EXPLANATION OF BIOMECHANICAL ETIOLOGY OF THE SO-CALLED IDIOPATHIC SCOLIOSIS (1995–2007). NEW CLINICAL AND RADIOLOGICAL CLASSIFICATION

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ABSTRACT

The article presents biomechanical etiology of the so-called idiopathic scoliosis [adolescent idiopathic scoliosis – AIS] (1995–2007). Development of scoliosis is connected with "gait" and permanent habit of "standing at ease" on the right leg. New classification of AIS describes: "S" shaped scoliosis in group I epg, "C" scoliosis – in group II/A epg and "S" scoliosis – in group II/B epg and also "I" shaped scoliosis – in group III epg (etiopathological group) which were distinguished in years 2001–2004 / 2006. In all children with so-called idiopathic scoliosis was found limited adduction of the right hip or even abduction contracture of this hip often connected with flexion and external rotation contracture.

The contracture, or only difference in adduction (smaller in the right hip), is connected with the "syndrome of contractures" in newborns and babies described by many authors but thoroughly and very exactly by Prof. Hans Mau.

The new classification makes clear therapeutic approach to every etiopathological group of scoliosis and gives us possibility to introduce causative prophylaxis.

Key words: Biomechanical etiology of the so-called idiopathic scoliosis, "Syndrome of contractures". New classification

1. INTRODUCTION

Through many years etiology of the so-called idiopathic scoliosis (AIS) was unknown. Many researchers searched for "etiological factors" of scoliosis like: genetic, hormonal factors, growth abnormalities, neuromuscular influences, disorders in bones, disorders in muscle and fibrous tissue, growth rate, left – right symmetry / asymmetry (and here directional asymmetry, anti-asymmetry, fluctuating asymmetry), anterior – posterior symmetry / asymmetry (and here directional asymmetry, anti-asymmetry, fluctuating asymmetry), asymmetry in growth of spinal cord and

vertebra bodies and in "asymmetry concept" – arm length, facial structure, trunk, hand & foot preference, "reducing" asymmetry with age, nervous system lateralization, dermatoglyphics, developmental instability, "boy gait" versus "girl gait", thoracic-spinal deformity primary as concept for idiopathic scoliosis – "multi-factorial" – "silent" concept, CNS, immature scoliotic vertebrae, circulating factor and plenty of other hypothetic influences (taken from *Second Round EFG 6 / International Federated Body on Scoliosis Aetiology (IBSE) / Electronic Focus Group-6 (EFG-6).* Coordinator – Prof. Peter Dangierfield).

Our first presentation on "biomechanical influences for development of spine" was in 1995 in Hungary. The biomechanical etiology of the so-called idiopathic scoliosis is based on asymmetry of movements of left and right hip and in result asymmetry of loading during gait, leading to asymmetry of growth between left and right side of the body witch results in time as scoliosis. All children with so-called idiopathic scoliosis have the habit of permanent standing "at ease" only on the right leg. This is connected with "real abduction contracture" or only limited adduction of the right hip often with co-existing flexion and external rotation contractures in comparison to the left hip. This makes the right hip – right leg „stronger", „more stable" and because of this „more easy for standing" on". This asymmetry of movements is connected with the "syndrome of contractures" in newborns and babies *(Originally in German – "Siebenersyndrom"* – Mau*).*

2. CLINICAL SIGNS OF „SYNDROME OF CONTRACTURES"

The „syndrome of contractures" has been described primarily and in detail by Prof. Hans Mau – Tübingen / Germany – as *Siebener [Kontrakturen] Syndrom*" (syndrome of seven contractures) [**1, 2**]. This syndrome has been also described by: Hensinger [**3**], Howorth [**4**], Green & Griffin [**5**], Vizkelety [**6**], Komprda [**7**], Karski [**8, 9, 10, 11, 12, 13**], Tarczyńska, Karski & Karska [**14**]. In 1932 Prof. W. Dega / Poland described the "syndrome of contractures" as "ultra positioning" of fetus [**18, 19**]. The causes of the „syndrome of contractures" can be related with fetus itself: heavier, longer body; or with mother conditions: small belly during pregnancy, lack of amniotic fluids, pelvic bone type: "androidal" or "platypeloidal"– inconvenient for proper fetus growth [**14, 15**]. Prof. Mau underlined influences of CNS on development of "syndrome of contractures".

Mostly we observe the "syndrome of contractures" as result of left sided fetus position. This position of fetus is connected with the "*first* fetus position" during pregnancy – 80%–90% (Describing by gynecologist – Oleszczuk) [**16, 17**]. In "syndrome of contractures" according to Mau there are:

1. scull deformity */plagiocephaly/* – flattening mostly of left forehead and *os temporalis*, left chick atrophy, eyes – nose and ears asymmetry / deformations
2. *torticollis muscularis (wry neck)* / shortening of sterno-cleido-mastoideus muscle/ – usually left-sided, related with plagiocephaly or / and traumatic delivery or with congenital "*tumor neonatorum" (fibrous tumor)*

3. *scoliosis infantilis* (infantile scoliosis) – other than idiopathic scoliosis. Usually recedes spontaneously at 80% of cases [**20, 21, 22**] or even at 100% (Mau) [**1, 2**]
4. contracture (shortening) of adductor muscles of the left hip. Untreated contracture can lead to development of hip dysplasia, which primarily can be observed only at 10% of newborns [**10**]. The remaining 90% of dysplasia are cases of secondary deformity resulting from the contracture and are classified as "developmental hip dysplasia" (DDH – Klisič).
5. contracture (shortening) of abductor muscles and soft tissues of the right hip (Karski) [**9, 10, 11, 12**], described as *Haltungsschwäche* ("weak posture") by Mau. This contracture may cause oblique positioning of pelvic bone observed at X-ray picture of hip joints in babies. With time asymmetry in movement causes asymmetry during gait and

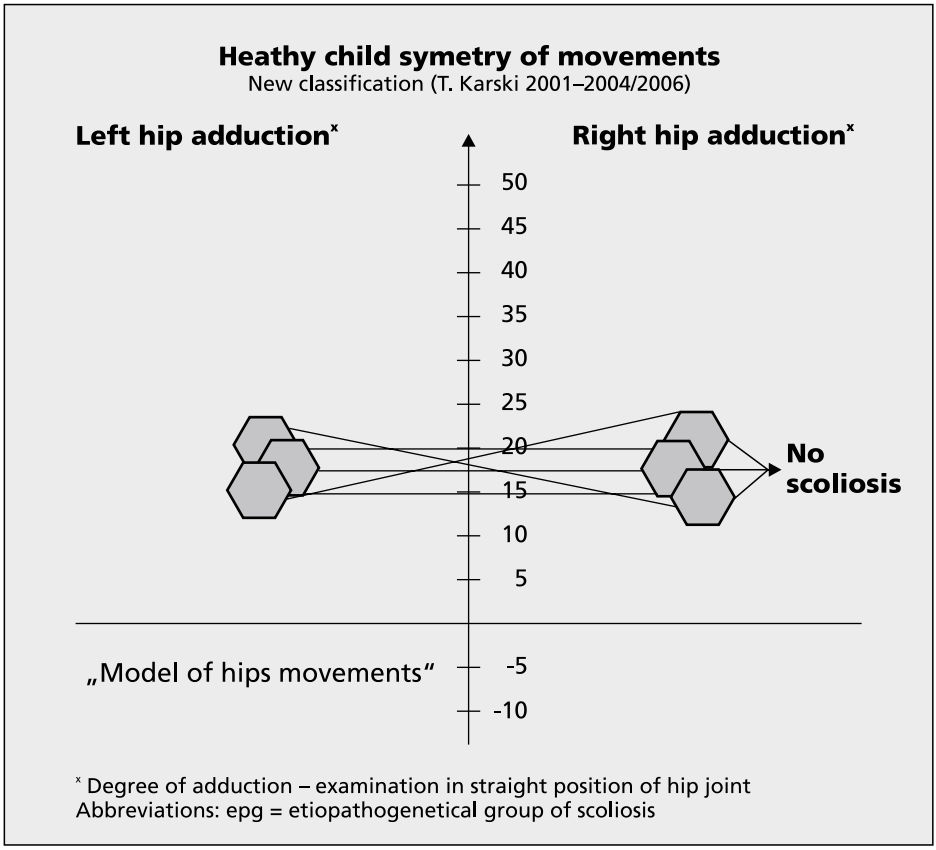
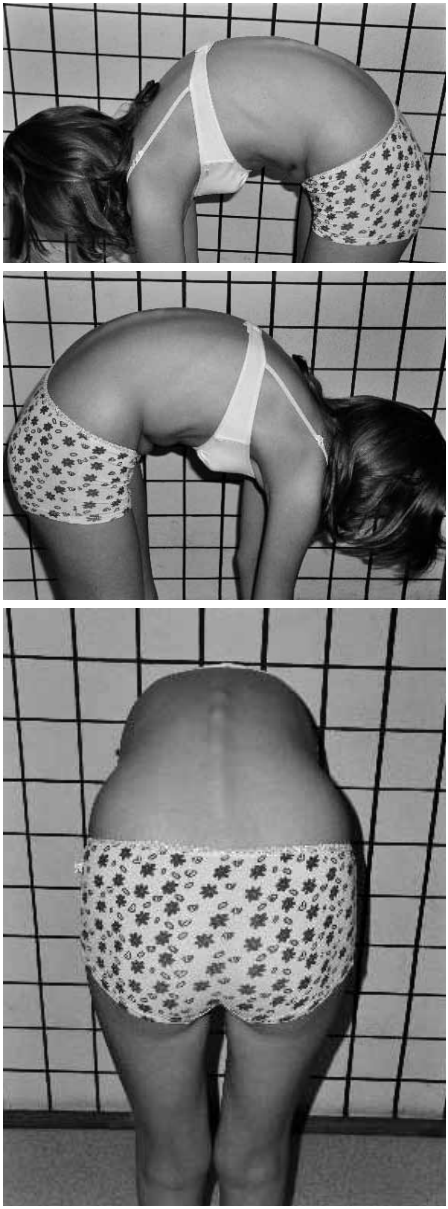


Fig. 1, 2. Model of hips movements. Symmetrical adduction of both hips. No danger of scoliosis, no scoliosis. Normal axis of spine, full flexion



Example of normal spine – child with normal axis of spine and full flection of spine. Symmetrical adduction of both hips.

loading; and with time asymmetry of growth and development of spine – as result: scoliosis (Karski 1995–2006) [**22, 24**])

6. pelvic bone asymmetry – the oblique pelvis positioning visible during X-ray examination for hip joint screening – [see above points 4 and 5]
7. feet deformities – such as: *pes equino-varus, pes equino-valgus, pes calcaneo-valgus*

In Lublin we also include to "syndrome of contractures and deformities in newborn and babies" excessive shank deformity (*crura vara*) which can lead with time to Blount disease. The development of this deformity and the causes are described in German in "Orthopädische Praxis" [Karski and coll.]

3. CLINICAL SIGNS OF "SYNDROME OF CONTRACTURES" IN CHILDREN WITH SO-CALLED IDIOPATHIC SCOLIOSIS QUOTED IN LITERATURE

In children with developed scoliosis, by exact examination of the patient, many researchers saw distant deformities described in "syndrome of contractures" (described above) like: plagiocephaly, torticollis, asymmetry of temporal bone, tilt of pelvis and asymmetry of the whole body. The authors noted in their research as quoted by Normelli, Sevastik [**26**] and others:

a) Willner (1972) quot. [**26**] „ ... *in general the left leg tends to be shorter than the*

right in childhood and this leads to development of the left convex lumbar curve. Pelvic obliquity has been observed in structural scoliosis"

b) Magoun (1974) quot. [**26**] „ ... *asymmetry of temporal bones has also been associated with scoliosis*"

c) Wynne-Davies (1975) quot. [**26**] „ ... *plagiocephaly has been considered to be closely related to infantile idiopathic scoliosis*"

d) Dangerfield and Col. (1995) quot. [**27**] „ ... *as with the plagiocephaly, the body asymmetry* (in children with scoliosis) *is as yet unexplained*"

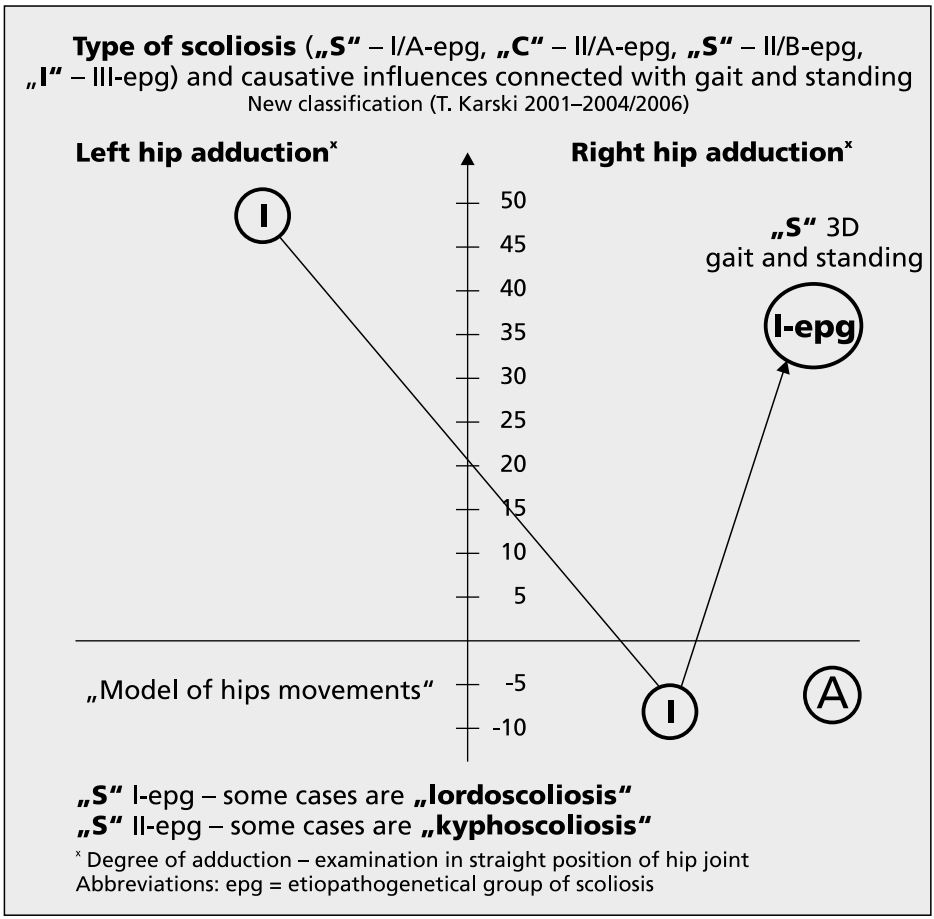


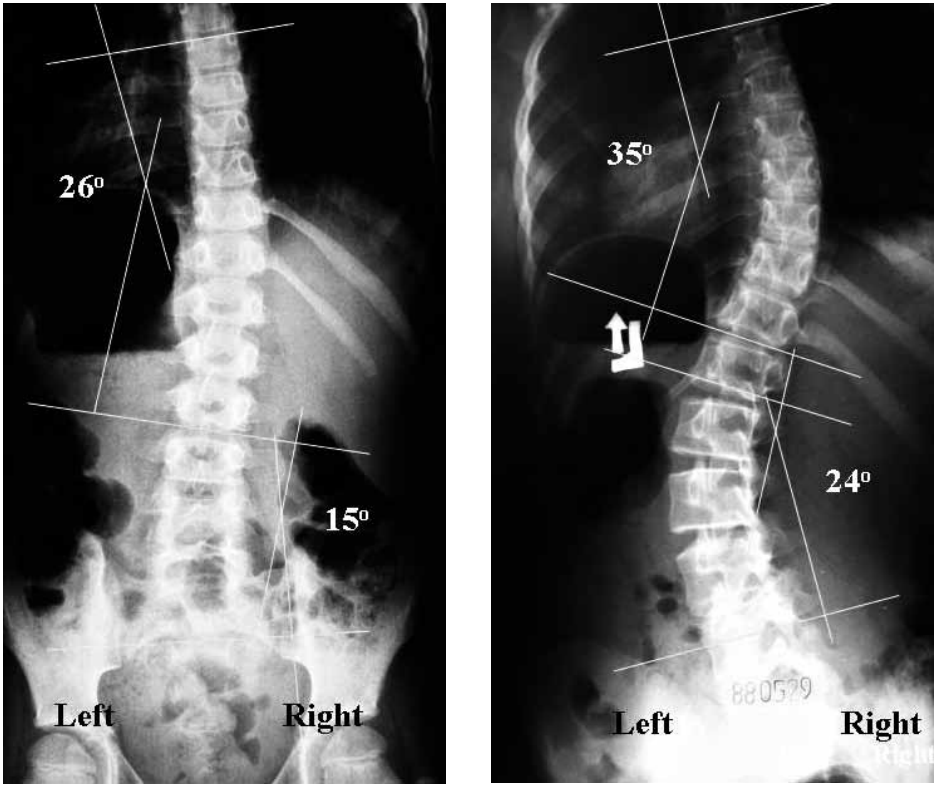
Fig. 3, 4. Model of hips movements in Ist epg – "S" shaped double scoliosis. Two different cases & phazes of deformity. Examples of: Ist epg / 3D /. In this group some cases – „lordoscoliosis". Causative factors: gait & standing.

e) Estève de Miguel C. (1991) quot. [**9**] „ ... *the difference in the length of extremities, /.../ pelvic tilt – secondary scoliosis*"

f) Tylman D. (1995) quot. [**28**] „ ...*tilt of pelvis is important sign of development of scoliosis*"

g) Gardner A. (2000) quot. [**9**] „... *so-called idiopathic scoliosis commonly occurs in combination with a characteristic pattern of soft tissue asymmetries in the hip and pelvis region*"

Also the sensibility to new rehabilitation exercises [**24**] underlines the biomechanical influences coming from the "syndrome of contractures" in early stages of deformity.



„S" scoliosis – Ist epg / 3D / some cases – „lordoscoliosis". Causative factors: gait & standing. Two different cases & phases of deformity

4. OTHER OBSERVATIONS IMPORTANT IN CLINICAL PICTURE OF SO-CALLED IDIOPATHIC SCOLIOSIS

Clinical observations indicate that progression in I epg is especially fast in children with joint laxity, rickets, pelvis and lumbar spine anatomy anomalies (*spina bifida occulta*), chest and ribs deformities (*pectus infundibiliforme*). Early important clinical signs in very young children with danger of scoliosis are among others signs of "straight position of trunk (of spine)" or later "stiffness of spine" with "flat back" and habit of permanent sitting straight up

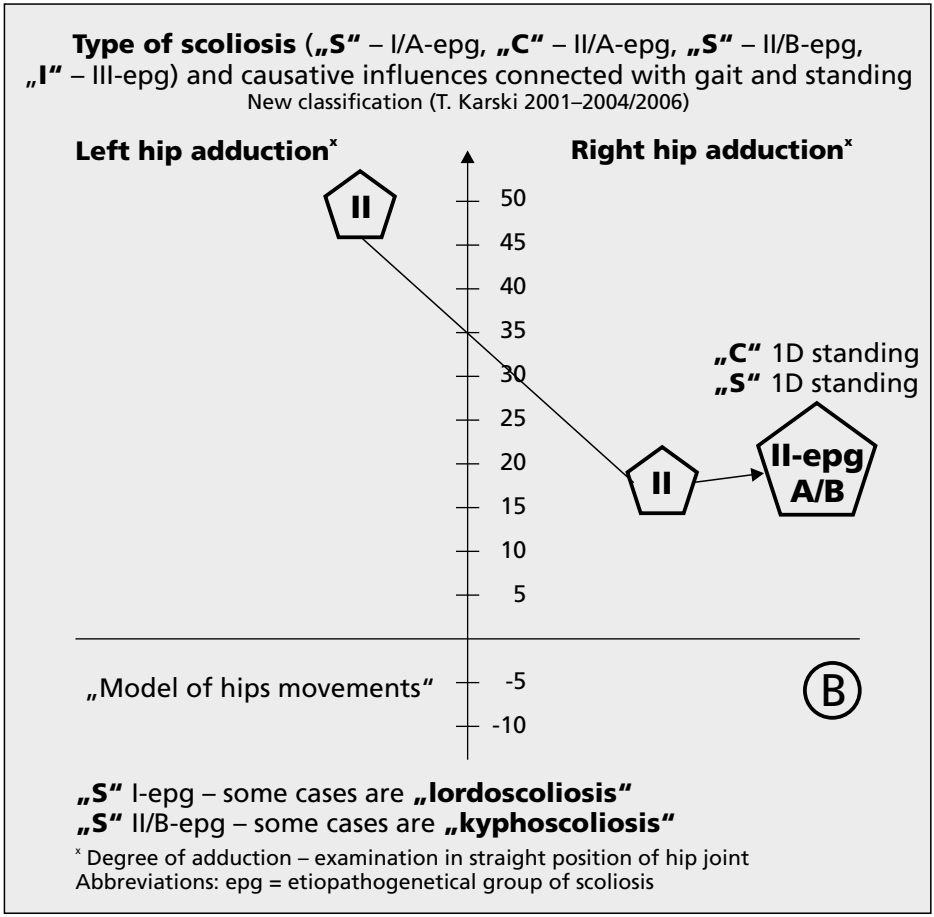


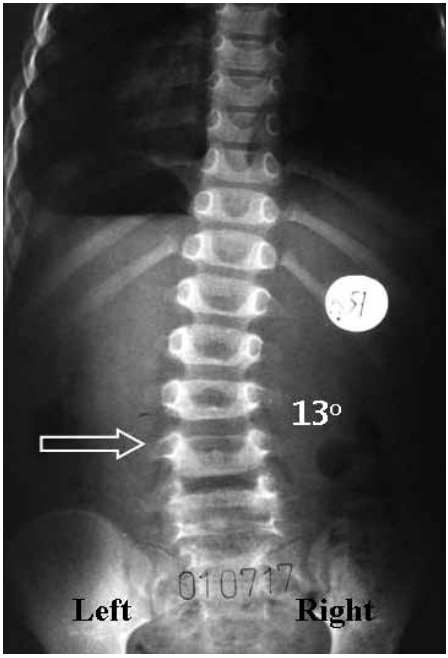
Fig. 5, 6. Model of hips movements in II/A epg and II/B epg – "C" shaped scoliosis or "S" shaped scoliosis. Two different cases & phazes of deformity. On the beginning physiological deviation deformity, after 10 years – scoliosis. Causative factor – standing.

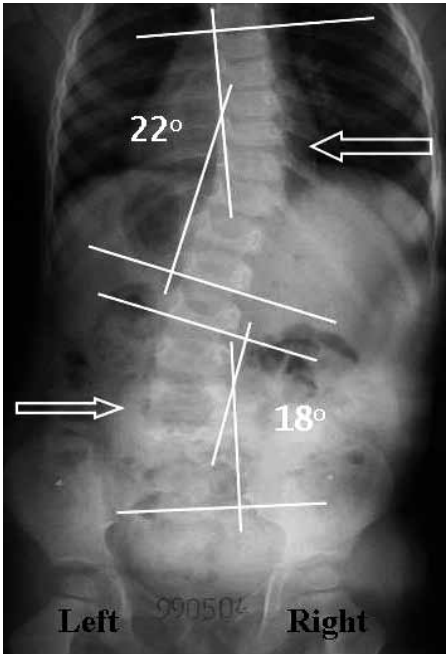
and standing "at ease" only on the right leg (Karski).

5. MATERIAL OF CHILDREN WITH SO-CALLED IDIOPATHIC SCOLIOSIS

The whole material consists of 1450 patients examined with spine problems over the period of 25 years (1980–2005). 364 of patient constituted control group. In this control group the adduction of both hips was symmetrical or nearly symmetrical. The axis of spine at these children was normal and flexion of spine is full **[Fig. 1, 2].**

In the studied material there were patients from I epg, II/A epg, II/B epg and III epg group of scoliosis (described in chapter 6). The observed period was one to ten years. Age of patients was – 3-rd to 21-st year of life. The largest group were children from 6-th do 14-th year of life. Distribution of the three groups: I epg group 593 children (41 %), II/A epg and II/B epg group 333 (23 %) children, III epg group 131 (9 %) patients – mostly young people, congenital scoliosis 29 (2%). In about 20% of patients there were radiological signs of *spina bifida oculta* and sometimes *pectus infundibuliforme*. In about 3% slight symptoms of minimal brain damage (MBD). In 10% of patients we observed





Early beginning of scoliosis – small children.
Left – example of II/A-epg, right – example of II/B-epg

family history of scoliosis. Mothers of 2% of examined children were previously treated with scoliosis.

6. NEW CLASSIFICATION. THREE ETIOPATHOLOGICAL (EPG) GROUPS OF DEVELOPMENT OF SCOLIOSIS (I EPG, II/A EPG, II/B EPG AND III EPG)

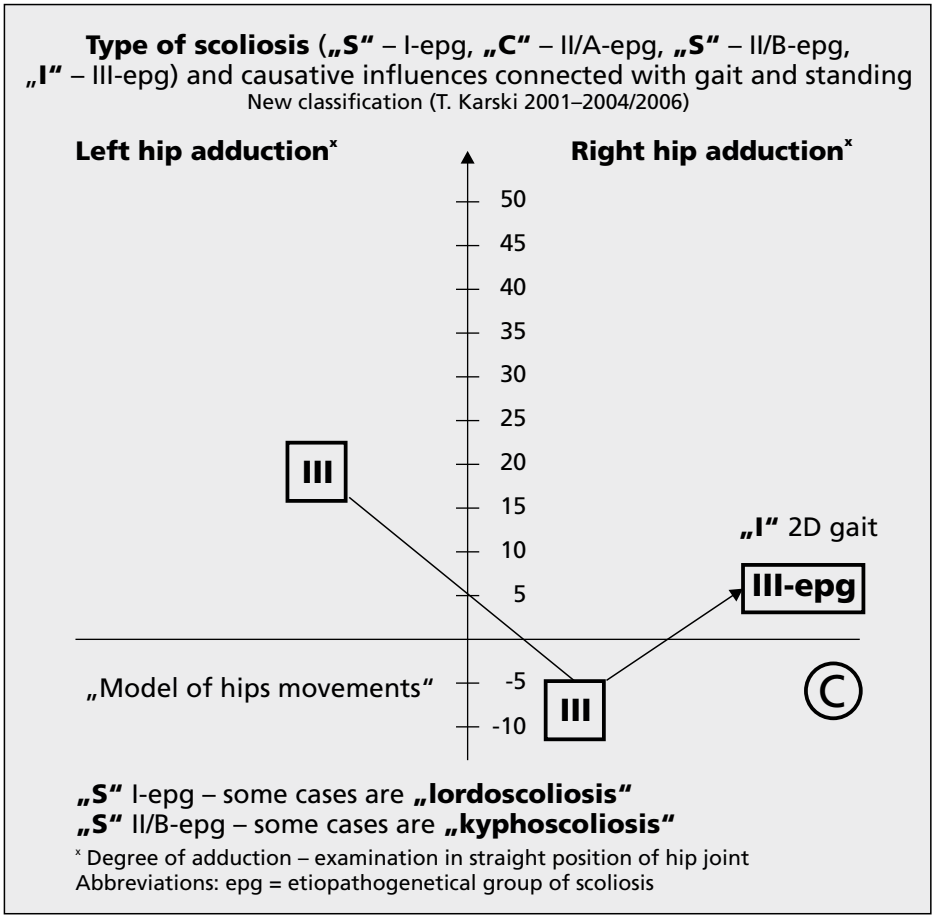


Fig. 7, 8. Model of hips movements in III epg – "stiffness of spine" in lumbar and thoracic part of spine. Two different cases & phazes of deformity: Rotation deformity. Small curves and small rib hump but large spine stiffness. Very often "back pain" in older patients. On the picture on right side – lordotic deformity of thoracic spine. Causative factor – gait.

Ist etiopathological group of scoliosis (I epg) [Fig. 3, 4]

(*Karski 2001*) ["S" deformity = double curve scoliosis]

In children from this group there is a real abduction contracture of the right hip 5–10 degree or adduction 0 degree. The adduction of the left hip is large: 40–45–50 degrees. Examination should be introduced in extension position of the hip joint. Development of this spine deformity is connected with gait! Additionally pathological influence is connected with habit of stand position "at ease" only on the right leg and lasts many years. Beginning of this type of scoliosis is to be observed just in small 3–4 years old children. The first is rotation deformity confirmed in computer gait analysis [**51**]. As result of rotational deformity – the spine becomes to be stiff with "flat back", some cases in I epg are "lordoscoliosis". Here are following three stages connected with severity of deformity: a) disappearing of spinous processes (*Karski*) during "bending test" (*Adams, Meyer*) or "side bending test" to the left and right leg (*Karski*), b) flat back – hipolordosis lumbalis, hipokyphosis thoracalis during flexion examination (*Vlach, Palacios-Carvajal*), c) lordotic deformity in thoracic part of spine during flexion examination (*Adams, Meyer, Tomaschewski & Popp and others*). After 2 or 3 years, sometimes later, the rib hump develops on the right side (*gibbous costalis*) and is easy to see. This type of scoliosis is progressive especially in acceleration period of growth.

IInd etiopathological group of scoliosis – II/A epg and II/B epg

(*Karski 2001*)

It is "C" left convex scoliosis - lumbar or lumbo-sacral or lumbo-thoracic as II/A epg type or double curves "S" scoliosis as II/B epg) **[Fig. 5, 6].**

In these children there is only limited adduction of the right hip in comparison the left side. Adduction of the right side is 10–15–25 degree; adduction of the left side is 35–45–50 degree. Examination should

Examples of III-epg. Two different cases and phases of deformity.
Rotation deformity. Small curves and small rib hump but large **spine stiffness**. Very often „back pain". On the right picture – lordotic deformity of thoracic spine.

be introduced in extension position of the hip joint. Firstly we observed physiological side movement of spine to the left by "stand position of the right leg", next gradual fixation of "C" shaped spine curve with clinical symptoms and changes of spine axis in X-ray picture in older children – at age 10–12–14 years. Pathological influence is connected only with the permanent habit of standing "at ease" on the right leg through many years. Beginning of left convex scoliosis is when the child starts to stand. Scoliosis becomes to be clearly visible if the child is over 10 years old. This type of scoliosis is not "paralytic scoliosis" as described by many authors [**46**]. It is also not "primary degenerative scoliosis" as thought some others authors [lecture of Prof. Stewart Weinstein at SICOT 2005 in Istanbul]. To this patients with "spondyloarthrosis" we could explain - scoliosis is the first and degenerative changes occur later after many years of life. The scoliosis II/A epg and II/B epg are without progression or small but with lumbar pain problems at adult age, typical for *spondyloarthrosis lumbalis, lumbago, ischias*. In the II/B epg there is "S" shaped scoliosis with double curves. The thoracic right convex curve is the secondary one. Some cases from this (II/B epg) group are kiphoscoliosis.

IIIrd etiopathological group of scoliosis

(*Karski 2004* – "scoliosis without curves or with small one" **[Fig. 7, 8].**

The main symptom in this group is the "stiffness of spine". As was told – in I epg of scoliosis, the first stage is the rotation deformity, which causes stiffness of spine. In III epg the time standing is "on right and on left leg" is the same or almost the same. In this group clinically and in X-ray examination we see no curves or only slight deformities. We see also no rib hump or slight. So, there can be "scoliosis without any curves" or with "sight curves" – unimportant clinically. These patients were mostly not treated before and through many years they did not know about the "spine problem". In youth period they have problems with sport activities. At adult age they show very large range of "back pain". The older patients from this group need "differential diagnosis" because some general doctors or internists diagnosed rheumatism, heart pain, circulatory problems and pulmonary illnesses like bronchitis or pleuritis, neurological or gynecologic problems.

7. DISCUSSION. „SYNDROME OF CONTRACTURES" AND „GEOGRAPHY" OF THE SO-CALLED IDIOPATHIC SCOLIOSIS

"Syndrome of contractures" can provide explanation to some unanswered questions in past time in etiology of idiopathic scoliosis:

- Development of scoliosis is connected with "growth period" and connected with "gait" and "standing 'at ease' on the right leg" (Karski)
- Scoliosis develops because of asymmetry of movement of hips, because of asymmetry of loading of right and left leg (pelvis and spine). These asymmetries are connected with "syndrome of contractures" (Mau),
- Scoliosis occur mostly in girls because the contracture of the right hip connected with the "syndrome of contractu-

res" comes mostly in girls (ratio boys: girls is 1:5) [**1, 2**].

- Lumbar left convex and thoracic right convex scoliosis and rib hump on right side are connected with the left sided "syndrome of contractures" witch occurs at 85%–90% pregnancies (Oleszczuk). The „S", „C" and "I" types of scoliosis (I epg, II/A epg, II/B epg and III epg groups) depend on the range of right hip abduction contracture or limited adduction in comparison to the left hip adduction – look "model of movement of hips" [2006] and other causes [**20**, Karski].
- Progression of scoliosis in acceleration period of child's growth is related to asymmetry of growth of bones and soft tissues [**9**]. Contractures (right hip abduction contracture also with flexion and external rotation contracture – Karski, Cheneau, Matussek) [**12**] do not grow and do not lengthen; only bones grow. This leads to fast progression of scoliosis because of bigger biomechanical influences especially in I epg [**21, 22**]. The faster growth of legs than trunk was also observed by Dimeglio [**25**].
- No scoliosis in fully blind children confirms the biomechanical influences (gait) in development of scoliosis. Different "manner of gait" protects against scoliosis.
- Absence of scoliosis in some countries (Mongolia – Prof. J. Hyanek – Czech Republic) confirms the biomechanical influences (gait) in development of scoliosis. The riding on horses of many Mongolian children protects against scoliosis.

In many orthopaedics books it is written that "scoliosis develops from the apex of curve". Now it is clear that scoliotic deformity is going from the "bottom of spine" it means from pelvis and sacro-lumbar region up to the upper spine.

Enlargement of scoliosis happens in the acceleration period of child's growth. It is visible especially in children with difference of growth between trunk and lower limbs, when lower limbs grow faster than trunk. Our observations confirm also *Dimeglio* (Paris EPOS Meetings). Sensibility for the „new rehabilitation exercises" which include removal of contractures (asymmetrical shortening of soft tissues) confirms biomechanical concept of etiology.

In discussion I want to express that sometimes we observe other types of scoliosis like: other curves direction, "three curves scoliosis" (rare). Other types of scoliosis in many European countries, as described in chapter above, are connected with wrong, strengthening-extension exercises applied in AIS. Habit of "standing 'at ease' position on the right leg" explains also: larger deformity of *crus varum dextrum* in children, *genu valgum dextrum* in children and more often right hip arthrosis in adults (Karski 2006).

8. CONCLUSIONS

1. The etiology of so-called idiopathic scoliosis is strictly biomechanical based of asymmetry of hips movements. The groups of scoliosis in new classification (2001–2004 / 2006) are divided in connection to "model of hips movements" (2006).
2. Development of scoliosis is connected with function – "gait" and "stand position 'at ease' – only or mostly on right leg". Without factors of "gait" and "per-

manent standing on the right leg" – the AIS would not develop.

3. The abduction contracture of the right hip is connected with the "syndrome of contractures" of newborns and babies described precisely by professor Hans Mau from Tűbingen and also by many authors – *Dega, Tylman, Gardner, Sevastik, Normelly, Burwell, Stokes, Saji&Leong, Dangerfield&Coll., Willner, Wynne-Davies, Green&Griffin, McMaster, Komprda, Magoun, Karski & Tarczyńska & Karska).*

4. Children in age of 2–4–6 old should be examined to discover the difference of adduction movement of hips and shape of spine in flexion (Adams test or Lublin test – *side bending test for scoliosis*). In case of asymmetry of adduction and habit of standing "at ease" position on the right leg they should undergo periodical precise spine examination and should make simple, flexion exercises for spine.

5. Asymmetry of pelvis at X-ray picture of babies (in DDH screening) should be later remembered as possible danger for spine development at children 3–4 years old and later.

6. In new classification there are three etiopathological (epg) groups of so-called idiopathic scoliosis. The first group (I epg) – double "S" scoliosis with rib hump – is connected with the asymmetry while walking, asymmetry in loading and growth of spine. The lumbar and thoracic curves appear at the same time, sometimes very early at the age 4–6 years. In small children the curve even of 5 degrees (X-ray) and "stiff spine" should be for doctors an "important actually sign of scoliosis problem".

7. In I epg – the first is rotation deformity which causes "stiffness" of spine with three stages:
   a) disappearing of *processi spinosi* Th6-Th12 [35, 12] (*Karski*);
   b) flat back and flattening of lumbar spine [41, 40, 11] (*Tomaschewski&Popp, Palacios-Carvajal, Vlach&Coll., Karsk*i);
   c) lordotic deformity in the thoracic part of spine (*Adams, Meyer*). This type of scoliosis is progressive. Because of severe rotation deformity some cases in this group are called "lordoscoliosis".

8. The second group – II/A epg – "C" scoliosis or II/B epg – "S" scoliosis – is connected only with the habit of "permanent stand position 'at ease' on the right leg" since first years of life. In this group the first and the only one (II/A epg) is the lumbar or sacro-lumbar or lumbo-thoracic left convex scoliosis. At these children we do not see rotation deformity with essential stiffness of spine, nor thoracic curve, nor rib hump and if any, these are not important clinically. In II/B epg "S" scoliosis, the lumbar curve is the first, the thoracic the second. Some cases in this group are "kiphoscoliosis".

9. There are also patients from the III epg group. In this group of scoliosis we note only "stiffness of spine" and in adult patients "back pain". This type of scoliosis is without or with very small curves or rib hump. The II/A epg, II/B epg and III epg groups of scoliosis are non-progressive.

10. All "endangered" children should be included in early program of "prophylactics": sit physiologically, never straight up; sleep in fetus position

and stand "at ease" on the left leg or on both legs. Early prophylactic programs should consist also of such exercises like: karate, kung fu, taekwo-on do, tai chi, aikido, yoga etc.

11. Neo-prophylaxis is possible and is effective - but it should be started very early already in small children just in kindergartens and in first classes of primary schools. It would be "very important progress" in program of prophylaxis in "Bone and Joint Decade 2000–2010".

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