observed that the clinical outcome was comparable; however, here too the exercises were very mechanistic. Stagnara *et al.*[54] and Perdriolle [2] in different ways support the usefulness of specific exercise and specific exercises before, during and after brace treatment or after surgery.

Other studies examine brace-induced alterations in respiratory function [100] and conclude that a transient reversible reduction in vital capacity and residual volume are inevitable. This means that brace treatment may reduce thoracic mobility. Refsum *et al.*[101] noted a reduction in vital capacity and total lung capacity, with an increasingly reduced forced expiratory volume which returned to normal levels within 24 months.

Recommendations

— Specific exercises should be performed in combination with brace treatment (C).

— Mobilization exercises should be performed to improve joint freedom of the spine braced full time but not during the release phase (B).

— Mobilization exercises are recommended as preparation for brace treatment (E2)

— Exercises to strengthen muscle tone during brace treatment are recommended (E1).

— Exercises and posture training to recover sagittal pattern during brace treatment are recommended (E2).

— Exercises in posture and function training are recommended, particularly during weaning off the brace and the postsurgical period (E2).

Sports activities

Results

Stagnara considers general sports activities an active counterpart to specific exercise;[102, 103] their role may be understood by specific differences. Specific exercise constitutes a personalized therapeutic approach to achieving a more flexible and functional posture of the patient, which in early phases is reducible by acting on the elastic component of the soft tissues.[104-107]

Sports activities provide a psychomotor rebalance that is generally advisable; sports should be taken up by the scoliotic adolescent in a manner appropriate to the type of patient and the severity and progression of the curve. Patients with scoliosis should play “the same as and even more than others”.[102, 103, 108]

One study highlights how psychological and social aspects are related to the patient’s negative image of his or her own body.[109]Motor activity allows patients to work on these aspects and to stay involved with their peer group, particularly but not only during physical education at school.

Swimming is not a panacea for scoliosis; some studies have indicated limits to swimming [108, 110-114] or even contraindications.[2, 108] A recent study found in girls practicing elite competitive rhythmic gymnastics an incidence of scoliosis of 12% compared with only 1.1% in control subjects. Intense spinal mobilization and stretching in at-risk subjects could be one of the contributing factors.[115] Similar doubts have been repeatedly expressed concerning general physical activities such as artistic gymnastics and dancing.[102, 103]

Recommendations

— Sports should not be prescribed as treatment for idiopathic scoliosis (E2).

— General sports activities are recommended which offer patients aspecific benefits in terms of psychological, neuromotor and general organic well-being (E2).

— During all treatment phases, physical education at school should be continued. Based on the severity of the curve and progression of the deformity and the opinion of a clinician specialized in spinal disease, restrictions may be placed on practicing certain types of sports activities (E2).

— Sports activities should be continued also during brace treatment because of the physical and psychological benefits these activities provide (E3).

— Swimming should not be used to treat pathologic curves (E2).

— Competitive activities that greatly mobilize or stretch the spine should be avoided in patients with scoliosis at high risk of progression (D).

Brace treatment

RESULTS

Brace treatment for scoliosis has recently regained support in published studies, after initial enthusiasm during the 1960s and 1970s, widespread though not unanimous criticism in the 1980s and re-evaluation in the 1990s.[20, 21, 64, 116-119] The natural progression of scoliosis in untreated patients was compared with that of treated patients.[64] A controlled prospective study verified the efficacy of proposed treatment.[116] Since many studies on the efficacy of conservative treatment for scoliosis use as the sole parameter only changes in Cobb angle on the frontal plane, this limitation influences claims about the real efficacy of brace treatment. It should be taken into account that progression of deformity, whichever the plane of presentation, always manifests also on the frontal plane.

Scoliosis evaluation has advanced with the introduction of more accurate radiographic diagnostic methods using standard radiology with extremely small radiation doses or with three-dimensional (3D) radiological diagnostic imaging techniques, such as computed tomography (CT) and magnetic resonance imaging (MRI), which have profoundly changed the evaluation of skeletal deformities and the construction of corrective braces. In addition, conventional brace systems like the Milwaukee brace have undergone substantial improvements in structure design and materials in recent years. Thoracolumbar braces efficacious in treating curves with an apex under T7 have been developed within 2 different schools (Anglo-Saxon and French).

Similarly, the advances in our understanding of the 3D biomechanics of the curve have led to marked variations in the approach to brace treatment, which today must contemplate a correct 3D approach targeted at correcting the curve on the frontal plane (Cobb degrees), horizontal plane (Perdriolle rotation and gibbous deformity) within the context of spinal sagittal attitude (kyphosis and lordosis). This has led many operators to abandon certain brace styles and to modify those currently in use.[120]

More than ever, the literature search reflects such cultural differences. Works published in indexed journals found on Medline refer almost exclusively to brace systems designed in the United States (Boston, Milwaukee, Wilmington, Charleston), except for a few articles in German on the Chêneau brace. Most studies on French braces are published in non-indexed European journals.

The most recent publications show positive outcomes with brace treatment *versus* natural history of the disease, with statistically significant data in relation to baseline Cobb degrees.[67, 121-128]

Nachemson *et al.*[116] conducted a prospective controlled study on 240 patients with thoracic or thoracolumbar curves between 25° and 35°, aged between 10 and 15 years, of which 129 were only observed and 111 treated with thoracolumbar braces. Progression of 6 or more degrees at 2 radiographic follow-ups to the first visit was considered an index of failure of the selected treatment (observation *versus* brace treatment). At 4 years of follow-up, the success rate for brace treatment was 74% (range, 52-84%), whereas the rate for observation was 34% (range, 16-49%).

Bergoin [121] carried out a revision of published studies on orthopedic and surgical treatment. The classic method of the Lyon school comprises treatment with a plaster brace followed by a 3- or 4-valve brace in relation to the level of the scoliosis; in prepubertal patients, a Milwaukee brace or a thoracolumbar brace in propylene or polyethylene. The study described the results of treatment of 56 scoliotic patients with an initial mean angle of 23° (<30°) at various levels, followed from 1974 to 1979, until after skeletal maturity (mean follow-up, 14 years), who achieved a mean final Cobb angle of 20°.

Pries *et al.*,[126] in a study on 70 cases of idiopathic scoliosis treated with the Lyon method (plaster and Plexidur brace), showed good outcomes in the reduction and maintenance of orthopedic correction of curves with baseline angles from 30° to 50°. The study was carried out using excellent methods.

Aulisa *et al.*[129] performed a retrospective study on 70 patients with thoracolumbar and lumbar scoliosis who received treatment with a brace of innovative biomechanical conceptual design, the progressive action short brace (PASB), controlled at least 5 years after weaning off the device. Variations in Cobb angle, apical vertebra rotation and average vertebral rotation of the curve were analyzed by ANOVA tests. The curve was corrected in 44 patients (63%), had stabilized in 23 (33%) and had worsened in 3 (4%). The results were statistically significant (P<0.000).

There are very few major studies comparing different systems for treating curves with similar clinical characteristics,[126, 127, 130] but at least one study was highly significant in the quality of the method it used.[127]

Rowe *et al.*[67] conducted a meta-analysis to compare the consistency of outcomes among several studies. Of a total of 1 910 patients, 1 459 received brace treatment, 322 electrostimulation, and 129 only observation. The weighted mean success rate was 0.39 for electrostimulation, 0.49 for observation, 0.60 for braces worn 8 h daily, 0.62 for braces worn 16 h daily, and 0.93 for braces worn 23 h daily, the last of which was the statistically most efficacious treatment method (P<0.0001). The most efficacious brace system was the Milwaukee brace (0.99) *vs* others (0.90), while the Charleston brace, which was worn only nighttimes, was the least successful (0.60) yet statistically still better than observation alone. This study contains certain limitations, however, particularly because it compares treatments prescribed by different physicians in different contexts, thus leading to results that are difficult to compare.

Studies on the 3D effect of corrective braces are few and still experimental in design,[131] due to the complexity of such studies.[26]

Recent studies on the Chêneau and the Charleston brace systems [21, 67, 132] have shown the attention the investigators place on brace construction using computer-aided design which, based on radiographic data, permits the creation of braces found to be more corrective on the 3D plane. At conferences, however, many operators have argued against the usefulness of computer-aided design in brace construction, preferring more conventional methods with plaster casting instead. Research into part-time-use braces is integrated with numerous recent studies that evaluate the often negative psychological impact of full-time braces on patients in long-term treatment.[133-135]

Concluding with a statement by Winter,[118] "The analysis of these different studies is difficult. Many surgeons looking at these results say that if the curve remains the same before and after treatment, the therapy is totally useless. Others, watching the same data, are admired by the results they consider good for having stopped the worsening of scoliosis and having spared these lucky adolescents surgical treatment".

Recommendations

— Brace treatment is recommended in the conservative therapy of idiopathic scoliosis (C).

— Brace treatment is not recommended in treating curves with a Cobb angle <15±5°, unless otherwise justified in the opinion of a clinician specialized in spinal diseases (E1).

— Brace treatment is recommended in treating patients curves with a Cobb angle >20±5°, future growth potential, and demonstrated progression of deformity or elevated risk of worsening, unless otherwise justified in the opinion of a clinician specialized in spinal diseases (C).

— A fixed brace (plaster or fiberglass) is recommended in treating curves with a Cobb angle >40±5°, unless otherwise justified in the opinion of a clinician specialized in spinal diseases (E2).

— Braces should be worn full time or no less than 18 h at the beginning of treatment, unless otherwise justified in the opinion of a clinician specialized in spinal diseases (E3).

— Braces should be worn and the wearing time gradually reduced until the end of vertebral bone growth (E2).

— The brace system should be specifically designed for the curve to be treated (E1).

— Brace systems proposed for treating scoliotic deformity on the frontal and horizontal planes should take into account the sagittal plane as far as possible (E3).

— The least invasive brace in relation to the clinical situation should be used to reduce its psychological impact and to ensure better patient compliance (E1).

— Braces should not so restrict thorax excursion that it reduces respiratory function (E1).

— The specialist should accurately inform the patient about the length of time the prescribed brace is to be worn (E1).

— Removable braces should be prescribed, constructed and fitted on an ambulatory basis (E1).

— A specific treatment team should be constituted (not necessarily directly working together), with close cooperation between the prescribing physician and the brace examiner, the orthotist constructing the brace and the rehabilitationist (E3).

— Braces should be constructed by an orthotist specialized in the construction of the prescribed brace system (E1).

— The brace system should be examined by the prescribing physician who shall personally verify the validity of the brace constructed by the orthotist and propose (and verify) all necessary corrections to ensure major brace efficacy and tolerability (E1).

— The construction and testing of a fixed plaster or fiberglass brace should be performed in a specialized setting (E1).

— A fixed plaster or fiberglass brace should be constructed *manu medica* (E1).

Deformities on the sagittal plane

Definition

Sagittal spinal deformities are defined as posterior (kyphosis) or anterior (lordosis) anomalies of the vertebral column, irreducible to various extent, due to alterations of various origin in disco-ligamentous and bone structures. Since the anomalies are comprised within the physiological curvature of the spine, they may be greatly augmented (thoracic hyperkyphosis and/or lumbar hyperlordosis) or diminished (thoracic lordosis and/or lumbar kyphosis).

The most common type of anomaly is Scheuermann's juvenile thoracic kyphosis (round back), which is caused by a minor growth in height of the anterior part of the vertebral bodies. In its classic form, 3 or more adjacent vertebrae present radiolographically, usually in the medial thoracic segment, with an anterior wedge deformity ≥5°.[136, 137] Sometimes, however, only 1 or 2 vertebrae are wedge-shaped.[138] The typical vertebral body end plates altrations (thickening, undulation, Schmorl's nodules, anomalies of the ringapophysis) may involve the non-wedge-shaped vertebrae or even be absent in the wedge-shaped vertebrae.[138] Sometimes the deformity may be associated with rachalgia due to movement and posture (mechanical backache).[137]

Although the etiology of the deformity is unknown, it is believed that due to primary histopathologic alterations in the fertile cartilage,[139, 140] vertebral body growth is inhibited by secondary mechanical factors.[141, 142]

Since physiological thoracic kyphosis in adolescence at standing radiographic evaluation ranges between 20-25° and 40-45°,[138, 143] Scheuermann's disease is generally considered mild when kyphosis is <50°, moderately severe from 50° to 70°, and severe over 70° to 75°.[138, 143, 144] However, when the deformity is located outside the physiological range of kyphosis, it is always considered pathological, regardless of the degree of the angle.[143]

A relatively unknown variant of the disease is found at the thoracolumbar level or in the lumbar area of the spine as a form of angular kyphosis, which is normally only slightly apparent due to the involvement of only 1 or 2 vertebrae (atypical lumbar Scheuermann's disease). This form is often the cause of low back pain, especially in the presence of excessive mechanical stress.[145, 146]

In prepuberty and adolescence, structural curves, because they are clinically less important, should be distinguished from functional curves that can be corrected (postural round back or kyphosis, postural lumbar hyperlordosis), which can, however, potentially undergo structuring.[138]

Psychological discomfort (body image, self-esteem) caused by thoracic deformity should not be underestimated.[147, 148]

Results

To date there is no definitive scientific evidence for establishing an assessment protocol. Published studies report indications about the following steps in evaluation.

— History taking (age at onset, family history, previous pathologies that could have caused kyphosis, social status).

— General evaluation to rule out comordibities.

— Examination of the skin, especially in the spinal area (hyperchromia, nevi, angiomas, neuromas).

— Examination of the spine on 3 planes in standing and bending positions (deviation on the sagittal plane of the line of spinal apophyses, frontal and transversal asymmetry of the trunk due to concomitant scoliosis).

— Surface measurements of the sagittal curves of the spine (inclinometer, arcometer, arrows, etc.).[1, 149-151]

— Evaluation of spinal mobility on various planes, particularly in anterior flexion (measurement of the range of motion of the spine and the pelvis).

— Evaluation of the degree of active reducibility of sagittal deviations according to various tests.

— Evaluation of tenderness on palpation and mobilization.

— Evaluation of the presence of laxity or capsulomyoligamentous retraction.

— Neurological assessment.

— Radiologic examination of the spine in anteroposterior and lateral projections, global and segmental, in standing and in supine positions (identification of structural alterations in the vertebrae, measurement of curves and wedge deformities of the vertebra with the Cobb method, measurement of the degree of curve reducibility, evaluation of the degree of spinal maturity based on Risser grading and ringapophysis).[1, 152]

In special cases, the following studies may be proposed:

— Imaging studies using MRI, CT, bone scintigraphy.

— Laboratory determinations (inflammation, etc.).

Recommendations

— On screening and general physical examination, pediatricians, internists and sports physicians should also evaluate the spine sagitally in children aged from 10 to 17 years (E3).

— Evaluation of patients with spinal deformities on the sagittal plane should be performed by a physician specialized in spinal diseases (E1).

— Patients with spinal deformities on the sagittal plane should be examined by the same physician. When this is not possible, the use of validated methods and standardized data collection forms is recommended (E2).

— Evaluation of patients with spinal deformities on the sagittal plane should be comprehensive, including clinical and radiographic assessment (E1).

— A comprehensive evaluation of the patient should comprise pathologic, cosmetic, psychological, functional and familial aspects (E2).

— History taking should be conducted during visits (E3).

— A non-invasive method of surface measurement should be used to document patient follow-up (E3).

— Sequential collection of clinical and diagnostic data should be recorded on specific forms (E2).

— Follow-up visits should be conducted every 6 months or more often in at-risk patients (E3).

— The decision to order radiographic studies should be left to the specialist (E3).

— Deformities should be measured using the Cobb method on the radiograph (E1).

— To reduce the invasiveness of follow-up procedures, no more than 1 radiographic study per year should be performed (E3).

Treatment

Results

To date there is no scientific evidence based on randomized controlled studies for the establishment of a treatment protocol. The treatment objectives obtained from the analysis of the literature are:

— Correction or containment of the progression of the curve and vertebral lesions.

— Improvement in biomechanical efficiency of the spinal support structures.

— Improvement in body neuromotor control.

— Improvement in cosmesis.

— Containment of psychological stress.

— Reduction in pain symptoms.

The choice of treatment depends on the presence of one or more of the following parameters.

Criteria for selecting specific exercises:[143, 153-163]

— Cobb angle >45±5°;

— optimal or total curves reducibility.

Criteria for selecting a spinal brace system:[1, 138, 144, 147, 154, 158, 161, 162, 164-168]

— Cobb angle >55±5°;

— good but incomplete curve reducibility;

— thoracolumbar and lumbar kyphosis.

Selection criteria for plaster braces:[1, 138, 158, 162, 167, 168]

— Cobb angle >65±5°;

— diminished curve reducibility.

Selection criteria for surgical treatment:[138, 147, 157, 163-165, 167, 169, 170]

— Cobb angle >75±5° and outcome of conservative treatment unsatisfactory for the patient;

— pain resistant to conservative treatment.

There are indications on the usefulness of specific exercises in association with brace treatment, plaster braces or surgical therapy.[138, 158, 159, 161, 163, 166, 168]

Recommendations

— The choice of therapeutic options should be made by a clinician specialized in spinal diseases on the basis of information from history taking, physical examination and diagnostic studies (E1).

— Kyphosis with a Cobb angle <45±5° should not be treated with specific therapy, unless otherwise justified in the opinion of a clinician specialized in spinal diseases (E1).

— Thoracolumbar and lumbar kyphosis should always be treated with specific therapy (E1).

— Specific exercises are recommended as a first step in the therapeutic approach to hyperkyphosis, also in functional forms (postural), since they may progress to stiffness and structuring (E2).

— Exercise programs should be proposed and conducted by a specialized rehabilitationist (E2).

— Exercises should be performed individually or, even better, in small groups with personalized programs (E3).

— Exercises should be practiced regularly (E2).

— Exercise programs should be personalized according to patient needs (E2).

— The goals of the exercise program are to improve postural control of the spine, balance and proprioception and to strengthen muscle tone of the back muscles (E2).

— Patients should be trained to maintain a correct posture in activities of daily living and involved in a comprehensive ergonomic training program (E1).

— Brace treatment is recommended in the conservative treatment for hyperkyphosis (E1).

— Brace treatment is recommended for hyperkyphosis with Cobb angle >55±5°, good but incomplete curve corrigibility and future growth potential, unless otherwise justified in the opinion of a clinician specialized in spinal diseases (E2).

— The use of a preliminary fixed brace (plaster or fiberglass) is recommended in treating hyperkyphosis with a Cobb angle >65±5°, reduced curve corrigibility and future growth potential, unless otherwise justified in the opinion of a clinician specialized in spinal diseases (E2).

— Braces should be specifically designed for the curve to be treated (E1).

— The least invasive brace in relation to the clinical situation should be used to reduce the psychological impact of the device on the patient and to improve patient compliance (E1).

— The specialist should accurately inform the patient about the number of hours the brace should be worn, in relation to the type of system prescribed and extent of the deformity (E1).

— Removable braces should be prescribed, constructed and tested on an ambulatory basis (E1).

— A specific treatment team should be constituted (not necessarily directly working together), with close cooperation between the prescribing physician and the brace tester, the orthotist constructing the brace and the rehabilitationist (E2).

— Braces should be constructed by an orthotist specialized in the construction of the prescribed brace system (E1).

— The brace system should be examined by the prescribing physician who shall personally verify the validity of the brace constructed by the orthotist and propose (and verify) all necessary corrections to ensure major brace efficacy and tolerability (E2).

— Construction and testing of a fixed plaster or fiberglass brace should be performed in a specialized setting (E1).

— A fixed plaster or fiberglass brace should be constructed *manu medica* (E1).

— Brace treatment should always be combined with a specific exercise program (C).

— Mobilization exercises should be practiced in preparation for brace treatment (E1).

TABLE III.—*Summary of recommendations.*

	Related references (No.)	Recommendations (No.)	A (No.)	B (No.)	C (No.)	D (No.)	E1 (No.)	E2 (No.)	E3 (No.)
Scoliosis									
— Definition	11	—	—	—	—	—	—	—	—
— Evaluation	21	24	—	—	—	—	9	9	6
— Kinesitherapy and specific exercises	38	15	—	—	1	1	3	8	3
— Kinesitherapy and respiratory exercises	15	1	—	—	—	1	—	—	—
— Kinesitherapy and brace exercises	8	6	—	1	1	—	1	3	—
— Sports	16	6	—	—	—	1	—	4	1
— Brace treatment	26	16	—	—	2	—	10	2	2
Total	135	68	0	1	4	3	23	26	12
Deformity on sagittal plane									
— Definition	11		—	—	—	—	—	—	—
— Evaluation	5	12	—	—	—	—	3	3	6
— Therapy	22	32	—	—	1	—	13	15	3
Total	38	44	0	0	1	0	16	18	9

— In brace exercises should be performed to strengthen muscle tone (E1).

— Exercises in posture and function training are recommended, particularly during weaning off the brace and the postsurgical period (E1).

— Sports activities should not be prescribed as treatment for sagittal plane deformities (E2).

— General sports activities are recommended which offer patients aspecific benefits in terms of psychological, neuromotor and general organic well-being (E2).

— During all treatment phases, physical education at school should be continued (E2).

— Sports activities should be continued also during brace treatment because of the physical and psychological benefits these activities provide (E3).

— A sedentary lifestyle should be discouraged as it constitutes a negative factor for the pathomechanics of hyperkyphosis (E2).

— In atypical Scheuermann's lumbar disease, particularly in the presence of severe lumbar pain, excessive mechanical stress on the spine should be avoided, as with several competitive types of sports (E2).

Conclusions

In concluding this review of the literature for establishing guidelines on the rehabilitation treatment of spinal deformities in adolescence, it appeared useful to emphasize the unique nature of this initiative, which has no international counterpart, and to highlight the sheer number of studies we found that lacked a scientific basis. As can be seen from the Table III, all recommendations, except one instance of type B evidence, fall within class C or lower, with the bulk of them in class E.

This circumstance led us to subdivide class E to give a better idea of the extent of scientific consensus in the literature. Here it appears necessary to underline how difficult it is in rehabilitation medicine to design and carry out studies according to rigorous criteria of evidence-based medicine. This may derive from various factors, including:

— the difficulty in defining inclusion and exclusion criteria, as with recruiting homogenous study samples due to highly variable patient characteristics;

— the difficulty in standardizing treatment due to the number of variables: type of physiotherapy (method), brace style, patient and family compliance;

— the difficulties intrinsic to the discipline itself. In rehabilitation treatment with the direct intervention of a rehabilitationist, including specific exercise and specific exercise programs for scoliosis, it is impossible to render the operator "blind" to the type of treatment the patient receives, and similarly so the patient;

— the difficulty in finding adequate case series and reliable data on the natural history of the untreated disease.

Moreover, it should not be forgotten that every scientific discipline requires a long, complex maturation process before it can produce quality studies and that rehabilitation medicine is one of the most recent autonomous branches of medicine. It is also important to remember the important role the pharmaceutical industry plays in providing incentives for conducting quality studies; the lack of incentives from drugs firms is a drawback to having research in rehabilitation published.

Having said this, we should not elude ourselves to thinking that our future work will be based exclusively on consensus. It is hoped, therefore, that more scientific research will be conducted using methodological criteria to fill the current gap.

It also appeared necessary to emphasize that the recommendations reported here do not constitute a recipe. Health care professionals need to operate the choices they think are the most appropriate to their knowledge and understanding, within the indications given by the literature, where available, based on their clinical skills, in response to the needs of their patients, who remain the unique reference point (and hence a possible exception to a forcibly non definitive scientific rule).

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