MEDICO-SURGICAL ENCYCLOPEDIA OF
REHABILITATION

THE ANTERO - POSTERIOR ABNORMALITIES OF the SPINE

AUTHORS:

Dr. Jean Claude de MAUROY
Médecine Orthopédique : Clinique du Parc ; 84, boulevard des Belges - 69006 LYON

Dr. Jean SENGLER
Chef de Service Rééducation : Centre Hospitalier de Mulhouse

Dr. Paule FENDER
Praticien Hospitalier : Centre Hospitalier de Mulhouse

Dr. Jean Jacques LALAIN
Chirurgie Orthopédique : Clinique du Parc Lyon

Pr. Biagio TATO
Professeur Associé en Orthopédie et Traumatologie : Université de Bari

Dr. Piera LUSENTI
Orthopédie et Rééducation : Piacenza

Mr. Marc GROSS
Kinésithérapeute, moniteur cadre : Centre Hospitalier de Mulhouse

Mr. Gioacchino FERRACANE
Thérapiste de la Réhabilitation : Centro Lionese Palerme
Summary

The verticality of the spine is a fundamental characteristic of the homo sapiens. The anteversion of the pelvis provokes a lumbar lordosis and the centring of the head on the line of gravity cervical lordosis.

The sagittal abnormalities of the spine contain essentially the thoracic or thoraco-lumbar hyperkyphosis and the lumbar hyperlordosis of which we shall evoke the various etiologies. We shall clarify the criteria of evaluation and the morphotypological limits of the physiological and the pathological.

Rehabilitation presented under form of clinical tables integrates into the physiotherapy, the adaptation of the environment and the orientation of the sports activity.

We shall evoke the various aspects of the conservative orthopaedic treatment which must be precocious and rigorous to avoid a surgery difficult and limited in its results with a permanent risk of neurological complication.

Keywords: KYPHOSIS, LORDOSIS, VERTEBRAL INVERSION, SPINAL DYSTROPHY OF GROWTH, SCHEUERMANN, SAT POSITION, SCHOOLBAG, REHABILITATION, ORTHOPAEDIC TREATMENT
1 Introduction

The antero-posterior abnormalities of the spine are usually indicated under the name of kyphosis and of lordosis. Term kyphosis derives from Greek: arched back and applies to vertebral abnormalities with posterior convexity, usually thoracic. Term lordosis means bent and applies to curvatures with anterior convexity, usually lumbar. There is in the sagittal plan a kyphosis and a lordosis physiological of which we are going to clarify limits in the chapter of morphotypology.

2 Anthropological reminder

The verticality of our ancestors australopithecus began there is about 7 million years. The first footprint dating 4 million years was found by Marie LAEKEY in the ashes of Laetolie's volcano in Tanzania. The imprint with link of the first metatarsus and median and anterior two vaults gets closer to that of the homo current sapiens. Main osteo-articular modifications connected in verticalisation are the following ones: Stabilization of the knee, Increase of the length lower limbs, Pelvic anteverision pulling a slope of the sacral plate forwards and a compensatory lumbar lordosis, medialisation of the occipital hole and cervical lordosis. Globally, at the homo sapiens the head falls at the level of the polygon of sustentation and verticality is almost possible without muscular activity. At muscular level one notes: intensification of glutei and dissociation of the thoraco-pelvic muscle structure allowing a pelvic step which does not exist at the big monkey. These progressive modifications end in an economic locomotion which is going to differentiate the homo sapiens of Cromagnon of the man of Neandertal. In the caves of the Dordogne one found stony necklaces of Pyrenees, distant from 400 km. Sagittal curvatures, dissociation of belts and development of glutei are so the key elements of the verticality and the locomotion of the Homo Sapiens. (Figure 1)

The child during the development reproduces all the stages of verticalisation. He begins by walking by falling and it is only towards the age of 5 years, as he begins to give the right hand that he acquires a walking of type homo sapiens. The development of the pelvis was not proportional in that of the cranium because of the hyperpressure connected to the excessive space of the femoral heads in unipodal support (Pauwels's balance). The baby is going to be born very immature and the characteristic puberty of the homo sapiens is going to allow a picking up. This picking up of growth comes along with a big fragility notably at the level of the spine and explains so the frequency of the abnormalities of the spine on the occasion of this juvenile growth.
3 Classification

One will distinguish first of all:

**The kyphotic or lordotic attitudes**, connected to a ligamentar hypermobility or a muscular hypotonia; these abnormalities are reducible during the test of hyperextension and improve with the specific rehabilitation.

**Paramorphisms** are the consequence of a sports activity favoring the kyphosis, for example: swimming (dolphin, butterfly).

Kyphosis or **constitutional** lordosis, corresponding to a domestic morphotype are usually stable.

Kyphosis or lordosis of **adaptation**: important nearsightedness determine a kyphotic attitude which can stiffen during the growth. Also the long obstinacy of the childish kyphosis at encephalopatic children favors the progressive structural deformation of the vertebral bodies.

**The structural deformations** which usually justify a specific coverage.

3.1 KYPHOSIS

3.1.1 Regular kyphosis

<table>
<thead>
<tr>
<th>REGULAR KYPHOSIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Postural</td>
</tr>
<tr>
<td>Constitutional domestic</td>
</tr>
<tr>
<td>Kyphotic attitude</td>
</tr>
<tr>
<td>Compensating for a structural</td>
</tr>
<tr>
<td>hyperlordosis</td>
</tr>
<tr>
<td>Paramorphism</td>
</tr>
<tr>
<td>Regular practice of a sports</td>
</tr>
<tr>
<td>activity in kyphosis</td>
</tr>
<tr>
<td>Idiopathic</td>
</tr>
<tr>
<td>Evolutive in juvenile period</td>
</tr>
<tr>
<td>Spinal dystrophy of growth</td>
</tr>
<tr>
<td>Scheuermann's disease</td>
</tr>
<tr>
<td>Neurological</td>
</tr>
<tr>
<td>Myopatic</td>
</tr>
<tr>
<td>Tetraplegic</td>
</tr>
<tr>
<td>Infectious</td>
</tr>
<tr>
<td>Tuberculosis …</td>
</tr>
<tr>
<td>Pott's disease</td>
</tr>
<tr>
<td>Rheumatic</td>
</tr>
<tr>
<td>Ankylosing spondylitis</td>
</tr>
<tr>
<td>Post-surgery</td>
</tr>
<tr>
<td>Laminectomy</td>
</tr>
<tr>
<td>Removal of a vertebral body</td>
</tr>
<tr>
<td>Radioterapy</td>
</tr>
<tr>
<td>Metabolic</td>
</tr>
<tr>
<td>Osteoporosis</td>
</tr>
<tr>
<td>Osteomalacia</td>
</tr>
<tr>
<td>Osteogenesis imperfecta</td>
</tr>
</tbody>
</table>

Vertebral-body deformation divides up on more than three vertebra.

**-Idiopathic**: we clarified with Pierre Stagnara this entity of evolutionary kyphosis in juvenile period by analogy to idiopatic scoliosis.

There is indeed a real vicious circle of the idiopatic kyphosis in juvenile period. (37 ( 60 ))
The cartilage of growth reacts to pressures according to Wolff and Delpech's laws. A hyperpressure inhibits the cartilage of growth, a hypopressure stimulates it. (19) In the apex of the kyphosis a prolonged kyphotic attitude decreases growth in the front of the vertebral body and stimulates the growth of the posterior arch pulling the constitution of an idiopathic kyphosis.

A second mechanism adds to the anterior hyperpressure when the vertebral body goes away from the line of gravity. Pressures become even stronger on the front of the vertebral body and so establishes the vicious circle of the idiopathic kyphosis.

-The spinal dystrophy of growth or Scheuermann's disease is a disease of the growing disc of the vertebral body, weakening cortical superior of the vertebral body and being able to provoke a cuneisation. (Figure 2 (3))

The vertebral listel or the secondary center of ossification, remainder at the man of the epiphysis, is only inhibited by the hyperpressure connected to the kyphosis; in case of conservative orthopaedic treatment by brace it can compensate for the incapacity of the cartilaginous disc and restore an oblong vertebral body. (2)(6)(10)(11)(12)(33)(45)(55)(58)(64)(71)

This disease stops in the end of the growth when the cartilage is not active any more.

-Neurological: the paralysis of abdominal muscles counterbalances by a lumbar kyphosis. (28) The paralysis of the spinal muscles pulls a lordosis, the patient uses remaining muscles as shrouds to maintain the spine in a position where it can be effective. The changes of the psychomotor development come along with postural abnormalities: either global kyphosis at the children who reached only the sat position, or hyperlordosis sometimes very unstable to the athetosic.

-Post-laminectomy: the extension of the laminectomy in the articular facets and in the posterior ligaments pulls in 80% of cases a kyphosis sometimes very severe. (32)

When Milwaukee's brace is insufficient it is necessary to envisage an anterior arthrodesis. (1)

-Postirradiation: in neuroblastoma and Wilms's tumors the sterilisation of growing cartilages and the shrinkage of mild parts can pull a kyphosis reacting usually favorably to the brace.

-Rheumatoid: the ankylosing spondylitis the symptomatology of which can begin before the age of 20 years. it is translated by a dysharmonious kyphosis with disappearance of the lordosis and projection of the trunk forward. Besides the anti-inflammatory treatment rehabilitation contains:

-Daily postures in proulna
-Practice of an in lordosis activity such as swimming. (20)

In extreme cases one can propose in lordosis posterior osteotomies to restabilize the head on the line of gravity.

-Osteoporotic of the adult: the kyphosis is often thoracic high with progressive incurvation of the trunk forward limiting respiratory function. This kyphosis is dramatic when it joins to a loss of the physiological lordosis. (5) (27)(53)(62)(63)
3.1.2 Angular kyphosis.

<table>
<thead>
<tr>
<th>ANGULAR KYPHOSIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Congenital</td>
</tr>
<tr>
<td>Defects of forming</td>
</tr>
<tr>
<td>Hypoplasia of the vertebral body</td>
</tr>
<tr>
<td>Defects of segmentation</td>
</tr>
<tr>
<td>Anterior vertebral block</td>
</tr>
<tr>
<td>Traumatic</td>
</tr>
<tr>
<td>Fracture collapse respectfully of the posterior wall</td>
</tr>
<tr>
<td>Chondrodysplasia</td>
</tr>
<tr>
<td>Achondroplasia</td>
</tr>
<tr>
<td>Mucopolysaccharidosis</td>
</tr>
<tr>
<td>Morchio disease</td>
</tr>
<tr>
<td>Neurofibromatosis</td>
</tr>
<tr>
<td>Recklinghausen</td>
</tr>
<tr>
<td>Tumoral</td>
</tr>
<tr>
<td>Primitive</td>
</tr>
<tr>
<td>Osteoid osteoma</td>
</tr>
<tr>
<td>Metastatic</td>
</tr>
<tr>
<td>Tetraplegic</td>
</tr>
</tbody>
</table>

Kyphotic congenital deformations
Are less frequent but more severe than those engendering a scoliosis, the risk of progressive paraplegy is important. One distinguishes from it two types:
Type I: hypoplasia of the vertebral body, the posterior arch is protected and pulls the kyphosis with the growth.
Type II: aplasia of the vertebral body. That is a congenital defect of the anterior segmentation of the called vertebral body "bar" or "block".
There is no secondary center of ossification and asymmetric growth in the sagittal plane provokes a kyphosis. (31) (41) (74)
When the discovery of the deformation takes place after the age of 2 years, a night brace of Milwaukee with transverse bar centred on the deformation allows to avoid worsening.
In major forms discovered before the age of 3 years a posterior epiphysiodesis can be to realize from the age of 6 months.

Fractures collapses of the vertebral body: mostly at the level of the thoraco-lumbar hinge. (56)
The achondroplasia: after the narrow lumbar canal it constitutes the second problem of these patients. The kyphosis is localized at the level of the thoraco-lumbar hinge and must be systematically prevented with the brace. In the most severe cases the surgery is of anterior type with use of a distractor. (35)
The recessive autosomic Morchio disease pulls an important vertebral wedging with thoraco-lumbar kyphosis. At these patients there is also a hypoplasia of the odotoïd apophysis with instability atlas / axis justifying a big caution during the rehabilitation. Table I (22) (23)

3.2 LORDOSIS

<table>
<thead>
<tr>
<th>Postural</th>
<th>Constitutional</th>
<th>Accentuation of the incidence and the slope of the sacral base</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attitude :</td>
<td>Abdominal hypotonia of the child before the juvenile growth</td>
<td></td>
</tr>
</tbody>
</table>
Spasm or shrinkage of the ilio-psoas

<table>
<thead>
<tr>
<th>Neuromuscular</th>
<th>Muscular dystrophy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post-laminectomy</td>
<td>Congenital</td>
</tr>
<tr>
<td>Myelomeningocele</td>
<td>Spina bifida</td>
</tr>
</tbody>
</table>

They are always regular.

We evoked the hyperlordotic attitude in prepuberal phase by abdominal hypotonia. The most frequent hyperlordosis is constitutional consequence of an increase of the lombo-pelvic incidence. It often comes along with a spondylolysis, a real fracture of fatigue of a posterior arch subjected to repeated constraints.

Hyperlordosis neurological:
The most frequent type is that of the spina bifida. The hypoplasia of the posterior arch comes along with a braking of the growth of this arch, stressing lordosis as rope of a bow which stretches out gradually. *Table II (4) (40)*

4 CLINICAL EVALUATION

4.1 Statics

4.1.1 The anamnesis specify:
The age of static disorders,
The existence of an usual hypotonia,
The pain which presents particular characteristics at the child. The child does not remember his pain, he lives in the present time. For lack of cortical representation of the spine, he does not amplify the pain. It is classified in 6 stages:
Stage 0: no pain,
Stage +: pain in the percussion of spinous apophyses,
Stage ++: mechanical pain in the effort, during or after the sport,
Stage +++: postural static pains: sat or standing prolonged,
Stage ++++: pain in the rest,
Stage ++++:+ taken of antalgic medicine, exceptional at the child.

After the puberty some back pains are connected to a neuromuscular hyperexcitability. Pains with muscular spasms arise in a sat position or up prolonged, join to an asthenia, shivers of eyelids and disorders micro circulatory: cold extremities of feet and hands.
The position of the clinical exam must be reproducible. One insists on feet joined at the level of ankle malleols and of big toe in rotation zero. Lower limbs are tense by limiting an excessive recurvatum. The trunk and the upper limbs are lax, palms of hands on the face external of thighs, glance is horizontal.

**Backwards**
A plumb line is placed on the axis of the column, the point localized at the level of the summit of the intergluteal fold. The hand which holds the plumb line is situated at the level of the back of the head of the child. The thread is usually tangent in the apex of the kyphosis in T7 (corresponding to the point of the shoulder blade).
The high thoracic arrow is measured in C7 (spinous apophysis the most striking at the level of the cervico-thoracic hinge: "vertebra proeminens ").
The arrow of lumbar lordosis is measured in the hollow of the lordosis in L2 (the corresponding vertebra L3 in horizontal one passing by 2 iliac crests).
The arrow of the kyphosis corresponds to the half-sum the high thoracic arrow and the arrow of lumbar lordosis. *(Figure 3)*

**PROFILE VIEW**
One will appreciate the global harmony of the spine, the plumb line to overlap on the same vertical line, in Tragus, in Acromion, in Trochanter and in Ankles.
Exam in sat position is indistinct and it is usually made at the beginning of visit where one notes the sat position of the patient during the interrogation.
In dorsal position one will appreciate the rigidity of belts.
At level under pelvic, ischio-crural muscles are very often retracted and one measures the popliteal angle : that is the vertical being thigh, the angle formed with this vertical line and the leg when one tries to spread the lower limb. *(Figure 4)*
For the shrinkage of the anterior plans and notably the psoas iliac, one bends the opposite member by asking the patient to hold the knee, leaving of the vertical line one lowers the opposite tense lower limb by asking for a looseness the patient. At the end of movement one can notice a tilt of the pelvis and one measures distance heel - table corresponding at the beginning of the pelvic tilt. *(Figure 5)*
At scapular level, one stretches out upper limbs behind and the shrinkage of pectoral muscles appreciates by the distance elbows-table by taking care of that the spine remains lying flat without hyper-lordosis. 

*(figure 6)*

In pronula one realizes a programmed exam with the spine:

- cutaneous palpation in search of a frequent fibromyalgia at the level of the cervico-scapular hinge.
- The percussion of spinous process can provoke pains usually corresponding to a spinal dystrophy of growth in the apex of the kyphosis and at the level of the thoraco-lumbar hinge.
- Muscle spasms will be found at the level of the painful zones lumbar vertebra and in the apex of the kyphosis.
- The pressure of transverse process with pain provoked at the level of the lombo-sacral hinge has to look for a frequent spondylolysis in case of hyper-lordosis (7 % of the population). A dehiscence at the level of the spinous apophyses of hinges evokes a spina bifida.
- Spinal rigidity will be appreciated in this position, upper limbs are placed along the body behind and one asks the patient for a movement of hyperextension of the spine. One measures distance manubrium-table and one appreciates the reducibility of the kyphosis in this position and one notes the location of the zone of rigidity (apex of the kyphosis or thoraco-lumbar hinge).

### 4.2 Dynamics

We use the quotation of Russe and Gerhard

**IN THE SAGITTAL PLAN**

The axis corresponds in horizontal one passing by 2 femoral heads, one draws a virtual straight line joining Acromion to Trochanter, the seesaw of this straight line with regard to the vertical line in extension and in flexion will be noted as well as distance finger-ground corresponding to the spinal and under pelvic rigidity.

For example 30-0-90 (from the extension to flexion).

**IN THE FRONTAL PLAN**

Virtual straight line joins the summit of the fold inter gluteal S2 and C7's spinous apophysis. One notes the extreme slopes of this virtual line from left to right F 35-0-30.

**IN HORIZONTAL PLAN**

One will note from left to right the rotation of the scapular belt with regard to the fixed pelvic girdle. Horizontal virtual at pelvic level joins two femoral heads, To scapular level horizontal virtual joins 2 Acromions (R 45-0-45). (38) (52)

### 5 RADIOLOGICAL EVALUATION

#### 5.1 Technology

The initial radiological evaluation contains an antero-posterior and profile X rays realized on cassette with progressive filter 30cm by 90cm in teleradiography with tube situated in 2 metres of the patient. Centring on T6 to avoid an excessive deformation of the vertebral body.
Radiographic irradiation for a spine is of 115 mRad at the level of the medula, of 165 mRad at the level of ovaries and of 15 mRad at the level of testicles. This radiotherapy is reduced by:

- Focus of X ray,
- The protection of gonads,
- A progressive filtering on the radiological tube,
- The use of cassettes of intensification in rare earths.

This day the digital systems of reconstruction are much more irradiant than the traditional X ray.

The digital radiography will be reserved for more specific zones to put in evidence for example the hurts of spinal dystrophy of growth. Mophotypological parameters will be carefully measured on the large X rays. It is only in case of particular etiology that we shall be brought to realize CT scan: for example to appreciate the state of the posterior wall in a fracture.

The lesions of spinal dystrophy of growth are very visible on clichés in nuclear magnetic resonance.

### 5.2 Classification of dystrophical lesions

The radiological lesions of the spinal dystrophies of growth are classified in 4 stages:

- **Stage +**: irregularity of the cartilaginous plates,
- **Stage ++**: introspongious hernia,
- **Stage +++**: cuneisation from 7 to 10° in the apex of the vertebral body,
- **Stage ++++**: cuneisation superior to 10° on a vertebra or distribution of dystrophical lesions on more than 5 vertebrae.

### 5.3 Morphotypology

We began 25 years ago with Pierre Stagnara a morphotypological study of the curvatures of the spine in the sagittal plan for a from 20 to 30 years old population.

At first we determined radiological position the most close to the clinical exam:

- Joined feet,
- Stretched out lower limbs,
- Arm slightly thrown forward, before horizontal arms, hands resting on a support,
- Relaxed spine,
- Horizontal glance. *(Figure 7)*

**Morphotypological parameters:**

**Overhang**: It corresponds to the distance of the center of the femoral head in a vertical line lowered by the middle of the sacral plate: on average $2.5\text{cm}$ at the back of the axis of the femoral heads. This distance varies according to the pelvic version. *(68)*

**Incidence**: It is formed with a perpendicular in the center of the sacral plate and the straight line center to the center of the femoral heads. This angle is on average of $53°$. This angle is constitutional, congenital and does not vary according to the anteversion. *(Figure 8)(29)*

**Inclination of S1 on the horizontal**: It is on average of $37°$. It varies according to the pelvic anteversion. It is correlated to the lordosis.
**Lordosis**: It is the angle formed by a parallel line in the L5's lower plate and a parallel line in the superior plate of the transitional vertebra the most tilted on the horizontal at the level of the thoraco-lumbar hinge. Most of the time T12. It is on average of 45°.

**Kyphosis**: It is the angle formed by a parallel line in the lower plate of the transitional vertebra at thoracolumbar level and arbitrarily parallel to the T4's superior plate because of the bad visibility on the X-rays of the high thoracic vertebrae. It is on average of 37°. (59)

**Sagittal list**: It is the angle formed between the vertical line crossing by the center of the bicoxo femoral axis and straight line uniting its point to the center of the apical vertebral body (usually horizontal in the apex of the kyphosis).

These parameters are identical for the men and the women.

There is any correlation between the size, the weight and the sagittal parameters. There is on the other hand a positive correlation between sacral inclination and angulation of the lordosis.

The distribution of angulations is of gaussian type, (median and average are identical, only curves are slightly asymmetric) with a standard deviation of 9° for main parameters. One can so use the laws of the normality and in these conditions beyond two standard deviations that is 55° for the kyphosis, an attentive surveillance is necessary and the angulation becomes openly pathological beyond 65° where one finds only 3 for 1000 of the population.

Jean Sengler and Paule Fender continued this study for a population between 30 and 40 years. Statistical results are superposable. (21)

Mac Ewen in United States realized an identical study at the children and one can say that, from the age of 5 years, the child acquires his grown-up morphotype. This age corresponds to that of the lateralization. (25) (70)

One notes however because of the hypotonia in phase prejuvenile a hyperlordotic attitude connected to the abdominal hypotonia which pulls a pelvic anteversion. In these cases incidence angle is normal.

In the standard conditions of exam, there is an excellent correlation between the clinical arrows and the radiological measurements. In commonness: general medicine, sports medicine, clinical exam is sufficient and it is only in case of accentuation of the arrows that one will have appeal to the radiography. (66) (67)

### 6 ADDITIONAL EVALUATIONS

#### 6.1 Electromyographic evaluation

Besides the search for a peripheral paralysis of the axial muscle structure, one will use the électromyography to put in evidence a neuromuscular hyperexcitability. It is about a real dysfunction of the neuromuscular zone with anoxia.

One puts in evidence of the characteristic polyplets on the 1-st interosseous after the ablation of a withers tightened in 20 cms of mercury at the level of the left hand. Characteristic signs appear 2 minutes after the levying of the withers and are favored with hyperpnea, about 10% of the population is positive in this test.

The axial muscles are more sensitive to the anoxia because working most of the time in statics to supply a stable support in upper limbs. Muscular contraction inhibits the peripheral microvascular circulation and when this one goes on arises the spasm.

#### 6.2 Spirometric evaluation

There is no repercussion of the kyphosis on the lung function, on the other hand obstructive syndromes of asthmatic type favor the constitution of a thoracic hyperkyphosis.
6.3 Psychological evaluation

The round back is registered in a cultural context which attributes it moral values and defines it with regard to standards: "hold straight ahead, otherwise you will become hunchbacked". The straight axis is an axis of will; the verticality of the body is an element of its expression. Relation between the body and the spirit is established on the basis of an identity: twisted body and twisted idea are the fact of the same to be.

Gibbosity is often seat of the ridiculous, the wickedness, as a reaction to the mockeries of which the children are the object. Evil spirit or devil sits in the hump. Saturn, the boss of the magicians, is often represented with a round back. If it is the sign of the curse it can also carry happiness "to touch the bump carries happiness".

This cultural evocation of the round back allows to clarify the attitude of the circle of acquaintances of the kyphotic children. The child who holds badly is different the others and the body bearer of a physical disgrace is depreciated. The kyphotic child can present feelings of aggressiveness, frustration and fold on one. The bent back, the attitude of the old age, those that "knocked about the world" destabilizes the teenager. The kyphotic child escapes this negative attitude by taking refuge with an imaginary world, he presents behaviour of shunning and abnormality by getting loose from the frustrating reality: "it is always I that one accuses, but maintaining that does not make me anything, I am in the habit."

Personality tests indicate insecurity, introversion and shyness. One notes difficulties of perception of the body. Personal emotional control is less good. They need support and encouragement in their actions. (30)

7 TREATMENT 1 : KYPHOSIS

7.1 History

Gym finds its best indication in hyperkyphosis and reducible hyperlordosis. Classic art position flower of lotus described as a contemplative position is an excellent posture of auto axial strain of the spine. In the end of 18-th century, the Swedish Ling created a gym based on the movements of recovery of the trunk with respiratory exercises. At the beginning of the 20-th century of numerous methods aim to treat vertebral deformations in specialized institutes. For stiff forms only gym turns out insufficient and Abbott, Erlacher, Cotrel describe techniques of plastered reduction which will be completed with the bearing of a brace "anti-gravity". The names of Spitz, Blount and Schmitt for Milwaukee and Stagnara’s brace for the bivalve plexidor brace are the most frequently quoted. (7) (61)

7.2 Free rehabilitation

Every physiotherapical practice has to make in lumbar locking especially when there is a rigidity at the level of the kyphosis. Exercises at the physiotherapist will be repeated daily at home and integrated within the surrounding of an additional sports activity and of a daily spinal hygiene from the sat position to the schoolbag. (13)

In a practical spirit we regrouped the various techniques in big tables corresponding to the daily activity: direct, indirect, painful and inverted hypotonic, dysharmonious, stiff kyphosis.

7.3 THE SAT POSITION

The Homo Sapiens became during these last years a Homo Sedens.
The control of the sat position is an act of separate rehabilitation:

1 °) Determination of the height of the seating : one uses the rule of the 90 ° : thighs and horizontal feet, legs are upright.

2 °) Determination of the slope of the chair : one horizontal seating is convenient for 80 % of the population.

In case of horizontalisation of the sacral plate with usually decrease of the incidence angle one will tilt the seating forwards and sometimes one will use one against support at the level of the knee to avoid gliding forwards. (34)

In case of excessive verticalisation of the sacral base with usually increase of the incidence angle, one will use one seating tilted towards the back or possibly a triangular pillow on one horizontal seating.

3 °) Determination of the height of the work plan.

The rule of the 90 ° can also apply so that arms are vertical and before horizontal arms tangent to the work plan. 

(Figure 9)

Inclination of the work plan : a slope of 15 ° does not pull gliding of the paper and limits the cervical kyphosis.

The screen of the computer will be placed in 10 ° below the horizontal line of the glance.

One will alternate notably at the school :

- The positions of listening: back laid to the file of the chair, trunk tilted to 10 ° with regard to the vertical line and the feet forward.

- The positions of writing: trunk laid to the anterior edge of the table, trunk tilted to 10 ° with regard to the vertical line, before arms and elbows from the work plan. In this position feet are behind, the ischions are situated on the front of seat

7.4 THE SCHOOLBAG

The weight of the schoolbag

It can be excessive when it exceeds the third of the weight of the body. In that case it is advisable to use a rolling schoolbag. In the other cases, we consider it as an instrument of physiotherapy of the spine and we take advantage of the occasion to learn the child to realize transfers in a economic way. (65)

Choice of the schoolbag

It must be balanced well on 2 shoulders, the center is localized 5cm below the apex of the kyphosis. Ideal structure is semi-stiff to avoid a deformation of the structure and well to distribute pressures on the surface of the back. We advise an abdominal belt of preservation as the rucksacks of mountain to avoid micro-traumatism repeated at the level of the spine. Belts must be wide to be tolerated well at the level of shoulders.

Walking with the schoolbag

The child has to avoid a projection of the trunk forward in case of kyphosis and of the trunk behind in case of lordosis.

Transfers

From the ground to the work plan : one will use the technique of the devoted knight with progressive passage from the ground to the heightened knee then from the knee to the work plan, the trunk remaining fixed. In certain cases one will be able to use the dynamic technique of the "binding” pushed aside feet, schoolbag placed slightly at the back of the line
of gravity, lower limbs bend, straight trunk, until hands reach the handle, one unsticks slightly the schoolbag of the ground and one realizes a pendulum's swing back forward by lifting the schoolbag until the work plan and by moving the take-off foot realizing an anterior crack. The schoolbag should be balanced well with distribution right-left books. The heaviest books will be placed the most close possible of the back.

7.5 The hypotonic kyphosis

The muscular hypotonia is physiological in juvenile period, the practice of a regular sports activity usually allows to compensate for it. We shall insist in rehabilitation on static musculation in axial active auto-strain such as "grand porter", this musculation is always completed by respiratory exercises by insisting on the deep inspiration.

Second exercise concerns proprioceptive control for example in proulna on Klein Vogelbach's balloon, movement of hyperextension of arms, lower limbs having by the physiotherapist.

7.6 The dysharmonious kyphosis

It can be associated to the hypotonic kyphosis: attitude evoking the person of comic strip "Gaston Lagaffe" bent lower limbs and trunk thrown behind and head forward. Radiologically one notices:
- A flexum of hips,
- A normal lordosis or slightly decreased,
- An accentuation of sagittal list,
- An removal of the vertebral apical body with regard to the line of gravity,
- An increase of the angulation of kyphosis.

Rehabilitation contains:
1 °) a postural correction: the child has to become aware of the back and acquire a better representation of his shape of it, its position and its dynamics in the space. This static and dynamic awareness is made due to the video, the camera being placed laterally to show sagittal plan. One explains to the child ideal position in the sagittal plan, the means to reach this ideal position with learning of the correction of noticed and received disharmonies first of all in a segmental way of bottom at the top then in a global way in statics, then during the movement notably of the walking. *(figure 10)*
2 °) a restoration of the femoral extension by techniques of softening of the psoas,
3 °) a restoration of the physiological lordosis for example technical Mackenzie,
4 °) a correction of the hyperkyphosis by musculation of the chest expanders of the spine.
The direct stiff kyphosis
Usually by spinal dystrophy of growth which pulls a pinching out of the disc with limitation of the segmental mobility.
One will insist in rehabilitation on the softening of the spine in extension:
Passive postures in proulna or in quadrupedia, (*figure 11*)
Stretching of the posterior intervertebral ligament in dorsal dorsal position apex of the kyphosis on a block, active and passive techniques with postures at the end of active extension,
Posterior articular mobilization in the 3 plans of the space by associating lateral inflection activates and hyperextension and active rotation with hyperextension. Global softening must be three-dimensional.
The segmental stiffening at the level of the kyphosis favors a limitation of thoracic amplitudes in deep inspiration, one will watch to mobilize coasts by respiratory exercises in extreme amplitude: inspiration and expiration deep. (42) (57)

7.7 The indirect stiff kyphosis
One notices mostly a rigidity of belts, doubtless primitive, pulling the spine.
The techniques of global postural rehabilitation by example Mézière allow a continuous softening of the anterior and posterior chains of the back from the head to the big toe (43)

7.8 The painful kyphosis
The origin of the pain is clarified by the programmed exam which we envisaged in the clinical exam.
The fibromyalgy of the cervico-thoracic hinge will be treated classicaly by massages, mesothérapy, physiotherapy. The practice of a sports activity such as swimming is quickly advised to decrease the inflammation of the muscular aponevrosis.

Muscle contractures can be secondary in a vertebral instability usually anterior
They can be primitive, when there is a neuromuscular hyperexcitability.
Indications are the following ones:
Warm bath during ¼ of hour in case of pain,
To drink at least two liters a day because muscular dehydration is one of the first factors of muscle spasm.
Practice of a sports activity favoring the peripheral vascular microcirculation, that is in 2/3 of the maximal capacity. Perspiration during the sports activity express cardiovascular effect.
An additional medicinal treatment with base of vitamins D, Phosphor and Magnesium decrease the asthenia felt usually by the patient. This medicinal treatment is renewed during 2 months in spring and in autumn.
Usual vertebral instability in case of spinal dystrophy of growth will often require appeal to the conservative orthopaedic treatment because little accessible to the classic rehabilitation.
The antalgic medicinals are not used at the child's to whom one has to explain that pain is mostly a witness of a defect of vertebral hygiene.
7.9 The inverted kyphosis

Clinical description
It contains:
- Decrease of the incidence angle,
- Horizontalisation of the sacral base,
- Thoraco-lumbar kyphosis,
- Flat back thoracic,
- Cervical kyphosis.

Principles
One inverts classic exercises:
- Stretching exercises in lumbar lordosis and pelvic anteversion,
- Thoracic rolling-up in flexion by using kyphotic traction of the upper umbilical part of abdominal muscles with work in concentric. The posterior thoracic paravertebral masses are mobilized in eccentric.
- Rolling-up of shoulders; the pectoral muscles are strengthened in systematic short position.

Methods
Postural rehabilitation can be realized, in sat position: lombo-pelvic stabilization in anteversion, feet behind, the ischion is at the back of the seating. The thoracic spine and the scapular belt wind in position of writing.
- Stretching concerns especially the lumbar spine in extension. The patient is in proulnka, a pillow placed under the breast and lordosis is obtained due to the passive extension of thighs on the pelvis. This exercise can be also realized on Klein Vogelbach's balloon.
- Musculation: at posterior lumbar level is realized in short position. At level thoracic they are the anterior pectoral muscles and the known upper umbilical abdominal muscles which are developed the muscle in short position.
- Globally exercises of rolling-up of the trunk forward for instance "to kiss a teddy bear" or carry of a big balloon. (14)

7.10 SPORT

The sport is an indispensable complement to the physiotherapy and to the conservative orthopaedic treatment. We notice that the sportsmen have rather less spine troubles than the home-bodies and numerous high-level sportsmen presenting a spinal pathology were able to pursue their sport in competition without pain and without accentuation of the spinal pathology. (8)

We distinguish 3 cycles of activity according to the age:
1-st cycle: 6 - 10 years, one will insist on the rhythm, the coordination, the enrichment of the body image and the space / time control.
2-nd cycle: 10 - 15 years, one will insist on the force, the speed and a sport rather collective.
3-rd cycle: 15 - 18 years, it is the age of the competition and of body building. The sport should be integrated into the activity of superior student or at the beginning of professional activity.

It is necessary to differentiate the school gym of the competitive sport.
THE EXEMPTION OF SCHOOL GYM is logical in phase of plastered reduction. In phase of brace, sports activity is resumed with, in case of spinal dystrophy of growth or spondylolysis, contraindication of the jumps of more than 50 cms: high jumps, broad jumps, hurdles, as well as dives in swimming.

For kyphosis
One can distinguish:
Sports without risk:
Swimming, by avoiding however styles dolphin and butterfly which favor the accentuation of curvatures in the sagittal plan.
The sports of extension of the spine: volleyball ball, basketball ball, ballet dance

Sports with risk:
Biking where one will take care of particularly the regulation of the guidon and the saddle.
Equitation which leads micro repeated traumatism.
Gym with movement forced in extreme amplitude of the spine
Football with constraint in acceleration and deceleration rough.

Sports dissuaded from principle:
Rugby, weight lifter, combat sport, motocross …
Before deciding definitively on the stop of the competition, a test of 3 months is usual; if clinical signs improve competition will be resumed at the conclusion of this delay. (16) (24)

-For lordosis one will prefer sports developing the muscle of the anterior chain by avoiding the badminton and the dive in swimming.
One will insist on heavy labour in aerobic metabolism by limiting at most efforts against resistance especially in anoxy.
Activity is practised in 2/3 of the maximal capacity, what it is always difficult to make understand to the teenager who practises the sport to win or to beat records.
Food must be rich in vitamins brought with fruits and vegetables, in proteins: meat or fishes, and in sugar with slow elimination such as pastas and rice.
Hydration is fundamental, it is necessary to drink at least two liters a day, more in case of sport (for example 3 liters in 100 km in cycle).
In certain cases of bad representation of the body image the practice of the dance and the theater facilitates postural control.

7.11 ORTHOPAEDIC JUVENILE CONSERVATIVE TREATMENT

7.11.1 PROTOCOL
First time is a reduction of the kyphosis made with a plaster cast which will be worn at least 4 weeks: necessary time to obtain one ligamentar fluage at the level of the anterior vertebral common ligament.
At the conclusion of this reduction is realized the moulding of the brace of type plexidur bivalve which is worn at night and in school sat position till the end of the statural growth and for a minimum of 18 months.
A specific rehabilitation is a part integral of the treatment. (15) (17) (18)

Techniques of realization of the plastered cast.
The trunk is covered with 2 Jersey internal of 20cm and external of 15cm.
Two felt-tips of 5mm are inserted between two Jersey at the level of the antero-superior iliac thorns.
The child is placed in Abbott’s frame, a classic traction is realized at the level of the pelvis and a chin strap connected with a dynamometer completes axial traction.
A light axial traction (6 kg) favors mobility loss of weight.
A transverse strip is placed under the apex of the kyphosis and a transverse felt-tip is placed between the linen strip and Jersey. Additional felt-tips protect the chondro-costal thoracic part, the sternal manubrium and the collarbones.
The flexion of hip allows to re-harmonize curvatures in the sagittal plan by a more or less important correction of the lordosis. The transverse strip is situated on the same horizontal that the metal bar of ischiatic support. One covers the trunk with circular plastered strips of 20cm so as to facilitate the adhesion of the 4 longitudinal plastered splints of 30 or 20cm of wide. The strips of 30cm being placed first and foremost forward and behind. These splints are shown solidarity with plastered strips of 20cm crossing up the shoulders well to stick high part at the level of the cervico-thoracic hinge. (figure 12)

At the end of some minutes the child is standing upright and the plaster cast cut:
At the level of the breast,
At the abdominal level where one draws a triangle with superior point,
At the level of the inguinal fold, so that the child can sit down without any trouble in before defined positions.
At posterior level an oblong window centred on the lumbar region will facilitate the care of skin.

An extensive drying on ergonomic chair seating in knees allows to realize this plaster cast in day hospital.
Rehabilitation begins from the drying. The sensation of breathlessness will disappear by the respiratory rehabilitation with movement of the current volume towards the spare expiratory volume. It is necessary to teach the child to breathe slowly and to expire profoundly. A videotape shows to the relatives how to realize the care of skin.
Daily rehabilitation will be pursued at home with control twice a week by the liberal physiotherapist. This one will take advantage of the lever arm supplied by the thoracic immobilization to stretch belts and to fight against the indirect rigidity. (figure 13)
A progressive felting in the apex of the gibbosity and possibly in the sacral level will allow to decrease direct rigidity.
It is necessary to take advantage of this period of plastered immobilization to control the gestures of economy of the column, for example: implementation of shoes in sat position, with rotation external of the lower limb, the ankle being positioned on the opposite knee.
7.11.2 The Brace

The plexidur bivalve brace includes:
A posterior pad T7-S3 cut under the point of shoulder blades to supply a lever arm facilitating the thoracic extension of the superior spine.
An anterior pad with manubrial support strengthened with a metal bar. (Figure 14)
Possibly, one can add Spitzy's cervical necklace and shoulder-plate allowing a retropulsion of the scapular belt.

We prefer however that the rolling-up of shoulders and the projection of the neck forward are corrected actively by the rehabilitation.
Rehabilitation in brace will be gradually muscular. One will pursue by means of the brace the stretching of belts taking advantage of the lever arm supplied with the brace. (Figure 15) (47)

Protocol of bearing of the brace: first 6 months the brace is worn at night and in school sat position. On the occasion of summer the wearing will be night-and according to the sat position and to the radiological correction, diurnal weaning will be possibly pursued.

7.11.3 INDICATIONS OF the CONSERVATIVE ORTHOPAEDIC TREATMENT (C.O.T.).

1 °) According to the angulation of the kyphosis.
The angulation has to exceed 55 ° and deteriorate on the occasion of successive controls.
2 °) According to the pain.
Pain translates essentially a spinal dystrophy of growth and when it persists in spite of the rehabilitation direct to the conservative treatment.
3 °) According to the rigidity.
As soon as there is a partial correction in hyperextension, the C.O.T. is going to allow to get back extension and so to facilitate the work of the muscle structure.
One will naturally take into account the disharmony, the hypotonia and the secondary rigidity.
4 °) According to the age, one will turn to Milwaukee's anti-kyphosis brace before the age of 13 years at the boy, not to deform a rib cage in growth. The bearing of the brace is night.
After the puberty Milwaukee becomes less effective because of rigidity and necessity of a bearing in sat position usually justifies appeal to the orthopaedic treatment of Lyons (plaster cast and brace). (39) (50) (69)
7.11.4 THORACO-LUMBAR KYPHOSIS

In the case of a low thoraco-lumbar kyphosis, the plastered cast can be realized in up position, hands crossed behind the nape of the neck, what allows a good modelling. An excess of lordosis will be corrected by a light projection of the trunk forward. The brace is in polyethylene monohull with anterior support now carefully the chondro-costal thoracic part. One will insist on the usual sat position, the brace touching the front of the work plan, elbows are on the table and the feet behind. (Figure 16)

7.11.5 ORTHOPAEDIC CONSERVATIVE TREATMENT PREPUBERAL

Indications are relatively rare except congenital forms.

Night brace of Milwaukee
One realizes Milwaukee's brace with lombo-pelvic moulding with decrease of lordosis and transverse bar of support centred on the apex of the kyphosis. This brace is worn at night. Rehabilitation will be daily with exercises of axial active auto-strain: unsticking of the chin, hands taking support on the anterior mast and exercises of hyperextension by taking support on the posterior transverse bar, the arms in candlestick. A weekly control by physiotherapist will allow a postural correction of the usual attitude and a control in sat position. (Figure 17) (7) (54) (72)
7.11.6 Raise back

It contains a stiff posterior pad for example there in plexidur to which are fixed:
- Spitzy's necklace to limit the projection of the neck forward,
- A shoulder-plate which passes in front of the acromio-clavicular joint
- A belt of abdominal stabilization which will take support under the chondro-costal zone. (*Figure 18*)

The child will wear the raise back some hours in the day rather in sat position because the brace controls by the lumbar lordosis.

It addresses reducible forms without hyperlordosis.

7.12 SURGICAL TREATMENT

It is essentially reserved for the angular kyphosis, indeed the neurological risk of stretching of Adamkiewitz's artery is major in the regular kyphosis where one will have appeal to a preoperative reduction in cranial halo. (9)

The posterior epiphysiodesis at a young child addresses the congenital kyphosis, blocking the growth of the posterior arch at the level of the zone of malformation and avoids the accentuation of the kyphosis.

A night brace of Milwaukee can settle post-surgery growth.

The other interventions: posterior arthrodesis or decompression, are indicated when there is a neurological suffering.

7.13 Preoperative period

One insists on the stretching with opening of the kyphosis by releasing of the vertebro-thoracic complex then the stretching of neighboring curvatures and belts completes segmental work.

**Education respiratory** watches to improve alveolar exchanges by decreasing spare expiratory volume and by lowering the diaphragm.

In certain cases one uses a berck traction with vertebral auto-strain practised several times a day. By efforts of symmetric push subject realizes an axial stretching is rhythmic: 7 seconds of traction, 7 seconds of rest, is a series of prolonged postures of about 5 minutes.

**The elongation plaster casts** contain a antikyphosis pad placed at the level of the apex of the curvature.

**The cranial halo** is used either in suspension in wheelchair with traction in the bed during at night, or on pelvic plastered belt connected with the halo by thread stalks.

Physiotherapy reconciles a trophic general maintenance in the neuromuscular relaxation.

7.14 Period post-surgery

cutaneous nursing,
Fast verticalisation on table with variable slope,
Respiratory exercises. In the ablation of the drain one re-educates the diaphragm to fight against the forming of the scar reins. The patient lies on the healthy side, what facilitates inspiratory position of the operated side. Deep and slow breath at the rate of 5 in 10 minutes
every hour, associated to static contractions of lower limbs to eliminate the venous stasis and to limit the risks of phlebitis or of embolism,
Muscular recovery:
The posterior muscular contraction of spine plans is of static type against strong resistance and holding for a long time. Opposite curvatures are placed in position of correction.
Abdominal muscles are worked in short position by insisting on obliques and transversal muscles.
Training in the walking, with stimulation of the balance, control of the dissociation of belts in the three plans of the space.
Global gym with advices of hygiene of life :
bearing of stable shoes with small heels,
correct bedding with supple mattress on a hard plan,
Organization of the driving place with pillow in the back,
Practice of a physical activity of open air such as the walking.
During the professional activity, one adapts the sat position with variations of positions during day. (44)

8 TRAITEMENT II - LORDOSIS

8.1 FREE REHABILITATION

Address essentially lordosis either with pain or associated to a spondylolysis or when the angulation exceeds 65 °. When incidence is high only rehabilitation, is usually insufficient and one will have appeal to the C.O.T.
Rehabilitation contains :
A softening of psoas muscle and group of the anterior chain by technique Mézière,
An intensification of the abdominal muscle structure,
A stretching of the lumbar paravertebral muscles,
A control of the pelvic version.

8.2 The C.O.T.

contains a plastered reduction by lumbar plaster cast realized in light flexum of hips and a projection of the trunk forward. It is necessary however to avoid any abdominal hyperpressure and insist on the modelling of the iliac crests allowing a real under costal grip.
The brace is usually in polyethylene monohull of 3mm and maintains correction obtained with the plaster cast.
Posterior part goes raises in T7 to stimulate the point of the shoulder blade and comes down enough low at level S3 (edge lower than 4 cms of the seating). Forward one maintains the chondro-costal zone.
When there is a strong hypotonia of the posterior abdominal belt one can use the lombo-pelvic module of Boston which maintains perfectly the abdominal region and opens behind.
The risks of hyperlordosis in sat position being limited, the brace is worn essentially after the sport and at night.
9 CONCLUSION

Hyperkyphosis, hyperlordosis and vertebral inversions form a very ill-assorted group of which it is sometimes difficult to assert pathological character so much individual variations are frequent. Evolution is very variable and difficult has to forecast. If respiratory function is not reduced in usual forms, accentuation or decrease of curvatures favor back pains and risk to stiffen the spine in a less favorable position late in life.

The most premature possible treatments, will be adapted according to multiple criteria of evaluation: age, anatomical deformation, pains, evolutivity by looking for constraint minimum with regard to the efficiency.
BIBLIOGRAPHIE

6 - Beyeler J, Reichmann B, Schneider W, Schweizer A. Morbus Scheuermann : thorakeler M Scheuermann 10 und mehr Jahress Suicide operativ und konservativ behandelten Pazienten. Orthopäde 1979 ; 8 : 180-183
7 - Blount WP, Moe JH. The Milwaukee brace. The William and Wilkins Co Baltimore
16 - Commandre F. Pathologie rachidienne d’origine sportive. Traumatologie sportive Masson 1979 : 149-159
19 - Dimiego A, Bonnel F. La croissance du rachis. Sauramps Médical 2° éd.1987
25 - Korovessis PG, Stamatakis MV, Baikousis AG. Reciprocal angulation of vertebral bodies in the sagittal plane in an asymptomatic Greek population. Spine 1998 ; 23 : 700-705
26 - Kovac V, Pecina M. Moiré topography in measurement of the sagittal curvatures of the spine. Coll Antropol 1999; 23: 153-158
46 - Ollier M. Rééducation dans le cadre du traitement orthopédique de la maladie de Scheuermann. Kinésith Scient 1978; 289: 5-10
50 - Platero D, Luna JD, Pedraza V. Juvenile kyphosis: effects of different variables on conservative treatment outcome. Acta Orthop Belg 1997; 63(3): 194-201
52 - Russe OA, Gerhardt J. International SFTR method of measurement end recording joint motion. Hans Huber Berne 1976
58 - Sorensen KH Scheuermann juvenile kyphosis. Clinical appearance, radiography, aetiology and prognosis Munksgaard Copenhagen 1964