SCOLIOMETRY – AN OBJECTIVE CRITERION FOR SCHOOL SPINAL SCREENING

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Summary. Scoliometry – an objective criterion for school spinal screening
Spine deformtities and especially scoliosis remains one of the most important problems of modern pediatric orthopedics. School spinal screening programs were created for early diagnosis of spine deformities and for reduction of number of the patients who were treated surgically. Scoliometry was introduced to get objective data from orthopedic examination because spine X-rays can't be used in mass screening of young population. The author presents its own practical experience of using scoliometer that gives the objective cut-off points for following referral of the patients with risk of scoliosis.
Key words: school spinal screening, scoliometry, scoliosis, objective test

Rezumat. Scoliometria – un criteriu obiectiv pentru screeningul diformităţilor coloanei vertebrale în şcoli
Diformităţile coloanei vertebrale şi special scolioza rămâne una din cele mai importante probleme în ortopedia pediatrică contemporană. Pentru diagnosticarea precoce acestei patologii şi pentru reducerea numărului de pacienţi trataţi chirurgical au fost create programele de screening al patologiei coloanei vertebrale în şcoli. Având în vedere că radiografia coloanei vertebrale nu poate fi folosită în screeningul populaţiei tinere a fost întrodusă scoliometria pentru obţinerea datelor obiective ale examenului ortopedic. Autorul prezintă experienţa sa proprie în utilizarea scoliometrului ce permite să elucidăm criteriile obiective pentru evidenţierea pacienţilor cu risc mare de apariţie a scoliozei.
Cuvinte-cheie: screeningul patologiei coloanei vertebrale în şcoli, scoliometria, scolioza, testul oiectiv

Резюме. Сколиометрия – объективный критерий для скрининга деформаций позвоночника в школах
Деформации позвоночника и, особенно, сколиоз остаются одной из самых важных проблем современной детской ортопедии. Для ранней диагностики этой патологии и уменьшения количества пациентов, подвергающихся хирургическому вмешательству, были разработаны программы скрининга деформаций позвоночника в школах. Так как рентгенография позвоночника не может быть использована для массового скрининга молодого населения, была предложена сколиометрия, которая позволяет получить объективные данные ортопедического обследования. Автор представляет свой собственный опыт использования сколиометра, что позволило выявить объективные критерии для выявления пациентов с риском возникновения сколиоза.
Ключевые слова: скрининг деформаций позвоночника в школах, сколиометрия, сколиоз, объективный тест

Background: The term of scoliosis believed to have been introduced by Hippocrates (scolios, which means crooked or curved) [33] and used by Galen (scoliosis), means an abnormal lateral spinal curvature. Today, scoliosis can be defined as a "three-dimensional torsional deformity of the spine and trunk" [14]: it causes a lateral curvature in the frontal plane, an axial rotation in the horizontal one, and a

disturbance of the sagittal plane normal curvatures, kyphosis and lordosis, usually, but not always, reducing them in direction of a flat back.

The Scoliosis Research Society (SRS) suggests that the diagnosis of scoliosis is confirmed when the Cobb angle (the angle of the scoliotic curve measured by Cobb method) is 10° or higher and axial rotation presents [24]. However, structural scoliosis can be seen with a Cobb angle under 10° [36], with a potential for progression.

In approximately 20% of cases, scoliosis is secondary to another pathological process. The remaining 80% are cases of idiopathic scoliosis [24]. Adolescent idiopathic scoliosis (AIS) with a Cobb angle above 10° occurs in the general population in a wide range from 0.93 to 12% [12, 22, 28,37]: two to three percent is the value the most often found in the literature [15]. Approximately 10% of these diagnosed cases require conservative treatment and approximately 0.1-0.3% require operative correction of the deformity. Progression of AIS is much more frequently seen in females during the growth spurt at puberty. When the Cobb angle is 10 to 20°, the ratio of affected girls to boys is similar (1.3:1), increasing to 5.4:1 for Cobb angles between 20 and 30°, and 7:1 for angle values above 30° [18, 26]. If the scoliosis angle at completion of growth exceeds a "critical threshold" (between 30° and 50°), there is a higher risk of health problems in adult life. When untreated, it may lead to severe trunk deformities, which limit the capacity and functional biomechanics of the chest, exercise capacity, general fitness and ability to work, all factors related with impairment on quality of life [24].

The widespread use of screening programs in schools for the early detection of spinal deformity has significantly reduced the need for surgical treatment because effective non-operative measures can be used if a scoliosis is found before it becomes severe [14]. In Minnesota, USA, a place with school screening in practice, a decreasing frequency of IS surgery was found, beginning in 1974 and continuing through 1979, the last year reported [18]. Torell et al. [31] reported that scoliosis school screening (SSS), reduced the number of surgically treated IS patients. Some recent reports are more convincing on the impact of conservative treatment on the frequency of surgical treatment of IS. The incidence/prevalence of surgery can significantly be reduced where high-standard conservative treatment is available [20, 25, 34].

However, some problems have been created by these programs. Large numbers of children with no scoliosis or a mild degree of curvature that does not require treatment are referred to orthopaedic surgeons or radiologists. This problem has the potential of making spine screening programs cost-ineffective [4, 32].

Scoliosis screening is a broadly discussed topic [7, 10, 11, 14, 17]. Arguments against screening are: (1) low predictive value leading to excessive number of children referred to specialists; (2) possibly increased amount of x-ray imaging in children; (3) lack of certainty about which small scoliosis (below 20° of Cobb angle) will progress and require treatment; (4) cost issue and (5) stress induced by examination [22, 32]. Despite those facts, screening is the most important factor preventing from the deformity progression. It has been reported that early scoliosis detection allows early treatment with better outcome [3, 10, 13, 19, 30, 31].

It is important to mention that scoliosis screening has not been designed to serve as a diagnostic method. Its main purpose is to select children with high probability of occurrence of idiopathic scoliosis out of total population. The most important criteria for screening test are: accuracy, reproducibility, sensitivity and specificity. The screening test should be quick, cheap, easy to perform, safe, noninvasive, acceptable and should have well-defined cut-off values [21, 23, 35]. The number of children positively screened (suspected of having scoliosis) should correspond to prevalence of idiopathic scoliosis in the population [27]. Children with intermediate trunk asymmetries should be rechecked within a few months as long as the asymmetry is not progressive [5, 37].

The gold standard for idiopathic scoliosis diagnosis is x-ray imaging, however children are not exposed to it for screening purpose, because of the radiation risk [9, 27]. That's why the basic method of school screening for scoliosis is clinical examination.

One aspect of the deformity of scoliosis is the asymmetry of the trunk which is seen best with the patient in the forward-bent position, as was first described by Adams in 1865. The Adams forward bending test (FBT) is well known to school and primary health care personnel and widely used to provide a subjective or qualitative evaluation of spinal deformity. Bunnell defines the "angle of trunk rotation" as the angle between the horizontal plane and a plane across the posterior aspect of the trunk at the point or points of maximum deformity with the patient in the position for Adams test [4].

The application of physical measurements provides a quantitative evaluation of deformity and the basis for objective referral criteria for screening, which substantially increases its effectiveness [2].

Many devices and techniques have been used, including measurement of the rib hump height using a level and ruler, stereophotogrammetry, flexicurve, ultrasound, thermography, back contour devices, etc. Moiré topography, a photographic method, and computerized surface mapping systems such as the Integrated Shape Imaging Systems (ISIS), Computer Optical Topography have been studied extensively and provide the most complete description of surface topography. The time and expense required to do these studies usually make them impractical for mass screening [6].

Inclinometry (measurement of the angle of trunk rotation (ATR) observed with the patient in the forward bent position) seems to be the simplest, quickest, most reliable, and least expensive objective measurement of trunk deformity. Numerous instruments have been presented in literature since the XIXth century (**Fig.1**). Some of them have only been presented in literature; others have undergone validation studies to document their reliability of the measurement on the gibbus in flexion.

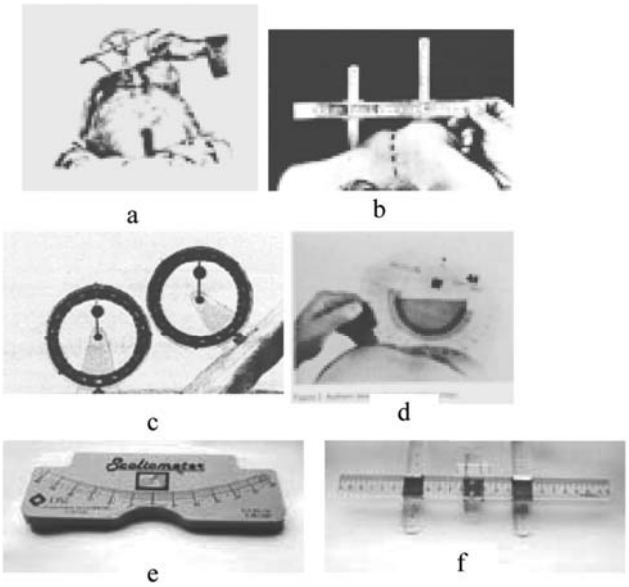

Figure 1. *Instruments for measurement of trunk rotation: a – Schultess' Inclinometer, 1902; b – Vinchon's Gibbometer, 1965; c – Rippstein's Hydrogoniometer, 1967; d – Prujs' level, 1992; e – Bunnell's Scoliometer; f – Ferraro's Inclinometer*

In 1984 W.P.Bunnell presented its specially designed inclinometer (scoliometer), which consists of a single-radius. u-shaped tube that is filled with fluid to dampen the motion of a ball: the ball quickly seeks the point that is lowest in the tube and from which the angle of rotation can be read directly [4]. The study presented by Amendt et al. [1] showed relatively high values for validity based on the predictive value of a positive test using the Scoliometer at the 5-degree ATR criterion level and the high intrarater and interrater reliability. These values have indicated that the scoliometer is useful for providing objective measurements. D'Osualido implemented an inclinometer made of an almost-rectangular element in plexiglas with a goniometric scale to whose centre a small rod (free to rotate) with a bubble is positioned (**Fig.2**). The free extremity of the rod has the reading index for the goniometric scale. The longest side of the rectangle has a recess in order to make its application on the patient easier (in the event that the vertebrae are protruding). The advantage of this device is that the ATR can be read after removing the instrument from the patient's back as well [8]. The comparison of scoliometer and modern techniques did not reveal advantage of the surface topography as a screening method in detection of idiopathic scoliosis in comparison to clinical examination with the use of the scoliometer [6].

Materials and methods: During the spinal screening program initiated by the author 126 pupils were clinically examined according to widespread guidelines [24]. Boys were 48 (38,1%), girls were 78 (61,9%). The age of the pupils ranged from 7 to 12 years, mean age consisted 10±0,79 y.o (p=0.05). Children and adolescents were examined during the lecture of physical education. A special mobile cabinet was formed to allow separation of the examinating child from the others to ensure his/her confidence. Students were asked to remove their shirts to better vizualization of the waist, hips, and legs. A special mesh screen (**Fig.2**) was used for better identification of the asymmetric findings.

Figure 2. *A special mesh screen*

We used 6 positions including Adams forward bending test [30]. The examination began with the standing erect position with feet slightly apart, knees straight, and arms hanging loosely at his or her sides while facing the examiner.

1) With the pupil facing front in the standing position (**Fig. 3, a**), the examiner checks for the following signs of a possible abnormal spinal curvature:

- One shoulder higher than the other
- Larger space from arm to the side of the body (compare both sides)
- Uneven waist creases
- Uneven hip levels

2) The next position is the Adams forward-bending test (**Fig. 3, d**). The pupil is standing erect with feet slightly apart and knees straight. With the palms of both hands touching, he/she bends forward until the back is horizontal. In this position we check for:

- Uneven contours, humps on one side
- Any curve in the spine

3) Viewing of the child from the side in the standing position (**Fig. 3, b**) and checking for:

- Exaggerated roundness in upper back
- Exaggerated arch in lower back

4) Viewing the pupil from the side in the forward-bend position (**Fig. 3, e**) checking for:

- Uneven contours, humps on one side
- Flexibility - can the student bend forward and touch upper shins or feet.

5) Viewing the pupil from the back in the standing position (**Fig. 3, c**) to note any of the following

- Head is not centered directly above crease in buttocks
- One shoulder higher than other
- One shoulder blade wing is higher or stands out more than other
- Curved spine
- Larger space from arm to the side of the body (comparing both sides)
- Uneven waist creases
- Uneven hip levels

If hips appear uneven, but no other abnormalities are noted, consider possibility of unequal leg length, and visualize alignment of knee creases if possible.

6) Finally, viewing the student from the back in the forward-bending position (**Fig. 3, f**) to check for:

- Uneven contours, humps on one side
- Any curve in the spine

ATR was measured by using D'Osualdo scoliometer (Chinesport S.A., Italy) (**Fig. 4**) according to standard technique:

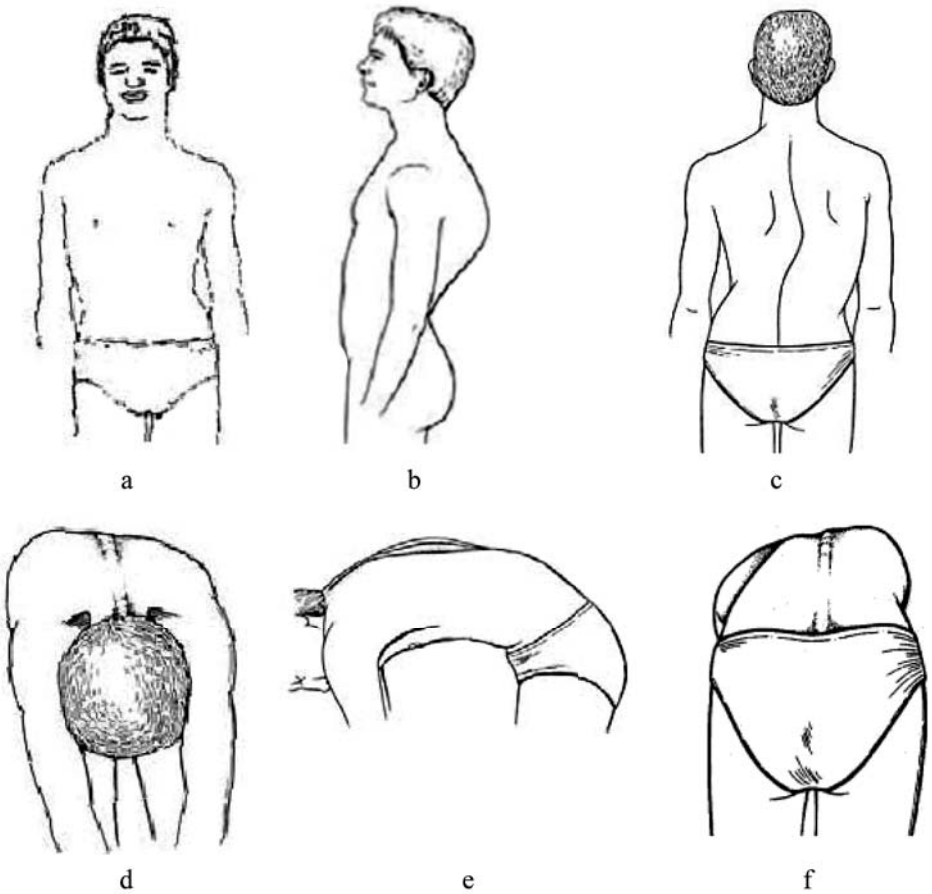

Figure 3. *Standard positions for orthopedic examination*

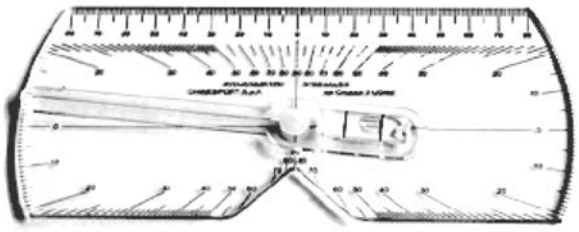

Figure 4. *D'Osualdo Inclinometer*

- the scoliometer is placed gently across the student's back at the point where a hump or uneveness is most prominent (**Fig. 5**).

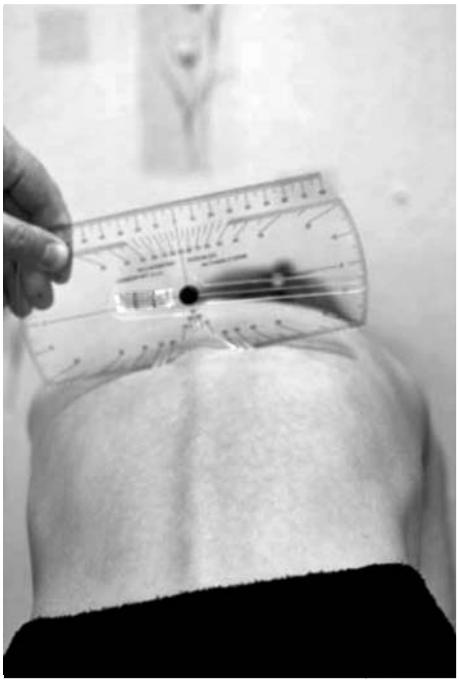

Figure 5. *Scoliometry*

- than the rotating stick is leveled (a bubble should be in the middle).
- reading the degree of rotation
- it is important not to press down on the device as that can distort the reading.

Results: All the pupils were divided in 3 groups:

I group – scoliometry less than 4° (n=91, 72,2%). It was recommended a usual clinical examination once a year. If some positive findings were obtained during the orthopedic examination (asymmetry of the shoulders, clavicles, etc.) it was considerate as a functional scoliosis (scoliotic posture) with no pathological changes in the spine. The main cause of asymmetric posture was difference of the lower limbs length. The use of special orthopedic shoes resolved the problem in the pupils of this group.

II group – scoliometry 5-6° (n=28, 22,2%). These pupils consisted a group of risk for scoliosis and other spine deformities. The majority of them (n=21) had clinical signs of asymmetry, Other 7 children had flat back which have been recognized like a predictor of possible scoliosis ("dark zone", prescoliosis). All these pupils are followed up every 4 months to prevent the appearance of severe deformities.

III group – scoliometry ≥ 7° (n=7, 5,6%). Spine X-rays were indicated to this group of pupils and mild scoliosis was confirmed. Individual program of treatment was elaborated for each patient.

Conclusions: Scoliosis remains one of the most important problems of modern pediatric orthopedics. School spinal screening programs were created for early diagnosis of spine deformities and for reduction of number of the patients who were treated surgically. The most important criteria for screening test are: accuracy, reproducibility, sensitivity and specificity. The screening test should be quick, cheap, easy to perform, safe, noninvasive, acceptable and should have well-defined cut-off values. Scoliometry meets all this criteria. Checked by the time during a lot of studies it remains the gold standard of many school spinal screening program guidelines near the Adams' test. Scoliometer examination reveals good repeatability and reproducibility [1]. For the cut-off value of the ATR equal to or greater than 7° the scoliometer examination is characterized by high sensitivity (83,3%) and high specificity (86,8%) [3]. Dr Bunnell states that "screening is vitally important, but we do not want to screen out a whole bunch of people who don't need medical attention because it's very costly. We're not looking for the cheapest way to screen – we're looking for a better quality outcome for our patients." [cited by Labelle et al., 16]

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