Regression of juvenile idiopathic scoliosis

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Abstract

For a young scoliotic boy the customary "wait and watch" management program for rapidly progressive juvenile idiopathic scoliosis was considered unsatisfactory in view of the poor prognosis. The management program devised was based on the congenital postural induction concept of scoliosis with progression accruing from mechanically induced bioengineering fatigue, cumulative molecular scissions, laxity of ligaments, and secondary bone deformation. A coexisting pelvic tilt with restricted movement of the hip and shoulder joints was overlooked initially. Possibly induced simultaneously with the scoliosis, it is considered a contributory factor in scoliosis progression and requires early diagnosis and correction. The rapid improvement in this child's spinal status achieved by physiological traction and specifically designed exercises was such that as a preventive measure the technique warrants further clinical assessment on young scoliotics.

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Introduction

Despite a poor prognosis, juveniles with early idiopathic scoliosis currently receive only periodic surveillance in the hope that the spinal curvature will spontaneously regress, there being no effective nonoperative therapy available to reverse or stabilize the deformity. This analysis of the management is aimed at improving the prognosis and hopefully at preventing the development and progression of this tragic deformity.

Scoliosis and posture

In approximately 15-20% of cases of scoliosis the initial cause is known and in the remainder the so-called idiopathic scoliosis is likely to be postural in nature (Stehbens, 2002). Like hallux valgus, scoliosis should be regarded as a biomechanical deformity highly prone to further progression. By convention, idiopathic scoliosis is of the infantile type when detected before 3 years of age and juvenile when manifest from 3 to 10 years of age. This arbitrary classification does not preclude the possibility that juvenile scoliosis commences earlier or even in utero. The need to separate juvenile from infantile scoliosis has been questioned (James, 1965; Mehta, 1992; Stehbens, 2002) as the former seems to accrue from undetected curvatures in infancy (Dickson, 1985).

The little known congenital postural scoliosis (Browne, 1956, 1965; Dunn, 1976a, 1976b) has been attributed to compression deformity in utero as a result of rapid fetal growth in late pregnancy, diminishing amniotic fluid, and impaired mobility, the latter indicated by diminished kicking and fetal inability to change position (Dunn, 1976a). While mobile the body appears to grow normally in utero. When comparatively immobile in a cramped and curved position, the relatively fixed spine and ligaments maintain growth in this incipient scoliotic position with muscles probably underdeveloped rather than atrophic from little use. After birth, when unrecognized and uncorrected, the small curvature is perpetuated as a "position of comfort" and ever so slowly and insidiously progresses to severe scoliosis especially as the upright position is assumed. Most of these curves are said to undergo spontaneous resolution (Dunn, 1976a; James, 1954a) with an undefined number

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passing unnoticed and presenting later as juvenile or adolescent scoliosis. The current practice of ignoring curves with Cobb angles under 10° masks an uncertain number of more slowly growing deformities (Stehbens, 2002). Other idiopathic scoliotics may develop habitual, undesirable postures in which the spine becomes relatively fixed due to growth of spinal ligaments in a scoliotic posture with later progression during a growth spurt or ligament failure.

Congenital postural deformity initially defined by Browne (1936; 1956) may be more important in idiopathic scoliosis than currently believed. Infantile "idiopathic" scoliosis has been associated with plagiocephaly and dysplasia of the hip (Browne, 1965; Dunn, 1976b; Lloyd-Roberts and Pilcher, 1965; Wynne-Davies, 1968, 1975) which like hip dislocation, bat ears, and torticollis can be produced by fetal compression in utero, the posture perpetuated postnatally as a position of comfort. With the femoral head held in its proper position, hip joints develop normally whereas intrauterine pressure on the limbs in an atypical position can lead to dysplasia or hip joint dislocation. Thus a thigh held in abduction or adduction for too long late in gestation precedes limited mobility of hip joints and eventual pelvic asymmetry (Cozen, 1968). Saller et al. (1963) reported that in newborn piglets hip joints maintained in extension for 8 weeks developed progressive femoral head dysplasia and slight subluxation. This was reversed after the piglets ran freely for 12 weeks. The authors concluded that in humans dysplastic hip instability and even subluxation may result from compression in utero or develop postnatally when a tightly wrapped baby is unable to move the legs freely (e.g., Navajo infants) (Coleman, 1968).

When one hip is dislocated, the other may exhibit varying degrees of dysplasia. Karski (2000) attributes most cases of idiopathic scoliosis to abduction contracture of the right hip. Unilateral congenital hip dislocation is more commonly left-sided (Watson, 1971) and varying degrees of hip joint subluxation or instability are frequent. Weissman (1954) contended that in infants with abduction contracture, the contralateral hip was often accompanied by hip dysplasia (a forerunner of dislocation) with abduction contracture. Coexisting changes in the two hips were considered to be interrelated as both thighs are directed to the same side and associated with pelvic obliquity, the abducted leg appearing to be longer (Wiseman, 1954) as the unstable head of the opposite femur slips out from under the cartilaginous rim of the acetabulum. Unless treated this readily missed joint instability can lead to pelvic asymmetry (Hart, 1942). Lloyd-Roberts and Pilcher (1965) reported that 10% of their infants with compression scoliosis had pelvic obliquity, the pelvis following the curve of the trunk and being higher on the concave side. Limited hip abduction was usually found on the convex side, the authors believing this to be a manifestation of the compressed fetal syndrome.

Dickson (1983, 1984) reported a pelvic tilt in 40 to 50% of adolescent scoliotics. Although the spine would be destabilized, he regarded the deformity as inconsequential with no propensity to progression. Previously Dickson et al. (1980) had attributed the pelvic tilt to unequal leg length, a concomitant of the spinal curvature or pelvic asymmetry per se whereas the latter is more likely to be secondary to severe scoliosis or to develop simultaneously under the same pressure. They also postulated that a substantial proportion of scolioses is entirely or partially secondary to the sacral tilt, that scoliosis did not progress in children with curves solely due to a sacral tilt, and that compensatory lumbar scoliosis (commonly produced by a sacral tilt secondarily to inequality of leg length) is never progressive.

The pelvic tilt in scoliotics is deserving of more attention. It is greatest in small curves and mostly associated with lumbar and thoracolumbar curvatures (Dickson, 1983). Regarding it as inconsequential is unwarranted for whatever the cause, the result is spinal instability unless the L5 vertebra is wedge shaped to compensate. Its frequent association with hip dysplasia and the apparent but not true inequality of leg length correlate with the compressed fetus syndrome as Browne (1965) and Dunn (1976a, 1976b) reported. The pelvic tilt, hip dysplasia, and fetal postural scoliosis seem to develop concomitantly. Although abduction contracture of one hip can self-correct in physically active children, the contralateral dysplastic hip on the convex side would take longer to rectify. A little known component of the fetal compression syndrome is the involvement of the shoulders for they too are likely to be compressed and immobile in late pregnancy (Minis, 1968).

Prognosis and progression

James (1951) divided infantile scoliosis into resolving (36%) and progressive (64%) types conceding inability to differentiate the two with any certainty (James et al., 1959). Nor do all in the resolving group resolve permanently. Of 86 cases of infantile scoliosis attending a clinic in the first three years of life, 24 were considered to be resolving, and 19 (curves ranging from 10 to 50°) were stable at that time. The remaining 43 infants (50%) with single or double curves all progressed substantially (33 requiring surgery) during surveillance (Thompson and Bentley, 1980). Browne (1965) contended that congenital postural scoliosis, if not treated early after birth, progressed to severe intractable deformity with dwarfism.

Most juvenile scoliotics progress and have a bad prognosis (James, 1954a, 1954b). Nash (1980) said that rapidly growing prepubertal scoliotic children have a 60% chance of progression. Tolo and Gillespie (1978) reported progression in 71% of juvenile scoliotics, although lack of progression does not equate with regression. Untreated, scoliotic juveniles progressed at a median rate of 6° per annum. In another 98 juvenile scoliotics 7 progressed during the follow-up, 8 remained stationary, and the remainder (85%) progressed, 56% requiring spinal fusion (Figueredo and James, 1981). In another 109 juveniles (Robinson and McMaster,
1996) with idiopathic scoliosis, 95.4% were progressive. The remaining five received brace therapy and the curves regressed to less than 10°, one with an original angle of 40°. The ominous prognosis and the widely recognized propensity for severe deformity (Dobbs and Weinstein, 1999; Epstein, 1976; Morin, 1999) justify concern over the absence of a satisfactory therapeutic program for juvenile scoliotics who remain vulnerable to progression during the pubertal growth spurt. Curve regression to below 10° does not ensure lack of progression at puberty or later.

The pathogenesis of the progression, irrespective of the initial cause, can be attributed to the unavoidable repetitive biomechanical stresses of daily living applied unremittingly and asymmetrically to the spinal deformity with its malaligned vertebrae and discs. As with joints elsewhere the spinal constituents of bone, cartilage, and ligaments manifest increased vulnerability to fatigue-induced degenerative osteoarthrosis involving cumulative, molecular scissions of macromolecules and polymers rather than assumed enzymatic self-destruction (Stehbens, 2002). Molecular disintegration accounts for the degenerative changes, laxity (and tears) of ligaments, and augmentation of the architectural deformity as in blood vessels (Stehbens, 1997).

Current management of scoliosis

Although conservative management of scoliosis has encompassed physiotherapy, electrical muscle stimulation, traction, and bracing, the aim here is not to appraise the use of orthotics. It is to consider conservative management in the early stages of the deformity in young pediatric subjects. Waiting for scoliosis progression to attain a specified degree of severity has to be an undesirable management procedure. Dickson (1985, 1999) maintains that if a deformity is acceptable at presentation, then preservation of this degree of acceptability is the aim. Acceptability to those resigned to severe progressive deformity and spinal osteoarthrosis with greatly restricted employment and a shortened lifespan from cardiopulmonary disease is far from optimal management which should be based on an understanding of the pathogenesis of the progression (Stehbens, 2002).

Boachie-Adjei and Lonner (1996) recommend close monitoring of pediatric scoliotics at 4 to 6 monthly intervals for curvatures up to 20°. Orthoses are considered for those in the range of 20 to 29° with progression of 5° and for any curvature of 30° or more in the skeletally immature with surgery proposed for deformities of at least 40°. In the absence of any therapy for children with curves up to 20°, school screening programs have fallen by the wayside. Galasko (1998) recommends that in general terms, idiopathic adolescent scoliosis is "treated" by regular observation until skeletal maturity if the curve is less than 25 to 30°. Moderate curves of 30 to 45° are frequently treated by bracing until skeletal maturity, whereas in a growing adolescent curves greater than 40-45° often require surgical correction and spinal fusion (Lonstein, 1994). For pediatric scoliosis the management generally advocated is periodic surveillance at variable intervals with radiological assessment until curves are sufficiently large to warrant bracing. No other effective nonoperative treatment is available (Dickson, 1996).

Exercise programs recommended for juvenile scoliotics with large curves have, in general, proved ineffective (Nash, 1980). Hungerford (1975) vigorously condemned exercises alone. With few exceptions description of the physical exercises is not provided. Whether the exercises are directed at reducing the curve, or compensating for inactivity of the relatively fixed trunk in the brace for most of the day, is unstated. Bjure et al. (1969) had recommended exercise on a bicycle ergometer, jumping up and down, throwing medicine balls, running on the spot, skipping, Indian jump, and bicycling, the purpose being to enhance a subject's general physique and vital capacity. However because it is impossible to prevent young children from running and playing, it is of the utmost importance that parents maintain close surveillance with avoidance of repetitive jumping up and down movements which are detrimental and cumulatively aggravate scoliosis. They are akin to impact loading the vertebrae and disks vertically and asymmetrically, thereby increasing the flexure and shortening the fatigue life of spinal constituents (Stehbens, 2002).

The Schroth technique is an intensive course of in-patient physiotherapy (4–6 weeks) for those 8 to 70 years of age. For 6–8 h/day patients are taught specific breathing exercises and asymmetrical postural exercises promoting body symmetry to correct the scoliosis and visible deformities (Lehnert-Schroth, 1992; Weiss, 1991, 1992). Mirrors monitor the correction and posture and physiotherapists monitor compliance and progress. Some patients receive electrical muscle stimulation and orthoses. In a 31-month follow-up, scoliosis was stabilized in two-thirds, progressed in 16.1% and in 15.2% had improved more than 5° with long-term effects uncertain. The prime benefit seems to derive from the improved vital capacity of 18% and stretching exercises (Weiss, 1991). Ferraro et al. (1998) also reported improvement and less progression in scoliotics given active postural correction exercises of different types over an average of 2 years. Sustained patient compliance was a major problem and long-term benefit uncertain. The consensus is that exercise programs have not provided significant benefit (Rowe et al., 1997; Stone et al., 1979) and the exercises are often detrimental. Nor has chiropractic anything expedient to offer (Lantz, 2001).

Longitudinal traction (as on a rack) has been used in scoliosis since the times of Hippocrates (Roaf, 1966). On current evidence it has proven to be a successful temporary maneuver in severe deformities prior to bracing or surgical fixation (Wilkins and MacEwen, 1977). It has been applied by means of halotraction (halo-femoral or halo-pelvic) particularly in severe scoliosis (Bradford et al., 1975), the halo being fixed to the skull and femoral or pelvic traction at the
lower end with the traction effected by weights. Given the serious and at times fatal complications (lesions of cranial nerves and brachial plexus, respiratory problems, abnormalities of swallowing), all traction must be applied with caution particularly in the presence of neurological disease.

Cotrel traction (Cotrel et al., 1980; Hancox, 1981) consists of horizontal stretching of the child's body day and night by means of a pelvic corset attached to scales at the bottom of the bed and a head halter with a 2-kg weight attached to the bed top through a pulley system. Additional self-imposed dynamic traction is achieved by means of a handle bar and stirrups attached to the static traction apparatus, self-elongation by arm pressure proving more effective than foot pressure on stirrups. Intermittent pressure is gradually increased in frequency up to 30 times per hour for 9-10 h per day with unspecified exercise sessions and time for schooling. The regimen continues for 7 to 10 days with radiological assessment of improvement. In 19 cases correction was over 40% and used preoperatively, the procedure obtains maximum possible correction. Cotrel (1965) achieved a curve reduction from 73° at 3 years 10 months to 54° at 5 and a half years prior to surgery. The technique induces some vertebral derotation and disadvantages are the prolonged periods of immobilization and ensuing muscle atrophy.

Vertical gravitational traction has been achieved by suspending children upside down by the feet while a pelvic brace with bars is held by the hands (Majoch, 1991). Treatment duration was increased from 12 min to 1 h daily and the loading on the head was increased up to 25% of the body weight for 4 weeks preoperatively and combined with muscle massage, manual curve correction, and swimming to improve lung capacity. The program was not applied to children with hypertension or a spinal or neurological disorder. A curve of 117° in a 12-year-old boy was reduced to 57° in 4 weeks and results were considered better than with horizontal traction. Tabjan and Majoch (1980) used vertical traction 6 times per week for 3 to 6 weeks preoperatively, the patient hanging from parallel bars by the legs and feet with additional weight or traction applied to the neck. This method improved respiratory capacity and allowed better corrective force on the spine despite its discomfort to the feet and legs. Thus, despite its hazardous and unphysiological application, traction remains the only technique known to reduce the curvature.

Rationale of management

Management of juvenile scoliosis should be based on the concept that it is not a specific disease but a mechanical deformity of the spine complicating many diseases and that the most common idiopathic group comprises instances of an habitual posture established in utero or postnatally and perpetuated biomechanically (Stehbens, 2002). Irrespective of the cause, progression of scoliotic curves results from bioengineering fatigue-induced severe accelerated osteoarthrosis (Stehbens, 2002). The acquired laxity of the weakened ligaments and degeneration and deformity of the discs and vertebrae associated with biomechanical fatigue potential further curve progression. In essence pediatric idiopathic scoliosis management aims to (i) detect the deformity at its earliest stage to initiate regression as soon as possible, (ii) be aware of and to minimize underlying mechanical stresses responsible for progression and limit the development of osteoarthritic degenerative changes, (iii) strengthen bones, ligaments, and surrounding muscles symmetrically by exercise using the spine in the manner for which it was designed, and (iv) encourage and sustain patient perseverance with the ameliorative program.

Bones are living tissues and readily reshaped, indented, or even eroded mechanically by pulsating arteries or aneurysms. Skull shape can be mechanically modified in utero or postnatally e.g., by plagiocephaly or hydrocephalus, and elongated by infant head bandaging by Chinook Indians (Dunn, 1969a, b). Tight bandaging of the feet of Chinese women produced gross distortion. Giraffe-necked Padang women (Roaf, 1966) were subjected to deforming pressure (up to 30 pounds weight) on the shoulder girdle to incorporate thoracic vertebrae into the neck. Valgus deformity of big toes with eventual deformation (bunions and osteoarthrosis) can result from poor shoe design. Once established, correction of joint deformities by physiological means becomes increasingly difficult. However, plagiocephaly can be modified or induced postnatally and in neonates some congenital postural and compressive deformities of the feet and hip dislocations can be rectified or improved by nonsurgical orthopedic methods. Similarly in orthodontics thumb sucking deforms the palatine arch and the position of teeth is dependent on the balance of opposing tongue and lip pressures (Proffit, 2000). Permanent teeth are more easily moved by continuous direct pressure from a dental brace to improve the alignment and bite in young children whereas long-established anatomical deformities are less amenable to correction. The recommendations borne out by amelioration of dental malalignment at an early age are relevant to scoliosis. The pressures exerted in orthodontics are gradual, persistent, and directly applied, whereas orthotic pressures brought to bear in scoliosis are of necessity indirect, not applied directly to the spine itself, and can cause secondary deformity of the rib cage. The spine and its ligaments continue to respond to prevailing stresses and mesenchymal cells are dependent on and respond to mechanical stresses, advantageous or otherwise, during growth and development. Thus the aim should be to detect scoliosis early while the spine is growing and maturing and more readily re-shaped to a near normal configuration before the development of serious spinal deformation and osteoarthrosis.

In an indefinite number of young subjects, scoliosis regresses spontaneously, with both the incidence of and the explanation for regression as yet unknown. The need to determine the factors responsible for such regression and to
assess the extent of residual curvature and the nature of long-term clinical sequelae in such subjects is obvious. Unrecognized physical activity seems to potentiate early regression and males with idiopathic scoliosis are more inclined to regression than females. This suggests that the unidentified physical activity is advantageous although mechanical stresses in males are likely to be greater.

Increased awareness of congenital postural scoliosis (Browne, 1956, 1965) and the need for its early detection and treatment with a splint similar to Browne's design permitting continued mobility while correcting the curve would seem worthwhile even if some curves regress spontaneously. Browne's success rate for treatment in the first 6 months was 100%. Conversely Walker (1965), assessing Browne's splint for infantile scoliosis, concluded that treatment benefit did not differ from that of untreated cases. However, neither his therapy nor patient group were comparable to Browne's. Even if 90% of early congenital postural scoliotics self-correct, when and how they were managed are unknown. The problem of treating young children with "intractable scoliosis," if spontaneous regression does not eventuate, is such that it would be wiser to treat all affected babies within the first 6 months of life as Browne recommended. There is also a need to search for dysplasia and abduction and adduction contractures of the hip and stiff shoulder joints and to treat the infants by early postural correction (Green and Griffin, 1982). Ceballos et al. (1980) were of the opinion that treatment is imperative as soon as the diagnosis of progressive scoliosis is made. They used a plaster "shell" to overcorrect the lateral spinal curvature rather than Browne's padded metallic splint. The plaster shell was extended to maintain flexure and moderate abduction of the thighs for hip dysplasia.

For older infants and juveniles traction can be applied by holding and gently swinging the child by the arms as if playing. This activity could be useful until a jungle gym is available and manageable by the child. As Browne (1956, 1965, 1969) emphasized, it is important to induce the child to use its back in the manner appropriate for its design (i.e., with symmetrical movements) and to discourage movements or postures perpetuating the curvature. Passive but gentle manipulation to slowly overcome the resistance to turn and bend toward the convexity could be useful. Likewise infants with a pelvic tilt, dysplasia of the hip joint, and adduction or abduction contracture of a hip could undergo gentle passive manipulation of the thigh to overcome the joint stiffness. Browne's curved splint (1956, 1965) would also benefit both dysplastic hips. Hip dysplasia in infants usually disappears after use of an abduction splint for 6 months (Weissman, 1954). Long-term follow-up of untreated hip dysplasia in the Navajo reveals spontaneous improvement by the time of skeletal maturity with only subtle radiological changes in 40% of the hips (Schwend et al., 1999).

**Therapeutic trial**

The boy, the youngest of three children, was induced at 38 weeks due to toxemia of pregnancy, associated with oligohydramnios and diminished frequency of kicking. He grew, developed well, and was active with no family history of scoliosis. At the end of winter when aged 4 years 10 months his asymmetrical stature in the bath was noticed. It became more obvious within 2 weeks and attempts to induce him to stand straight were unsuccessful. His chest was asymmetrical with the left scapula higher and more prominent than the right. A prominent gap was noticeable between his left arm and hip. His chest protruded slightly on the left side and appeared slightly twisted. Thick clothing in the colder months of the year had apparently masked the abnormality and rapidity of the vertebral change. The child's grumpiness and lethargy had been attributed to a growth spurt in excess of his peers. He had occasional pain over the lower left thorax. Scoliosis was confirmed by X-ray (Fig. 1). During the 3 weeks wait to see an orthopedic surgeon, his deformed stance became even more pronounced. The two orthopedic surgeons consulted found no neurological abnormality or underlying disease. They found equal leg lengths and normal flexibility and movement of his head and neck. Radiologically there was mild thoracolumbar scoliosis, convex to the left (within the range of 15°-20°). The apex was at the T12-L1 level and no abnormality was detected by magnetic resonance imaging. Anticipating that the curvature would regress spontaneously, one surgeon recommended surveillance at 6 monthly intervals and the other at 12 monthly intervals. This was at variance with the progression over previous weeks and the proven adage "as the wind blows, so the tree grows."

One of us (W.E.S.) recalled that in the late 1940s, traction, a body cast, and physiotherapy were utilized. Because of concern that the curve would continue to progress and become increasingly difficult to correct during prolonged surveillance, it was reasoned that traction was the only way abnormal spinal curvatures (with rotation and whether single or double) could be corrected. We conceived of exercising the child on a jungle gym (monkey bars). This metallic frame resembles a horizontal ladder suspended well off the ground with steps at either end for access; the child hanging by his hands from the cylindrical rungs swings from rung to rung (back and forth). Soon adept at this, he played on the bars several times per day with alacrity, the activity proving to be enjoyable for him and his siblings. The swinging motion applied the stresses equally to both sides of his body, the weight of his lower body providing the...
Fig. 1. This X-ray, taken 2 days after his fifth birthday, demonstrates the left thorocolumbar scoliosis. Another X-ray demonstrated that the 12th rib was deflected downward more so than the right. The pelvic tilt to the left and the narrowing of the nonossified cartilaginous gap in the left sacroiliac joint were overlooked.

mineral density. The visual improvement prompted a comprehensive analysis of conservative therapy and additional reinforcing exercises.

This subject, a tall child with a left scoliosis and a pelvic tilt, conforms to the previously undetected congenital postural scoliotic profile. The overlooked pelvic tilt (Fig. 1) represents a component of congenital postural scoliosis. Mehta (1992) considered scoliosis in most juveniles to be of this infantile type. The curvature concave to the right is associated with pelvic obliquity (Lloyd-Roberts and Filcher, 1965) and abduction contracture of the hip in at least 10%. When this possibility was perceived in the present case, nosuch contracture was detected and the pelvic tilt, although still present in an X-ray one year later, was less pronounced (Fig. 3). Plagiocephaly, also associated with the syndrome (Cehallos et al., 1980; Wynne-Davies, 1975), was absent. Even after improvement in the scoliosis, on standing upright the child suddenly and subconsciously assumes the pelvic tilt with a sudden jerk reminiscent of Coleman's description (1968) as the femoral head slips over the posterior acetabular ring (the "jerk" of exit and entry). Significantly this is now not nearly so pronounced. The observation is consistent with hip dysplasia which seems to be more important than the contralateral abduction contraction emphasized by Karski (2000). The limited mobility of the child's left arm (possibly adduction contracture) became obvious when he attempted to swim freestyle. Unequal mobility of all limbs had already been recognized as a component of the fetal compression phenomenon (Trinnis, 1968).

The pelvic tilt drew attention to the difference in the sacroiliac (SI) joints which had been overlooked and the possibility of left hip dysplasia. On consultation with a radiologist, computerized tomography was performed 5 months after the X-ray in Fig. 3 because it was thought that rotation might be responsible for the difference in the SI joints. This revealed that the legs were of equal length and the nonossified cartilaginous gap in the anterior portion of the right joint was 2 mm wider than that of the left. The more posterior portions were symmetrical. Overall the improvements in the pelvic tilt, the SI joints, and rib displacement with a reduced list of the torso and loss of the gap between the left hip and the elbow indicate that they occurred simultaneously with reduction in the scoliosis. The boy can now stand on his left leg unassisted. The narrowing of the left SI joint, which has not previously been observed in the fetal compression syndrome, is likely to be due to asymmetrical pressures on the hips.

Little information could be found on therapy for juveniles although physiotherapy combining passive manipulation and exercises emphasizing lateral abduction of the hip and shoulder is currently meeting with some success in this juvenile. In view of the absence of an abnormal gait in this child and the radiological and visual improvements achieved, the present management policy will continue. The improvement obtained by traction postoperatively in subjects with severe scoliosis provides support for his continued use of the more acceptable jungle gym. Daily exercises on a jungle gym over a longer time span can only be beneficial and prophylactic in such children.

The X-ray in Fig. 3 was taken 1 year after that in Fig. 1, both parents being pleased with the visual and radiological improvement. The lateral spinal deviation was so reduced that the radiological report indicated no "scoliosis" and hip joints were normal. His chest expansion is now equal and symmetrical, his left scapula is less prominent with the overall cosmetic appearance vastly improved and with no recurrence of chest pain. Whether the displaced left 12th rib (Fig. 3) will resume a more normal position is unknown at
Fig. 2. Photographs taken 11 weeks after purchase and regular use of a jungle gym. (A) The distinct list to the left and asymmetrical stance with a prominent gap between the elbow and hip on the left side. Black ink dots indicate the tips of the vertebral spine. The list is still clearly visible whereas the hack demonstrates improvement of the curvature. The left scapula is still elevated and more prominent than the right.

this stage. It is anticipated that sustained monitoring and further exercises with symmetrical stresses on the spine and hips will improve his habitual stance.

Recommended exercises

The child, now aged 51 years 8 months, is probably an example of congenital postural scoliosis and was therefore destined to severe deformity. The historic concepts of prolonged traction outlined above were drastic. The exercise program and frequent use of the jungle gym led to cessation of progression and distinct improvement within 11) weeks. This physiological, more natural use of traction, where the lower half of the body provides the traction, is preferable to a vertical or horizontal rack with immobilization. It is acceptable to the child and has benefited the hip joints and pelvic tilt. Good nutrition being essential, this child is given a traditional high protein diet with meat, eggs, milk, and a variety of fruit and vegetables (Stehbens, 1993).

Other regular and varied short periods of daily exercises include (i) push-ups, (ii) repeated lateral flexion of the trunk to the left (convex side) when sitting, standing, or supine which tends to reverse vertebral torsion and reduce the primary curve with no bending to the concave side, (iii) lying supine with hips and knees flexed and abducting and adducting both hips against moderate resistance provided by a parent, (iv) touching the toes of the left foot with legs wide apart in sitting and standing position, (v) lying supine while peddling in the air. and (vi) deep breathing exercises with and without slight restrictive parental hand pressure over the lower right side of the chest to facilitate maximum left side expansion of the thorax.

Lying supine on a firm surface while simultaneously performing exercises tends to exert pressure on the prominent ribs on the convex side posteriorly. As subjects becomes older and stronger, chin-ups should be included and some simple gymnastic exercises on parallel bars or rings to manipulate the legs always omitting the final jarring jump off the apparatus. Scoliotics under treatment should avoid all strenuous exercises such as jogging, jumping, hopping, skipping, marching, tramping, weight lifting, and any vibrational exposure (tractors, bumpy roads, horse riding, pogo sticks, trampolines) likely to result in vertical impacts transmissible to the spine. Habitual use of a sponge rubber cushion when in a car is also recommended.

The angle of curvature diminishes by a mean of 9° in the supine position, the difference in 93% of subjects so exam-
The Wellington Medical Research Foundation provided financial support and Dr. G.T. Jones assisted with the printing of Fig. 3.

Older infants, juveniles, and even adolescents with scoliosis could be candidates for similar management in hopeful anticipation of benefit at the earliest stage rather than waiting until bracing or surgery is mandatory. For patients with advanced scoliosis (severe angulation or double curves) exercises should probably be limited or avoided until the angle is much reduced by the mild persistent traction effected by a jungle gym or parallel bars.

**Discussion and conclusion**

Routine examination of neonates and young infants for compressive postural spinal deformities and appropriate treatment should be routine. Obstetricians, midwives, pediatricians, and general practitioners should be trained in their early detection. School screening could be reintroduced and appropriately trained personnel could detect early curvatures, advising teachers and parents to routinely encourage children to spend time on the jungle gym which should be standard playground equipment in primary schools with such traction activity also of benefit to those with lordosis or kyphosis.

Since mechanical stresses of everyday life are the dominant force responsible for progression, it is logical to deduce that as in orthodontics, counteracting forces can inhibit, ameliorate or cause curvature regression. Longitudinal traction must be the mainstay of management and is the only mechanism known to regularly reduce scoliotic curvatures. The logic of this exercise program is consistent with the pathogenesis of the deformity (Stehbens, 2002) and the evidence provided indicates that it is likely to benefit those with early scoliosis. The overall aim of pediatric scoliosis management should be (1) to detect the deformity at its earliest stage because geometrical abnormalities predispose to osteoarthrosis (Stehbens, 2002), (2) to induce regression of any deformity, to prevent or limit progression to obviate the need for orthotics or surgery, (3) to prevent relapse and ensure good compliance, (4) to prevent development of scoliosis in the community, and (5) to increase awareness of this deformity in the community and perinatal and pediatric health services. This proposed management program will hopefully restore the vertebrae and intervertebral discs to a more appropriate anatomical position, shape, and more balanced mechanics and should then consolidate their retention of the normal status.

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**Fig. 3.** X-ray taken two weeks prior to his 6th birthday. The radiology report stated that no scoliosis was present. A very slight residual curve is centered at approximately T11. The 12th left rib is clearly deflected downward and a slight pelvic tilt remains. The difference in width of the cartilaginous gaps in the SI joints is less pronounced.
References


