International SportMed Journal, Vol. 9 No.3, 2008
pp.131-140, http://www.ismj.com

ISMJ

International SportMed Journal

FIMS Position Statement

Scoliosis and sports participation

[*1]Professor Jan L Gielen, MD, PhD, [2]Dr Els Van den Eede, MD

[1]Department of Radiology and Medical Imaging, University Hospital Antwerp, Edegem, Belgium
[2]Department of Physical Medicine and Rehabilitation, University Hospital Pellenberg, Pellenberg, Belgium

Introduction

As the prevalence of health problems associated with a sedentary lifestyle increases, there is a worldwide promotion of sporting activities to stimulate physical activity. Hence the number of children and adolescents participating in recreational and competitive sports is growing. As a consequence, more children will seek a pre-participation physical examination. During this evaluation, scoliosis is often detected for the first time. In order to give adequate information, a physician dealing with children and adolescents has to have knowledge about scoliosis, its progression and potential complications.

***Dr Jan L Gielen, MD, PhD**

Dr Gielen is the Vice-Chairman of the Department of Radiology (Musculoskeletal and Sports Radiology) at the University Hospital Antwerp. Also, he is the Coordinator of the Department of Sports Medicine.

Dr Gielen is a Visiting Professor to the Department of Morphology, Faculty of Medicine, Antwerp University and University Hospital, Edegem, Belgium.

Dr Els Van den Eede, MD

Dr Van den Eede's interests are in physiotherapy, rehabilitation and sports medicine at the MaartensKliniek, Nijmegen, The Netherlands. He has a special interest in the imaging of orthopaedic sports lesions. His main research interests are in stress-related muscle and tendon physiology and disease.

Dr Van den Eede is the President of the Flemish Society of Sports Medicine (VVS). He was the Organiser of the STMS Congress in 2007 (Society for Tennis Medicine and Science) held in Antwerp, Belgium.

[*]Corresponding author. Address at the end of text.

Dr Van den Eede is the author and co-editor of *Imaging in Orthopaedic Sports Injuries,* published in 2006 by Springer Verlag.

Email: elsvdeede@gmail.com

Scoliosis: Subtypes and aetiology

Scoliosis is defined by the Scoliosis Research Society as a lateral deviation of the normal vertical line of the spine which, when measured by PA (postero-anterior) spine X-ray, is greater than ten degrees (Figure 1). Scoliosis consists of a lateral curvature of the spine; however in many cases it is a more complex three-dimensional spinal deformity [1], with rotation of the vertebrae within the curve (Figure 1). Scoliosis often presents during the adolescent growth spurt.

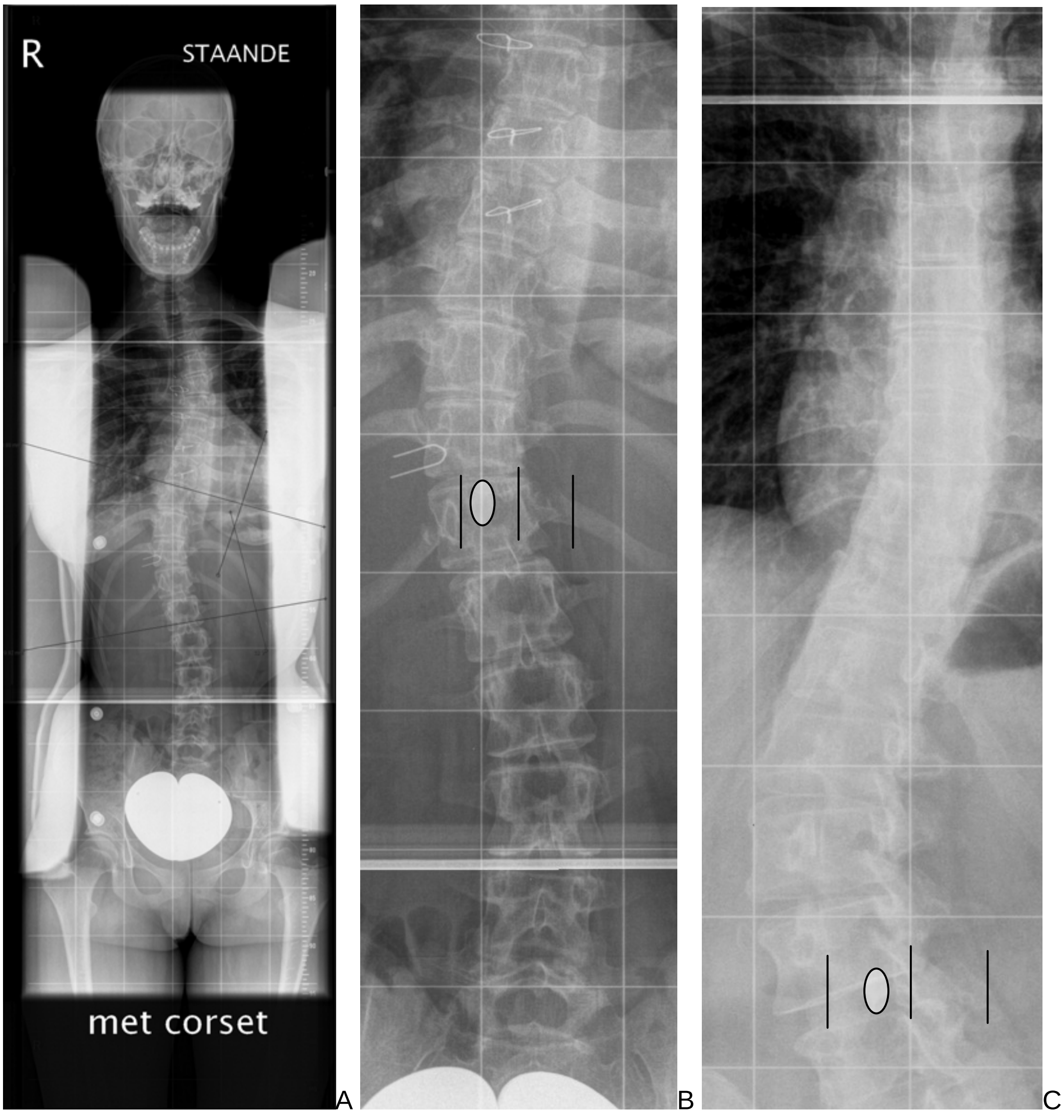

Figure 1A-C: Radiological assessment of lateral and rotational scoliosis components

<u>Figure 1A:</u> The lateral scoliosis component is measured by calculating the angle between a line along the upper endplate of the upper body and a line along the lower endplate of the lower body of the end-vertebrae (shown above). The end vertebrae are at the upper and lower limits of the curve and tilt most severely toward the concavity of the curve. The angle between both lines is defined as Cobb's angle. If the endplates are not well established a line along the top and bottom of the pedicles of the end-vertebrae may be used as alternative. In follow up examinations of scoliosis these end-vertebrae are constant and should be mentioned in the

radiological report. Figures 1B and C: The radiologist should also estimate the rotational scoliosis component at the apex of the curvature. This is done by evaluation of the pedicle position relative to the midline of the vertebral body (vertical line). Five rotation grades are distinguished. In grade 0 no rotational component is present. In grade 3 the pedicle is projected on the midline of the vertebral body. In grade 4 the pedicle is projected on the contra-lateral half of the vertebral body. In grade 2 (Figure 1B) and grade 3 (Figure 1C) the pedicle is rotated more or less than 2/3 to the midline respectively. (Figures 1A and B are of the same patient).

Scoliosis is a descriptive term, not a diagnosis. Although in most patients, the cause of scoliosis remains unclear, the physician has to rule out other causes, before calling it an idiopathic scoliosis.

Scoliosis can be divided into two main types: (i) non-structural and (ii) structural scoliosis.

(i) In non-structural scoliosis, there is no deformity of the vertebrae, and the deviation is seldom more than 10 degrees. The lateral curvature disappears with lateral bending to the convex side. Non-structural scoliosis can be due to poor core stability (postural scoliosis), or to compensatory conditions, resulting from tilting of the pelvis from real or apparent shortening of one leg (compensatory scoliosis). Sometimes scoliosis is caused by a unilateral protective muscle spasm, as in some cases of prolapsed vertebral disc. Non-structural scoliosis does not develop to structural scoliosis.

(ii) Structural scoliosis is characterised by a deformity of the vertebrae. Physical examination reveals that lateral bending does not influence the deformity, or even worsen it. This type of scoliosis can be divided in two subgroups: a group with a clear underlying cause and a group where the cause is unknown: the *idiopathic* scoliosis. By far the largest group of structural scoliosis is idiopathic in nature.

In the *non-idiopathic* scoliosis group, due to bony abnormalities of the spine, the cause can be *congenital*. This can lead to fast progression of the curvature during growth. Congenital scoliosis is often associated with urogenital defects. Open congenital scoliosis goes hand in hand with neurological deficits (Figure 2).

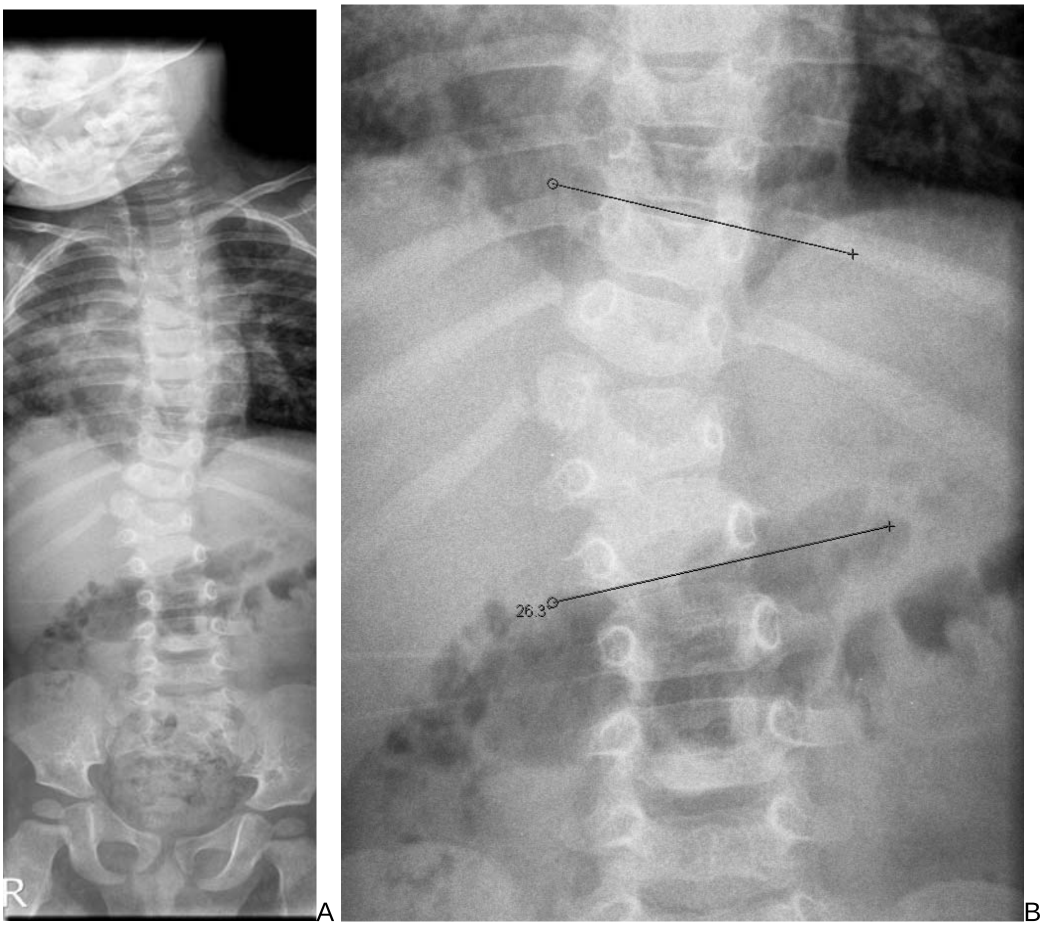

Figure 2: Non-idiopathic structural scoliosis

Structural scoliosis is caused by congenital hemivertebrum of the 12th thoracic vertebrum that is absent on the left side. According to Cobb, right convex lateral scoliosis of 26° between the upper endplate of Th10 and lower endplate of L2. There is no rotational component.

Neuromuscular disorders are often associated with scoliosis, due to weakness of the spinal musculature or trunk tone asymmetry. Other diseases, with a high incidence of scoliosis are neurofibromatosis (von Recklinghausen disease) and *mesenchymal disorders* such as Marfan's Syndrome and Ehlers-Danlos Syndrome. In later life, scoliosis is often seen as a consequence of *degenerative* spondylosis.

However, in 80% of cases of structural scoliosis, the cause remains unclear, although a great deal of research and effort has been put into clarifying the underlying cause of the *idiopathic* scoliosis. Prevalence of idiopathic scoliosis has been estimated between 0.5% [2] and 4.5% [3] of the population. A meta-analysis of the literature of idiopathic adolescent scoliosis in twins [4] reveals a significantly higher rate of concordance in monozygous twins than in dizygous twins, which provides strong evidence for a genetic aetiology. Awaiting further understanding about the aetiopathology of scoliosis, idiopathic scoliosis is classified according to the age of the patient at the time of diagnosis.

Infantile idiopathic scoliosis is diagnosed before the age of 3 years. Children diagnosed between 3- and 10-years-old suffer from *juvenile idiopathic scoliosis,* while those older than 10-years-old at the time of diagnosis suffer from *adolescent idiopathic scoliosis.* Although this classification was already proposed by James [5] in 1954, and is apparently arbitrary, it has an important prognostic significance. Infantile scoliosis is the only type of idiopathic scoliosis with a possible spontaneous resolution and is found more frequently in boys than in girls.

International SportMed Journal, Vol. 9 No.3, 2008
pp.131-140, http://www.ismj.com

Another characteristic that distinguishes infantile idiopathic scoliosis from the other categories is the left thoracic curve pattern, instead of right thoracic curve common in juvenile and adolescent idiopathic scoliosis.

Juvenile idiopathic scoliosis is found more frequently in girls and the curve pattern is in most cases dextroconvex thoracal. It has a high rate of curve progression [6] and almost 70% of these patients end up undergoing surgery. Therefore it is often considered as a malignant subtype of adolescent idiopathic scoliosis. In adolescent idiopathic scoliosis, more girls than boys are affected, and most of them show a dextroconvex thoracal curvature and a sinistroconvex lumbal curvature. A sinistroconvex thoracal curvature is rare and requires further evaluation, because there is often an underlying cause, such as syringomyely. The younger the onset of this type of scoliosis, and the greater the curve at discovery, the more chance that the curve will progress to pathologic levels.

Table 1: Scoliosis: Subtypes and aetiology

Non-structural scoliosis	
Postural scoliosis	
Compensatory scoliosis	
Antalgic scoliosis	
Structural scoliosis	
Non-idiopathic	***Idiopathic***
Congenital	Infantile
Neuromuscular disorders	Juvenile
Neurofibromatosis	Adolescent
Mesenchymal disorders	
Degenerative	

Scoliosis: Diagnoses

History and physical examination

Medical history

The most important component of preparticipation physical examination (PPE) is a medical history. In the case of a newly diagnosed scoliosis, special attention should be focused on possible underlying diseases. Severe pain or pain at night in a newly diagnosed scoliosis is considered as a red flag and can point to a possible tumour. Changes in bowel or bladder function indicate possible neurological disorders. Information of other family members with spinal deformity can be useful.

Traditionally, scoliosis is considered as a painless condition, but more recent studies show a higher incidence of back pain in scoliosis patients [7].

Physical examination

In children and adolescents performing asymmetric sports, an asymmetry in trunk musculature is sometimes seen even at a young age. The muscle hypertrophy on the dominant side can give the impression of scoliosis. Even the Adam’s forward bending test can be positive in such a case. Careful examination is required to distinguish this from genuine scoliosis. In structural scoliosis, a full spine PA X-ray should be performed. In non-structural scoliosis, leg length discrepancy is the most common cause.

A physical examination for scoliosis should start with an assessment of the body posture. A left thoracic curve in an adolescent patient is considered a red flag, suggesting underlying pathology.

The second goal of physical examination is to make a distinction between structural or non-structural scoliosis. In non-structural scoliosis, the curve is corrected by lateral bending towards the convex side. In

International SportMed Journal, Vol. 9 No.3, 2008
pp.131-140, http://www.ismj.com

scoliosis due to leg length discrepancy and poor core stability, the scoliosis will disappear when the patient is seated.

In structural scoliosis, the curve remains during sitting and with lateral bending to the convex side. When bending forward, a rib hump is present. The Adam's forward bending test, in conjunction with a scoliometer has long been found to be an effective screening tool. However, there are recent data suggesting that it is not a good screening method and it has been taken out of USA schools [8]. If a rib hump is noted in the Adam's forward bending test, the patient should be sent for an upright full spine PA X-ray to confirm the diagnosis.

In patients with structural scoliosis, a distinction has to be made between idiopathic scoliosis and scoliosis due to an underlying pathology. Symptoms of underlying pathology should be considered. Therefore a neurological examination that includes assessment of extremity and abdominal reflexes, ataxia and balance is required. Careful examination of the skin is important as café-au-lait spots may suggest neurofibromatosis. Hypersensibility of the skin is one of the features of Ehlers-Danlos Syndrome during PPE. A fat pad or hairy patch is suggestive of spina bifida.

Tall stature, together with hypermobility, is an advantage in many sports, but can be associated with Marfan's Syndrome. In Marfan's Syndrome, scoliosis is often associated with tall stature, decreased upper:lower segment ratio; arm span:height ratio >1.05, arachnodactily, pectus deformities or lens dislocation. Since a new mutation is uncommon, and the typical features of skeletal disorders, lens dislocation, and cardiovascular abnormalities can be inherited independently, the diagnosis is often missed unless at least one family member has characteristic changes in at least two of the three connective tissue systems. As in patients with Marfan's Syndrome, mitral valve prolapse and aortic aneurysm are common, a thorough cardioascular evaluation is recommended, especially those presenting with scoliosis and other skeletal characteristics of Marfan's Syndrome.

Finally, since curve progression depends on skeletal growth, assessment of the physiological maturity, using Tanner and Whitehouse or Greulich and Pile bone maturity staging can be added to the physical examination; however, a more accurate skeletal maturity determination, such as a Risser score, is often required.

Table 2: Signs of underlying cause of scoliosis

Red flags
Severe pain
Changes in bladder and bowel function
Left thoracic curve
Abnormal neurological examination

Scoliosis: History and complications

Non-idiopathic scoliosis

In non-idiopathic scoliosis, the progression risk depends on the underlying cause. In congenital scoliosis, curve progression risk is dependent on vertebral malformation. In neuromuscular scoliosis, such as muscular dystrophy, the curve increases as walking ability diminishes.

Idiopathic scoliosis

Curve progression risk

In only about 0.25% of cases, the curve progresses to the point where treatment with brace is warranted. Girls with a skeletal age of less than 16 years and a curve of between 30° and 60°, have a risk of curve progression of between 70% and 90 %. Curves of less than 30° in a mature patient do usually not progress.

Mortality

There are a few studies with long-term follow-up of untreated idiopathic scoliosis. Adolescent idiopathic scoliosis does not result in an increased mortality rate [9]. However, in patients with a curve greater than 110° and a vital capacity of less than 45% predicted for age and size, respiratory failure can occur, which results in a mortality rate twice as high as in the general population [10].

Pulmonary dysfunction

In patients with curves greater than 80°, an increase in dyspnoea is noticed. For patients with smaller curves, dyspnoea seems not to be increased [11]. Patients are often unaware of their pulmonary limitations and measured, pulmonary dysfunction can be affected, even in patients with relatively small curves [12].

Pain

Although, scoliosis is often considered as a painless condition, pain is common in the adult scoliosis patient [7]. In a large study, scoliosis patients showed a higher incidence of pain ten years after diagnosis in adolescence. Similar results were reported >44 years after diagnosis. Incidences of chronic pain were almost threefold higher in scoliosis patients [13].

Function

Based on questionnaires, small-scale scoliosis may create difficulties for carrying out physical activities, particularly in females with curves greater than 40°. Exercise capacity can therefore be reduced, due to decreased mobility of the chest wall.

Self-image

Self-image, measured by a validated questionnaire, was significantly worse in scoliosis patients than in the control group [13].

Scoliosis: Treatment

Curve progression is most likely to occur during growth. As curvatures of more than 40° at maturity tend to be progressive, the risk of developing pulmonary dysfunction exists. The aim of treatment in general is to maintain function and to prevent symptoms, and the goal of scoliosis management is the prevention of further curve progression. Treatment decisions should be left to an experienced orthopaedic surgeon.

Observation

In general, for curves less than 20°-25°, observation is recommended. Until maturity has been reached, X-rays of the spine should be performed every six months. When the curve progression is more than 5° at six-month intervals, bracing should be considered [14]. Little evidence exists about the effectiveness of an exercise programme for preventing the progression of the curve.

Bracing

Bracing is the treatment of choice in curves of between 20°, 40° and 50° [14]. Systematic reviews [15, 16] showed that bracing is significantly more effective than electrical stimulation, or no treatment. The goal of bracing is to prevent curve progression. Curve normalisation cannot be expected. The most common braces are the Milwaukee brace, the Boston brace and the Charleston brace. There is still confusion about the effectiveness of part-time bracing compared to full-time bracing [17]. Some studies show no difference between these options, while others are in favour of full-time bracing. In these authors' experience, most orthopaedic surgeons recommend wearing of the brace full-time, which means 24-hours-a-day. Because this results in an under-stimulation of trunk musculature, exercise therapy and physical activity is often recommended. However, there is no scientific evidence to support the adjuvant effect of exercise on bracing.

Surgery

Surgery is usually recommended in curves greater than 40°-50° [14]. In patients with neuromuscular scoliosis, surgery is performed when the scoliosis interferes with sitting and care, or when pulmonary function is affected. The aim of surgery is prevention of further curve progression. The curve is corrected as much as possible, but complete straightening is rarely achieved. Surgery of scoliosis should be reserved for specialised

International SportMed Journal, Vol. 9 No.3, 2008
pp.131-140, http://www.ismj.com

orthopaedic surgeons. Spinal fusion is the most widely performed surgery for scoliosis. Modern spinal fusions have generally good results. New methods, such as retarding the normal growth on the convex side, are still being developed.

Scoliosis and the preparticipation examination

As more children are involved in competitive sporting activities, more children apply to the sports physician for a preparticipation examination. In this age group, scoliosis is most likely to be encountered. A sports physician needs to pay sufficient attention to this as early diagnosis and treatment can prevent further curve progression.

Medical history

The most important component of the PPE is a medical history. Besides more general medical information, in case of the assumption of scoliosis, a medical history should reveal if the scoliosis had been previously diagnosed. In such a case, more details are required, such as, age at diagnosis, Cobb angle, underlying pathology, family history, the physician in attendance, etc. In order to obtain accurate information, it is imperative that the medical history form is available well in advance.

In the case of a newly diagnosed scoliosis, special attention must be paid to possible underlying diseases. Serious neuromuscular diseases are usually known at the time of a PPE. Severe pain or pain at night in a formerly unknown scoliosis is considered a red flag as it can point to a tumour. Changes in bowel or bladder function may indicate neurological disorders.

Physical examination

Besides the cardiovascular assessment, the sports physician should also focus on the musculoskeletal examination. As most sports physicians are well trained to administer a musculoskeletal examination, they are often the first to discover a scoliosis.

In children and adolescents performing asymmetric sports, an asymmetry in the patient's trunk musculature is sometimes seen even at a young age. The muscle hypertrophy on the dominant side can give the impression of scoliosis. Even the Adam's forward bending test can be positive in this case. Careful examination is therefore needed to distinguish the hypertrophy from a genuine scoliosis. The Adam's forward bending test is very sensitive for structural scoliosis, but it is not specific. In most cases, but not in all cases, it can distinguish a non-structural from a structural scoliosis. In case of an assumption of a structural scoliosis, a full spine PA X-ray should be performed.

In non-structural scoliosis, leg length discrepancy is the most common cause. Furthermore, symptoms of underlying pathology should also be considered. A tall stature, together with hypermobility, is an advantage in many sports, but can go hand-in-hand with Marfan's Syndrome. Since a new mutation is seldom seen, and the typical features of skeletal disorders, lens dislocation, cardiovascular abnormalities can be inherited independently, the correct diagnosis is often missed. As in patients with Marfan's Syndrome, mitral valve prolapse and aortic aneurysm are common, a thorough cardiologic evaluation should be performed in athletes presenting with scoliosis and other skeletal characteristics of Marfan's Syndrome, such as tall stature, decreased upper:lower segment ratio; arm span:height ratio >1,05, arachnodactily, and pectus deformities.

In patients with scoliosis, a careful examination of the skin is important. Café-au-lait spots may suggest neurofibromatosis. Hyperextensibility of the skin is one of the features of Ehlers-Danlos Syndrome. In sports requiring great flexibility, it is not unusual that an athlete with Ehlers-Danlos Syndrome attends a PPE. Finally, since curve progression is dependent on skeletal growth, assessment of the physiological maturity, using Tanner staging, can be included in the physical examination.

Scoliosis and sports recommendations

In general, there is little scientific evidence related sports participation and scoliosis (see Table 3).

Table 3: Participation recommendations

Non-structural scoliosis	**Recommendations**
Postural scoliosis	No sports participation restrictions
Compensatory scoliosis	No sports participation restrictions
Antalgic scoliosis	Physician follow-up indicated
Structural scoliosis	
Non-idiopathic and idiopathic	
Back strenuous sports (weight lifting, gymnastics, shot-putting, javelin throwing, rugby football, bodybuilding, golf)	No sports participation in cases of back pain Physician follow-up indicated
Low strenuous sports for the back (swimming)	No sports participation restrictions
Intermediate strenuous sports for the back (cycling, running, skiing, tennis, soccer, etc)	Sports participation not indicated in cases of back pain

In patients with *non-structural scoliosis*, there are no restrictions on sports participation. On the other hand, patients with postural scoliosis will benefit from sports participation. Most people with structural scoliosis are able to participate normally in sports and recreational exercise.

In *non-idiopathic scoliosis,* a sports recommendation is dependent on the underlying disease. In *idiopathic scoliosis*, there is no evidence that sports participation is detrimental to the scoliosis. As scoliosis is not caused by carrying heavy weights or athletic involvement, it is unlikely that participation in sports will influence the progress of scoliosis. However, during growth spurts, careful monitoring of curve angles is recommended.

Sports benefits

Sports can stimulate self-esteem and physical fitness, which are often diminished in scoliosis patients. For the same reason, children or adolescents treated with bracing are usually allowed to take off the brace for sports participation. Moreover, Athanasopoulos [18] showed a significant increased pulmonary function in girls with idiopathic scoliosis, training four times a week with 30 minutes on the cycloergometer for two months. Sports with extreme axial loading, such as weight-lifting or where there are extreme hyperlordosis patterns, are potentially harmful and require careful monitoring.

Sports restriction

The fact that back pain is more frequent in scoliosis patients, competing in strenuous sports at a high level can be difficult for the patient. In older athletes, early development of osteoarthritis in the spine may hamper sports participation. Patients with severe scoliosis, leading to impaired pulmonary function, may be restricted in strenuous exercise. Post surgery, vigorous sports may be restricted for the patient with scoliosis for at least one year in order to attain a solid fusion. Thereafter sport recommendations should be individualised. The loss of flexibility depends on the extent of the fusion. In general, most surgeons recommend sports at the recreational level, but dissuade patients to partake in competitive sports after scoliosis surgery.

Address for correspondence:

Dr Jan L Gielen, Department of Radiology and Medical Imaging, University Hospital Antwerp, Edegem, Belgium.

Email: Jan.Gielen@uza.be

References

1. Asher MA, Burton DC. A concept of idiopathic scoliosis deformities as imperfect torsion(s). Clin Orthop 1999 Jul (364):11-25
2. Stirling AJ, Howel D, Millner PA, et al. Late-onset idiopathic scoliosis in children six to fourteen years old: A

cross-sectional prevalence study. J Bone Joint Surg Am 1996 Sep; 78(9):1330-1336
3. Rogola EJ, Drummond DS, Gurr J. Scoliosis: Incidence and natural history: A prospective epidemiological study. J Bone Joint Surg Am 1978 Mar; 60(2):173-176
4. Kesling KL, Reinker KA. Scoliosis in twins: A meta-analysis of the literature and report of six cases. Spine 1997; 22(17):2009-2014
5. James JI. Scoliosis in children. Br J Radiol 1954; 27(321): 511-523.
6. Robinson CM, McMaster MJ. Juvenile idiopathic scoliosis: Curve patterns and prognosis in one hundred and nine patients. J Bone Joint Surg Am 1996; 78(8): 1140-1148
7. Ramirez N, Johnston CE, Browne RH. The prevalence of back pain in children who have idiopathic scoliosis. J Bone Joint Surg Am 1997 Mar; 79(3):364-368
8. Cote P, Kreitz BG, Cassidy JD, et al. A study of the diagnostic accuracy and reliability of the Scoliometer and Adam's forward bend test. Spine 1998; 23(7):796-802
9. Collis DK, Ponseti IV. Long-term follow-up of patient with idiopathic scoliosis not treated surgically. J Bone Joint Surg Am 1969,51:425-445
10. Pehrsson K, Danielsson A, Nachemson A. Pulmonary function in adult idiopathic scoliosis: A 20-year follow-up. Thorax 1998;46:476-478
11. Weinstein SL, Zavala DC, Ponseti IV. Idiopathic scoliosis: Long-term follow-up and prognosis in untreated patients. J Bone Joint Surg Am 1981, 63:702-712
12. Mankin H, Graham J, Schauk J. Cardiopulmonary function in mild and moderate scoliosis. J Bone Joint Surg 1964,46A:53-62
13. Weinstein SL, Dolan LA, Spratt KF, et al. Health and function of patients with untreated scolioisis: A 50-year natural history. JAMA 2003,289:559-567
14. Fabry G: *Leerboek kinderorthopedie*. Leuven-Apeldoorn: Garant, 1997, pp.127-136
15. Lenssinck ML, FrijlinkAC, Berger MY, et al. Effect of bracing and other conservative interventions in the treatment of idiopathic scoliosis in adolescents: A systematic review of clinical trials. Phys Ther 2005; 85(12):1329-1339
16. Rowe DE, Bernstein SM, Riddick MF. A meta-analysis of the efficacy of non-operative treatments for idiopathic scoliosis. J Bone Joint Surg 1997;97: 664-674
17. Allington NJ, Bowen JR. Adolescent idiopathic scoliosis: Treatment with a Wilmington brace: A comparison of full-time and part-time use. J Bone Joint Surg Am 1996;78:1056-1062
18. Athanasopoulos S, Paxinos T, Tsafantakis E. The effect of aerobic training in girls with idiopathic scoliosis. Scand J Med Sci Sports 1999;9(1):36-40