

Hyperkyphotic posture among adolescents – still a public health problem

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ABSTRACT

Posture, hyper-kyphosis or “the postural round back”, and balance are topics that have been extensively studied, although with some conflicting findings. Body position is representative of physical and mental health. Bad posture can lead to spinal complications (affects the muscular system, deforms the skeletal bone, and causes abnormal development) and the same can be said the other way around. As the standard of living increases, there is an increase in consumerism for technological devices, especially among teenagers. Identified as a public health problem, postural changes among children and adolescents have a high prevalence, emphasizing the need for prevention, diagnosis, and early initiation of treatment, especially from the growth and development phase of the body, because during this period teenagers are most vulnerable to live changes. Taking these elements into consideration, we conducted an extensive literature review of the subject, considering adolescence a key element for early diagnosing and the institution of a complex rehabilitation program, with full functional restoration. Efforts to reduce the prevalence of bad posture will improve not only body posture but will also reduce the prevalence and the severity of spine deformities.

Keywords: hyperkyphosis, posture, adolescents, the postural round back, balance

INTRODUCTION

By studying medical literature, we can identify several definitions of good posture. Kendal et al. are by far, the most used to define good posture as a “state of muscular and skeletal balance which protects the supporting structures of the body against injury or progressive deformity, irrespective of the attitude in which these structures are working or resting. Under these conditions, the muscle will function most efficiently, and the optimum positions are afforded for the thoracic and abdominal organs” [1,2]. We must also take into consideration that posture is a complex process based on the interaction of sensorial and motor systems [3-6].

Using search keywords “hyperkyphosis”, “posture”, “adolescents”, “the postural round back”, and “balance” we analyzed 138 human studies from the PubMed Database, written in English. After the exclusion of reviews, case presentations, and articles that showed that they were not specifically dedicated to hyperkyphosis, 56 abstracts were screened and the most relevant articles covered the identification, evaluation, and treatment alternatives of this condition. The other articles were used to find arguments for the clinical and non-invasive treatment alternatives. After evaluating the articles and mentioning the references to experimental studies, those articles were also revised.

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As any epidemiological research has to be substantiated by the identification of the pathological mechanisms and optimal treatment mechanisms, this review aims to describe the current knowledge about the pathological links between poor posture and hyperkyphosis, a spinal complication.

For a correct posture, the spine must be straight in a frontal plane (from a clinical observational point of view) and must maintain in a sagittal plane the physiological curves (cervical lordosis, thoracic kyphosis, and lumbar lordosis). The normal thoracic curvature (measured on the profile thoracic x-ray, from an orthostatic position, by Cobb angle) should be between 20-25 and 40-45 degrees. Less than 20 degrees we define as “flat back” and more than 40-45 degrees we define as hyperkyphosis [7-10]. Epidemiological studies have reported an increased prevalence of postural vertebral deviations with a high incidence of back pain of musculoskeletal origin in children and adolescents [1,4-7].

Etiology, incidence, and risk factors among adolescents

There are 2 types of kyphosis: postural kyphosis and structural kyphosis. Postural kyphosis has a simple explanation leaning on the effects of a poor posture and it is easily possible to be corrected just by adopting a good posture. Structural kyphosis can be primary or secondary and has many causes in relation to different structures of the spine.

It may occur as the result of trauma, congenital conditions, or Scheuermann's disease or it may be a consequence of spinal tumors with laminectomy. It may also be found in children with connective tissue disorders, osteochondral dystrophies, osteogenesis imperfecta, idiopathic juvenile osteoporosis, neurofibromatosis, myelomeningocele, endocrine diseases, spina bifida, infection, muscular dystrophy, and spondyloepiphyseal dysplasia. Spinal kyphosis must be differentiated from the postural round back. The discussion in this article focuses on postural round back but some elements about congenital kyphosis and Scheuermann's disease will be briefly presented, mainly for a clear differential clinical diagnosis.

Congenital kyphosis

Congenital kyphosis is a primary one and presents normal posterior elements of the vertebra and aplastic/hypoplastic anterior elements. An abnormal vertebral spine leads to progressive kyphosis. Usually, this condition is a result of a combination of more defective segments [1,11]. The natural progression includes progression, cosmetic deformity, back pain, and neurologic deficit. It is the most common cause of spinal cord compression generated by spinal deformity [1,11-13]. Even if an anterior unsegmented bar at the dorsal-lumbar spine junction

produces mild/severe deformity, there is no reported paraplegia. In this case, the optimal treatment is surgery to prevent future progression [11-13].

Scheuermann's disease

Scheuermann's disease is also a primary kyphosis and represents a rigid form of postural kyphosis. Initially, Schuermann considered this kyphosis osteochondritis – nowadays is considered to be a genetic condition. It is neglected many times, with a high incidence during childhood and adolescence and most of the time associated with a bad posture. The incidence of this condition during the adolescent period is between 1 and 8% in medical literature, unequally distributed between males and females, with up to a 2:1 ratio [1,14-16,69]. The first signs typically occur before puberty.

Some studies demonstrate an important genetic prevalence with no environmental component [14-18]. Histological studies had shown disorganized endochondral ossification, reduce collagen with fine fibers, and increased amount of mucopolysaccharides. IRM studies show disc degeneration in half of the patients with Scheuermann's kyphosis [19].

Postural Round back

Among adolescents, posture disorders are considered a public health problem because they can be a predisposing factor for degenerative conditions of the spine in adult age [20].

Adolescence is accompanied by important biological, psycho-behavioral, and social transformations. The word “adolescence” comes from the Latin word “adolescent”, which means “to grow”. “Growing” appears earlier in girls rather than boys and is accompanied by a sudden increase in height in this period [21]. The correlation between feminine gender and thoracic kyphosis has a prevalence ratio of 1.18 according to specialized studies [10,22-28]. Several studies about posture – especially in adolescents – concluded that the lack of adopting a correct posture will determine in time the development of degenerative articular disorders, major muscular imbalances, and dysfunction of the kinematic chains, with spinal or irradiated painful episodes, with improper development and with deformities that impact on the functionality and also negative psycho-emotional disorders resounding on the social condition of the adolescent [1,25-32].

Peria, Elsa Mariela Robles have found an increased prevalence of thoracic hyperkyphosis in a sample of children with hearing deficiencies (75%) and suggested that this alteration can be associated with natural physiological modifications related to the growth and individual development of the child [28]. Also, obesity will be noted as an aggravating factor of dorsal pain [33-35].

Lemos et al. investigated the sites most frequently affected by postural alterations when children carried weights smaller, equal, or greater than 10% of their body weight and discovered that postural alterations appear when the weight is greater than 10% of the body weight [36].

Thoracic hyperkyphosis is also associated with incorrect posture while writing or prolonged incorrect sitting on a seat. Also, recent studies showed that using a computer or other electronic devices for a period longer than 4 hours represents an additional risk factor for the development of postural thoracic kyphosis [37-42].

Although there are conflicting data about the time spent in a vicious position and the risk of developing postural kyphosis, incorrect posture per se is a risk factor for the appearance of sagittal plane postural kyphosis. More than that, most of the postural studies underline the fact that when we analyze the sitting position, either for study or recreational activities, adolescents tend to adopt incorrect posture which involves exaggerated flexion of the trunk [34,38-41].

Hyperkyphosis also negatively influences the respiratory muscles, leading in time to their hypotonia which determines a mechanical restriction, the limitation of the pulmonary vital capacity, and the decrease of the total and residual pulmonary volume [43-45].

Postural habits, the overuse of some muscle groups, and the paravertebral ligament system influence the degree of thoracic kyphosis. Habitual incorrect posture, although easily reversible at the beginning tends to become fixed in time. The paravertebral extensors and abdominal muscles' tonus is important in maintaining a correct posture [25,26,46-49]. Furthermore, postural habits from childhood and adolescence will perpetuate in adult life [1,41-44].

EVALUATION

History and physical examination

The evaluation of the patient must begin with the inspection of the spine in the frontal and sagittal planes from orthostatic. The inspection from the lateral side allows the evaluation of the head's position about, the pelvis.

The most obvious sign of thoracic kyphosis is the round back due to the exacerbation of the thoracic curvature. The patients will have spinal pain with great variability: from easy to severe. The pain is frequently associated with asthenia, fatigue, and increases along with the mobilization and anterior movement of the head [1,6,9,24].

The range of motion of the thoracic spine is usually around 90 degrees of flexion, 30 degrees of ex-

tension, lateral inflections, and rotations. Hyperkyphosis diminishes these degrees and produces stiffness in the movement of the spine. The assessment of the posture from dorsal decubitus allows us to accurately differentiate structural from postural hyperkyphosis. In the case of structural hyperkyphosis, the patient's position will be rigid. Dubousset has proven the influence of the pelvis position on the spine, which must be considered in the case of dorsal kyphosis [50-51].

There is a posterior sagittal imbalance in the case of a pelvic anteversion, which tends to compensate through suprajacent thoracic kyphosis and hyperlordosis. It is frequently associated with a hypertonic predisposition and a tendency to hollow feet. Also, there can be a posterior sagittal imbalance with a pelvic retroversion which can be sometimes associated with a reduction of the dorsal curvature or sometimes with an exacerbated kyphosis. In these cases, there is a hypotonic predisposition with the association with flat feet [52-56].

The patient must also be asked to walk. The careful observation of the gait in these cases is very important. Usually, the young patient limits some movements while walking to avoid the appearance of pain. The angle of kyphosis is correlated with the movement of the center of gravity in a frontal and sagittal plane during gait [2,5,6,31,36]. An exaggerated flexion of the hips and knees while walking shows that the patient compensates for the hyperkyphosis by altering the position of the hip and knee. Even if this compensation is efficient for walking it involves a great energy expense and it negatively correlates with the quality of life [51-55].

In the case of Schuermann's disease, clinical findings include tight pectoral and hamstring muscles, increased thoracic kyphosis with a compensatory hyperlordosis, and anterior head posture. 38% of patients with Schuermann's disease had pain and 20% of children associate scoliosis [15].

Neurological examination

A thorough neurological examination is also important in the assessment of kyphosis. A gait with a large support base can indicate cervical or thoracic spinal stenosis. Exacerbated flexion of the hip and knee while the swing phase can indicate muscle deficit on the ankle dorsiflexors as a consequence of the compression of the lumbar nerves. Muscle testing must be performed systematically and bilateral so as not to miss slight muscle weakness. Hyperactive or pathological reflexes like clonus or Babinski can indicate central motor neuron dysfunction or a problem at the cervical or thoracolumbar spine. On the other hand, diminished or absent reflexes can indicate peripheral motor neuron dysfunction.

In children, we must look for abnormal reflexes, the capacity of maintaining a unipedal stance, mus-

cle deficiencies, or skin manifestations that can indicate modular dysraphism (hemangiomas, lumbosacral hairy areas).

Other symptoms, like numbness or paresthesia, muscle spasm, weakness, or bowel/bladder changes are usually not seen in a round-back pathology.

Paraplegia is usually associated with progressive congenital kyphosis located in the upper thoracic spine when the anterior compartment growth is poor [57].

Imagistic examination

To evaluate the degree of kyphosis, on the profile cervical-dorsal-lumbar spinal x-ray we measure the Cobb angle. The Cobb angle is considered the gold standard for measuring kyphosis. Initially, it was used to measure the angle of scoliosis. By modifying the direction of the radiographic image from the frontal to the sagittal plane, Cobb's angle became useful in measuring kyphosis. Usually, we use the angle between the T4 and T12 vertebra. The Cobb angle is measured by drawing a line above the T4 vertebra and a second line below the T12 vertebra. At the intersection of these two lines, the Cobb angle can be measured [37,58].

Along with hyperkyphosis, it stands out the association of scoliosis as a posture disorder among adolescents. In a recent study (2019), Tobias et al. found that of 4640 participants 15 years of age who had thoracic X-rays, 267 (5,8%) also had scoliosis [59] (Figure 1).

Photogrammetry with various spinal posture evaluation protocols can be used. A combined protocol and software providing detailed postural analysis is then needed [65].



FIGURE 1. Congenital kyphoscoliosis

Another possibility for diagnosis is the motion analysis camera system, which will offer information about spinal shape and motion and need specific software and a well-trained specialist to interpret data [66].

Radiographic criteria for Schuermann's disease, are irregular vertebral endplates; narrowing the intervertebral disc space; anterior wedging of 5° or greater for three or more contiguous vertebrae; kyphosis greater than 40° that is uncorrected on active hyperextension [15,17]. The X-ray will highlight irregularities of the vertebral plates, Schmorl nodes (disc protrusion into the spongiosa) on both sides of the vertebral disc, and the cuneiform deformity of the vertebral bodies [16]. Untreated, the disease will aggravate, stiffening the spine at the end of the growth period. The kyphosis is placed in the dorsolumbar region, the evolution is painful especially in the area T12-L1, with anterior diarthrosis and superior lumbar retrolisthesis (Figure 2). Other irreducible kyphosis includes congenital malformations, Pott disease, spina bifida, achondroplasia kyphosis, neurofibromatosis, and dwarfism.



FIGURE 2. Schuermann kyphosis

Biomechanical insight

The relationship between paraspinal muscles and sagittal spinal alignment disorders has been associated with sarcopenia which consists of degenerative modifications of the muscles and is considered a disease that decreases the patient's quality of life and precipitates or aggravates their spinal problems [1,17,47].

Paraspinal muscles allow an extensive tri-dimensional trunk movement and at the same time ensure the stability of the spine. Prolonged activity in front of the computer involves maintaining the sitting position for a long time, which is extremely difficult [47].

Postural control is about the consolidation of a posture against gravity and ensuring the maintenance of balance. This balance ensures postural stability while voluntary movement and balance recover after its disruption. Posture awareness is based mostly on proprioceptive feedback from the periphery to the central nervous system [18].

Kyphotic posture and the associated pain

Some studies from the literature identified a correlation between thoracic kyphosis and lumbar pain. But this fact is suggested especially in adults, and adolescents with kyphosis, and pain is present mostly at the scapulohumeral joint [1,2,5-8,53-56].

We must be extra careful with spinal pain especially if it appears at night, is constant, and is progressive. This pain is associated with infections or tumors. The clinician must discern between pathological and nonorganic pain – typical muscular back pain.

Contradictory results from medical literature also appear because of the demographic, cultural, social, and populational characteristics. The studies on this aspect are essential and we must not generalize the results of some local-level studies to the general population. The variables posture and musculoskeletal pain have an important social and cultural influence [29,32,41-46].

TREATMENT

Congenital kyphosis

The treatment for congenital kyphosis consists of surgery to prevent future progression considering the patient's age, size of the deformity, and neurological status [16,19]. Many surgical procedures were applied through anterior, posterior, or combined approaches with no clear indication of which one is the best to correct the deformity [60,61].

Recently, with the development of surgical techniques and instrumentations, the posterior approach became the preferred technique to perform pedicle subtraction osteotomy (PSO), posterior vertebral column resection (PVCR), or vertebral column decancellation [62]. Current recommended treatment includes posterior arthrodesis for deformities of less than 50° to 60°, and anterior release or decompression, anterior fusion, and posterior instrumented arthrodesis for large deformities and cord compression [63].

Scheuermann's kyphosis

In the case of Scheuermann's kyphosis, treatment includes exercise, orthotic management, and/or surgery [16,19,62,63]. Exercises consist of active stretching of the trunk extensor, postural correction

exercises, and hamstrings stretch [1,8,25]. Sports like volleyball, swimming, and aerobic exercises are recommended [8,25,26,31].

The main objectives of the rehabilitation program are to improve postural alignment and to increase flexibility and extensor strength.

According to some studies, exercises alone have not been established as effective, but in association with other methods in the early stages, are more beneficial [16,19,61].

Orthotic treatment is recommended, according to several studies when kyphosis is greater than 45° and below 65° [65]. Even so, skeletally mature patients do not respond to this treatment. The best results seem to be in the case of immature skeletal. Most of the studies recommended a Milwaukee-type brace, worn 22 hours per day for 12 to 18 months [64]. Once the maturity is reached, the Milwaukee-type brace can be used part-time at night, but only for maintenance, not for correction [19,62-64].

An antilordotic brace (like Boston Overlap Brace) is an accepted alternative when other methods have been ineffective or as a primary option, followed by a TLSO brace after the first stage and always combined with a physical therapy program till skeletal maturity.

According to the Scoliosis Research Society indication for surgery are: curves continuing to progress despite the use of orthosis during adolescence; when curves are greater than 65°; when degenerative kyphosis is present [64]. Surgical protocol for a less rigid curve includes posterior fusion or, in the case of a more rigid curve, an anterior in combination with a posterior approach [2,64].

A less complex and invasive procedure that reduces the impact on soft tissue and the bony skeleton is the procedure using a posterior approach with only three anchor points on one side of the spine, but studies show high failure rates [67,68].

Postural Round back

The main purpose of the treatment of postural kyphosis is to prevent the aggravation of the thoracic curvature and also the prevention of its complications.

The treatment of hyperkyphosis depends on age, type of kyphosis, the severity of the curvature, and symptoms [69].

The overall health and the number of remaining growing years are also important.

The curvature must be monitored by periodic x-rays during adolescence because it can aggravate with time, adolescence being a period of the rapid growth of the bony skeleton and especially the spine (Figure 3).

The compensatory lordosis should be also monitored and the subject should be treated with an integrated approach.

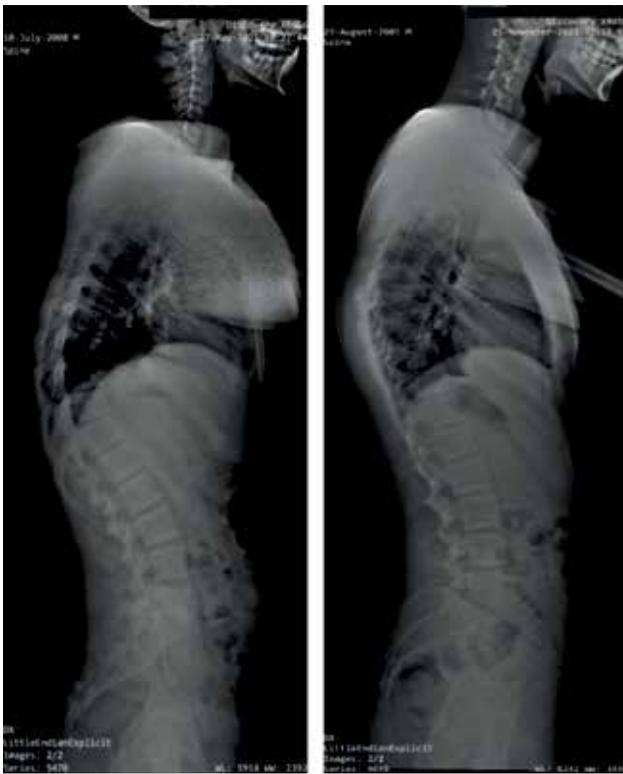


FIGURE 3. Thoracal kyphosis

Physical therapy

Specific exercises (kinesiotherapy) can be effective when the thoracic curvature isn't fixed and there is a low angle of kyphosis. They play a role in strengthening the back muscles and in the education of the adolescent to obtain and maintain a correct sagittal alignment. In some cases, improvement of the mobility of the spine along with the strengthening of the paravertebral muscles is necessary [1,8,25].

Kinesiotherapy is necessary, acting through general exercise, and respiratory gymnastics. There are used intermediate postures, without an overcorrection of the curvatures. Paravertebral muscle duplication is contraindicated! Anyway, the rehabilitation will be individualized, depending on the patient's resistance. The exercises of attitude correction have the starting point on a created position, of axial extension, without exaggeration, not to favor the inversion. There are used isometric paravertebral and abdominal muscles exercises, belt muscle exercises, contractions of the spinal and abdominal muscles, lower limbs flexion and extension exercises, getting up and down, dorsal and ventral reptation exercises, jumps, games etc. Relaxation mustn't be neglected, allowing the obtaining of balanced tonus.

The objectives of the physical therapy program are: 1. Improvement of the mobility and elasticity of the thoracal spine in the direction of extension; 2. Consolidation of the endurance capacity of the dorsal spinal extensors; 3. Release muscle retractions when they occur; 4. Learning the correct posture to

be adopted in the activities of daily living; 5. Respiratory re-education; 6. Enhancing the effort capacity; 7. Decreasing the level of anxiety by using general relaxation techniques.

Also, another important aspect of physical exercise is the generation of psychological well-being. Body and mind have an inseparable connection. It is proven that simple continuous exercises have had a benefic effect on anxiety, depression, and general mood because of the monoamine and endorphin release that adjust these aspects of mental health [41-44]. Making a habit out of maintaining a correct posture is essential for the functioning and health of the human body.

Some simple exercises might be recommended, in order to improve the mobility of the pelvis, enhance the stretching ability of the hamstrings, and associate proprioception therapy for postural awareness. Adolescents need to practice sports activities to gain force in the axial muscles and improve their mobility and coordination [69].

Practicing performance sports presented an association with scoliotic modifications, facilitating postural modifications [69]. Researchers analyzing school-age children found an association between the presence of scoliosis and practicing intensive physical activity [28,29,36].

Practicing sports activities to strengthen the core muscles like Pilates or yoga promotes mobility and pain improvement [70].

Raised awareness and changes in the activities of daily living

Children and adolescents need to have information and advice about the activities of daily living. They should not carry the schoolbag on one shoulder but on both. It is important to correct their position when they are sitting to limit the cervicothoracic flexion [71].

Observing different deviations of the children's spine involves everyone around him. Only this way appropriate treatment (rehabilitation and/or orthotics) can be applied in time being able to correct un-aesthetic aspects and prevent severe functional complications which, in the end, compromise the children's health.

Sleep and physical rest

It is been observed that persons that sleep more than 10 hours at night present an association with thoracal kyphotic and scoliotic modifications. It appears that adequate time of sleep (approximately 8 hours/night) can be considered a protective factor for the development of postural modifications [71,72]. On the contrary, insufficient sleeping (less than 6 hours/night) predisposes to low back pain and postural alteration [72,73].

Adequate diet

Although some researchers say there is no evidence-based proof that dietary habits play a role in developing kyphosis or scoliosis [74], others have proven there is a difference in spinal posture and mobility between obese and normal-weight individuals [75].

Maintaining a normal body weight may also lead to improved back pain.

Osteopathy

Osteopathy continues to provoke some different opinions regarding efficacy for spinal deformities. Some authors emphasize its importance [69], while others have proven no effect on trunk morphology or spine flexibility [76]. Osteopathy tries to remove the blockages that sometimes affect not only the spine but also the upper and lower kinetic chains.

Osteopathy assesses also the shoulder and pelvic girdle, the knees, and feet and aims to improve posture and mobility of the whole body.

Bracing

Braces are specially used for spinal deformities caused by Scheuermann's disease but may be also recommended for patients with severe postural kyphosis who are in the growth period. The type of brace and the daily period to be worn depends on the severity of the curvature and the parameters will be adjusted as the correction is present. The brace needs to be worn until the child reaches skeletal maturity which is usually around 14 – 15 years of age. Bracing needs a combined therapy program, always associated with physical therapy. The classical Milwaukee brace is very difficult to be worn, although it offers good results [77], but there are some modern models easier to be used. Still, there is poor scientific evidence that bracing for round back is efficient in the medium and long term [78].

Medication

Analgesic drugs are used to relieve back pain, but this is a rather rare situation usually combined with a long and fixed position in anterior flexion or with a more important angle of the curvature (>50 degrees). The most commonly used medication includes ibuprofen and paracetamol.

DISCUSSIONS

Chronic defective habitual postures can lead to variate harmful effects on the spinal stabilizing muscles like disabling, deconditioning, low capacity to generate strength, and decrease in strength and endurance. All these factors produce an added load and pain in the spine support tissue, thus increasing the risk of hyperkyphosis [79].

More studies are necessary to investigate the association between the strength and endurance of the spinal extensors and the development of postural hyperkyphosis [31].

The thoracic kyphosis angle tends to increase with aging. Hyperkyphosis may be a potentially modifiable risk factor for adverse health outcomes, like fall risk and fracture for the elderly [80].

Making a habit out of maintaining a correct posture is essential for the functioning and health of the human body.

The decreased level of physical activity in the last decade along with the advances in modern technology allowed people to engage in destructive postures.

Modern civilization must make an effort to educate the new generation on how and why a correct posture is an integrated part of their physical and mental health [81].

The development of health policies that decrease the risk factors to reduce the prevalence of postural modifications is very important [3,10-16].

Although, subjects with spinal deformities have a decreased general flexibility and present more often chronic back pain, some studies revealed no impact on having more sedentary jobs and no tendency to take more pain medication compared with control group [82].

There are different possible symptoms of kyphosis, like exaggerated flexion of the head, difference in shoulder height or scapular position, tight hamstrings, back pain, numbness or paresthesia, muscle spasm, weakness, but they are usually more severe in the congenital kyphosis and Scheuermann's disease, and each subject may experience a different pattern.

The risk factors for postural hyperkyphosis in children and adolescents are postural habits, like incorrect posture while sitting, using electronic devices for many hours daily, habitual incorrect posture, and they are easier to correct in the first stage. In adults they tend to become chronic and to worsen.

Many clinical and imagistic tests for the assessment of spinal deformities are available, but the correct diagnose is usually easy to be chosen by clinical examination only. For detailed information (angles, associated changes, evolution) though, a radiological examination should complete the clinical findings.

In terms of therapy, there are many modern options to improve hyperkyphosis, but the gold standard remains physical therapy, learned and practiced with professionals and continued at home for a long period of time. Stretching and strengthening exercises for the trunk, hamstrings and pectoral muscles are recommended, incorporating sensorimotor and kinesthetic goals, corrective and bre-

athing techniques in a well-designed and individualized program for each subject [83]. This will not only have a good impact on global flexibility and maybe spinal correction, but also on pain and well-being.

CONCLUSIONS

Early identification of postural alterations must be one of the main objectives of the medical and auxiliary staff and also of the didactic personnel involved in children and adolescent activities. Growth spurts that appear in these patients represent the starting point for the onset of spinal postural alterations, caused by several adaptations, adjustments, and physical and psychosocial changes that characterize

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