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SCHOOL SCREENING PROGRAMS OF SCOLIOSIS: A META-ANALYSIS

PROGRAME DE SCREENINGURI ŞCOLARE ALE SCOLIOZEI: O META-ANALIZĂ

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Abstract: In this paper we will analyze more than 20 studies published in the last four decades in school screening topic, by different authors and from different parts of the world. The number of screened children, the applied screening methods and the prevalence rate of scoliotic children are presented in this meta-analysis. The end of this study presents the latest results of studies made in Romania, regarding physical deficiencies.
METHODS: The data analysis method was used to collect the relevant data in order to write this paper. The selected studies were chosen by the following basic criteria: if the used screening methods were the same and if the age of the pupils was from 9 to 15 years. The keywords were introduced for searching in the following databases: PubMed, PubMed Central and BioMed Central.
RESULTS: The adolescent idiopathic scoliosis is a common disease with an overall prevalence of 0.47% - 5.2% in the literature. The girls to boys ratio ranges from 1.1:1 to 8:1 and increases substantially with age.
CONCLUSIONS: The scoliosis is the most frequent spinal disorder in the case of the children and adolescents. A scoliosis is characterized by a side to side curvature of the spine >10º, usually combined with a rotation of the vertebrae. The most indicated method to perform a school screening program is the Adam's forward bending test associated with scoliometer reading.
Keywords: scoliosis, school screening program, adolescents, spine.

Rezumat: În această lucrare vom analiza peste 20 de studii publicate în ultimele patru decenii pe tema screeningului şcolar, de către autori diferiţi şi din diferite părţi ale lumii. Această meta-analiză prezintă numărul copiilor examinaţi, metodele de screening aplicate şi ratele de prevalenţă ale copiilor. La sfârşitul articolului sunt prezentate ultimele rezultate ale studiilor făcute în România pe tema deficienţelor fizice.
METODE. Metoda analizei datelor a fost folosită pentru a colecta datele necesare realizării acestui studiu. Criteriile de selecţie fundamentale ale lucrărilor au fost: dacă au fost folosite aceeaşi metode de screening, şi dacă vârsta elevilor a fost cuprinsă între 9-15 ani. Bazele de date în care au fost făcute căutările după cuvintele cheie sunt următoarele: PubMed, PubMed Central şi BioMed Central.
REZULTATE. Scolioza idiopatică a adolescentului este o boală frecvent întâlnită cu prevalenţe cuprinse între 0,47% - 5,2% în literatura de specialitate. Raportul dintre băieţi şi fete variază de la 1.1:1 la 8:1 şi creşte în mod substanţial odată cu vârsta.

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CONCLUZII. Scolioza este deviația coloanei vertebrale cea mai des întâlnită la copii și la adolescenți. Este o deviație a coloanei în plan lateral care depășește 10º, de obicei este combinată cu rotația vertebrelor asociate. Cea mai indicată metodă pentru efectuarea screeningurilor școlare este testul Adam's asociat cu măsurarea scoliometrică.
Cuvinte cheie: scolioza, program de screening scolar,adolescenti, coloana vertebrala

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BACKGROUND

The start of school screening for scoliosis began in 1963 in Aitken, a little town in central Minnesota (Lonstein, 1977). From that moment the spinal screening was implemented in numerous countries like in the USA, Japan, Netherland, South Korea, Singapore, Great Britain, Canada, Sweden, Greece, Germany, Turkey, Australia (Grivas, et al., 2007).

In some countries the school-screening program is mandatory by law like Japan, in others it is just optional or recommended but is not obligatory, like USA and Australia (Spine Society of Australia, 2015). The value of scoliosis screening programs was often debated and is still a controversial issue as indicated in some studies. In this paper we decided to present the prevalence/proportion of the affected persons from different parts of the world by this dangerous curve of the spine and not to debate the effectiveness (technical, clinical, program, treatment or cost) of the school screenings (Plaszewski, Nowobilski, Kowalski, & Cieslinski, 2012).

Scoliosis is a partly-fixed lateral curvature of the spine. It can be caused by congenital, developmental or degenerating problems, but in most of the cases (80-85%) the cause is unknown and it is called idiopathic scoliosis (IS). It usually develops in the thoracic spine or the thoracolumbar area of the spine. The curvature of the vertebral column may develop as a single curve, double or triple curves. Scoliosis occurs mostly during the growth spurt just before puberty. The appearance of it is showed by some clinical indicators that include unevenness in the shoulder height, shoulder blades, rib cages and hips (Lehnert-Schroth, 1992). Although scoliosis is characterized by lateral deviation of the spine, a 3D deformation is responsible for geometric and morphologic changes in the trunk and rib cage (Nault, et al., 2002).

The most frequent type of idiopathic scoliosis is the adolescence idiopathic scoliosis (AIS) which is the most common spinal deformity affecting adolescents 10 to 16 years of age. Is characterized by a lateral bending of the vertebral column and an associated rotation of vertebral bodies over 5 to 10 vertebras (Killian, Mayberry, & Wilkinson, 1999).

The goal of scoliosis screening is to detect scoliosis at an early stage, when the deformity is likely to go unnoticed and there is an opportunity for a less invasive method of treatment, or less surgery, than would otherwise be the case. If the school screening program is assisted with scoliometer or any surface measuring device, it can reveal children with surface, mainly thoracic deformity (Patias, Grivas, Kaspiris, Aggouris, & Drakoutos, 2012).

There are several methods to perform a school screening or to monitorize the progression of the curved spine of the patients with an idiopathic scoliosis at the periodical examinations. The primary screening test for scoliosis is the physical assessment of the back, which includes the Adams forward-bending test (FBT), while the scoliometer quantifies the trunk deformation. Several other optical techniques are used to recognize a person with measurable clinical signs of scoliosis, but usually these are more complex and difficult to apply in a school screening (Patias, et al., 2012).

Optical systems have been developed as non-invasive imaging techniques. Examples of such systems are the Moiré-fringe mapping (Takasaki, 1970), the structured light techniques like the Integrated Shape Imaging System (ISIS) (Wiesz, Jefferson, Turner-Smith, Houghton, & Harris, 1988) or the Quantec system (Goldberg, Kaliszer, Moore, Fogarty, & Dowling, 2001) or the Ortelius scanners. Other devices that scan 360º torso profiles (Schmitz, Gabel, Weiss, & Schmitt, 2002), ultrasound systems, 3D body scanners (Suzuki, Yamamuro, Shikita, Shimozo, & Iida, 1989).

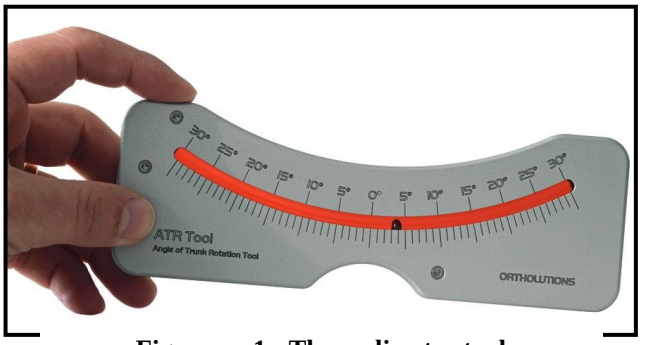

Figure no.1 - The scolimeter tool

OBJECTIVES

The purpose of this study is to analyze various publications which inform us about the results of scoliosis school screening from different parts of the world. We would like to present: a) the proportion of the persons – mostly children – with this type of spine deviation; b) the prevalence according to gender; c) the used screening methods; d) to compare the international results with the results published in our country, in Romania.

School screening for scoliosis in different countries

In order to write this chapter of our paper we consulted different databases like: PubMed, PubMed Central and BioMed Central to gain precise informations about the screenings made in certain coutries.

In Singapore the routine examination for spinal deformity as part of a school health screening programme was introduced in 1981. In 1985 Daruwalla, Balasubramaniam, Chay, Rajan, and Lee investigated three different ethnic groups included in this cross-sectional study, that provided figures for the prevalence of idiopathic scoliosis in Asian population. A total of 110,744 children in three age groups were studied. In those aged 6 to 7 years the prevalence was 0,12%, in those aged 11 to 12 years was 1,7% for girls and 0,4% for boys, in the group of girls aged 16 to 17 years the prevalence was 3,1%. There was a significantly higher prevalence in the case of Chinese girls as compared to Malay and Indian girls. The forward bending test for spinal deformity was used in this investigation. They concluded that the optimal age for screening is 11 to 12 years, and under 8 yeats the prevalence is sligth.

In Finland a retrospective cohort study was conducted by Nissinen, Heliovaara, Ylikoski, and Poussa (1993). A group of children with an average age of 10.8 -13.8 years was followed-up annually to assess various measures of trunk asymmetry for their predictive value in the screening of scoliosis. A number of 1,060 children participated in the final examination and the trunk asymmetry was measured by the forward bending test and moiré topography. The prevalence of scoliosis (Cobb angle > or = 10 degrees) was 9,2%. They concluded that the FBT is preferable to moire topography in screening for scoliosis.

In Sweden, 17,181 school children born in the years 1961-1965 were screened for scoliosis once a year between the ages of 7 and 16 years during 1971-1980 by Willner and Udén (1982). Thus with clinical signs of scoliosis including a positive forward bending test were admitted to the Orthopedic Surgery for reinvestigation and anterior-posterior roentgenograms. Considering the

fact that 10 Cobb degrees as the lower limit, the prevalence was 3,2% in girls and 0,5% in boys. This study was a longitudinal one.

In Quebec, during the 1977-78 academic year 29,195 children aged 8 to 15 years were included in a cross-sectional prevalence study and screened for idiopathic scoliosis by Morais, Bernier and Turcotte (1985). The prevalence among these children was 4,2%. It was higher among girls (5,19%) than among boys (3,2%)

Initially the screening test was positive for 3,336 children (11,4%). 322 (9,7%) refused any further examination or were lost to follow-up. 93 (7,8%) went to their family physician and 53 (1,6%) consulted a chiropractor, therefore in the final results 19,1% of the initially found children with positive clinical signs were not included. The symmetry of the back was inspected by the FBT.

In the United States of America a retrospective cohort study of children who attended kindergarten or first grade at public or private school was conducted by Yawn, et al. (1999), and followed-up until 19 years or until they left the school district. Of the 2,242 children screened 4,1% were referred for further evaluation and an additional 328 parents were notified of possible abnormalities.

The prevelance of spinal curves was 2,3% for 10º to 19º, 0,8% for 20º to 39º, and 0,1% for 40º or more at 18 years of age, so 3,2% of this children were diagnosed with a treatable curveture. In the discussion of this study they mentioned that were identified some children who ultimately receive treatment but refers many more who do not.

A two-year prospective study was performed by Soucacos, Soucacos, Zacharis, Beris and Xenakis (1997) to assess the prevalence of scoliosis in schoolchildren in northwestern and central Greece. A total of 82,901 children were screened for scoliosis, who were nine to fourteen years old. 4,185 (5,05%) of them were referred for posteroanterior radiographs because they had a positive result on the forward bending test. The prevalence of the scoliosis (10º or <) was 1,7% and most (1,5%) of the curves were small, 10 to 19 degrees. The ratio of boys to girls was 1:2.1 over-all but varied according to the magnitude of the curve In the school screening the FBT was applied.

In the island of Crete a cross-sectional prevalence study was organised by Koukourakis, et al., (1997) on 21,220 children, ages from 8 to 12 years, to report at the first time the prevalence of scoliosis in that isolated area. Of the examined population, 9,6% were referred for radiological examination, and 1,7% of the screened children were found to have spine deformities with at least 10º Cobb degrees. The FBT and scoliometer reading was used to measure and analyze the asymmetri of the trunk.

A point prevalence survey of 72,699 schoolchildren was performed by Wong, Hui, Rajan and Chia (2005), to determine the prevalence rates of IS in Singapore. Those with scoliometer reading of more than 5 degrees underwent radiographic evaluation, but the prevalence rates were calculated at a predefined Cobb angle of 10 degrees. Prevalence rates were 0,05% for girls and 0,02% for boys at 6 to 7 years of age, 0,24% for girls and 0,15% for boys at 9 to 10 years of age, 1,37% for girls and 0,21% for boys at 11 to 12 years of age, and 2,22% and 0,66% for girls and boys at 13 to 14 years of age. These findings compared to a previous study (Daruwalla, et al., 1985) we can observ that, there was a significant increase in the prevalence rate in girls 11 to 12 years of age. An other benefit of this screening was, that they identified a significant number of 11 to 12 and 13 to 14 years old girls who were indigent to be treated by a kind of brace.

From 2000 to 2008, 1,134,890 children were screened for scoliosis in South Korea. This was a nine year cross-sectional epidemiologic study conduced and performed by Suh, Modi, Yang, and Hong (2011). In this screening children with ages from 10 to 14 years were included. They were randomly selected with no special consideration for geographic or economic representation. All screened children were of Korean origin, with the child and both parents having been born in

Korea. The forward bending test was applied and those who had (77,910 [6,2%]) positive scoliometer readings (>5º) were referred for radiograms. The overall prevalence rate of scoliosis (10º or <) was 3,26%, and girls had a higher prevalence 4,65% than boys 1,97%.

A retrospective cross-sectional study was performed by Yamamoto, et al., (2015) in Japan, to determine the prevalence of idiopathic scoliosis, define the distribution of the curve magnitude and to evaluate the accuracy of moiré topography as a screening tool. A total of 195,149 children aged 11-14 years were screened. The initial screening was performed using moiré topography. The prevalence rate of scoliosis in the fifth grade was similar to that in the sixth grade girls (0,337% and 0,369%), in the seventh grade girls was 0,727%. In boys the prevalence rate was very low, at all the time lower than 0,1% at every grades. These findings seem to be extremely low, but they are confirmed in other studies too. They find that over 23 years, the prevalence of scoliosis in girls increased compared to that in the first decade of the study, in boys was lower than in girls and did not change significantly over the 23 years. The moiré topography test had a high false-positive rate (Ohtsuka, Yamagata, Arai, Kitahara, & Minami, 1988).

A cross-sectional prevalence study was preformed by Grivas, Samelis, Polyzois, Giourelis and Polyzois (2002) in a heavily industrialized area to make a comparison of the findings of IS prevalence of this program with those of programs performed in non-industrialized areas of the same country. The FBT asisted by the scoliometer reading was applied on 3,039 schoolchildren, aged 5.5 to 17.5 years. 8,6% were referred for further evaluation, whereas 3,9% of this children underwent radiological examination. 2,9% of the screened population were found to have a Cobb angle > or = 10 degrees. They concluded that the incidence found in this area is similar to the incidence observed at other non-industrialized geographical deparments of that country (Greece), and the industrial enviromental factors probably do not significantly influence the prevalence of AIS.

In the Table 1. we presented a part of the studies made in the scoliosis screening subject. We tried to find the latest publications in this topic from our continent and the more relevant publications from the other regions of the world. There was made a summary of the: used screening methods, number of screened persons, age of screened children and founded prevalence Some cells in this table are vacant, because in some cases we found just the abstract of the whole work, and these did not contained all the necessary information.

It is clear that the most common used scoliosis school screening method is the forward bending test (FBT) (the official name is Adam's forward bending test) assisted by a scoliometer measuring. The scoliometer is a specially designed inclinometer developed by Bunnell (1984) which is a very useful objective measuring instrument to quantify the angle of trunk rotation. It has achieved widespread usage with numerous reports of its reliability, but this technique is not diagnostic. Radiographs are required to establish the diagnosis, etiology and severity of spinal deformity.

In some cases the Moiré topography was used to determine the extent of the back asymmetry. This screening method is more complicated and it seems not to be more sensitive like the FBT.

Each study included in the Table 1. shows that the girls are more affected with this dangerous curve than the boys. The prevalence ratio female to male varies on a large scale, from 1.1:1 rising up in some cases to 8:1. Several studies report about higher Cobb angle in girls than in boys, indicating that scoliosis in girls progresses to a higher grade of severity. For patients with a Cobb angle of more than 30º the prevalence ratio gets as high as 10:1 (Weinstein, Dolan, Cheng, Danielsson, & Morcuende, 2008).

Table no. 1 - The prevalence of adolescent idiopathic scoliosis in different countries

Author(s)	Year of publication	Place of the screening	Methods used	Nr. of children screened	Age of children	Prevalence	
Willner & Uden	1982	Sweden	Forward bending test (FBT)	17,181	7-16 y.	girls	3,2%
						boys	0,5%
Daruwalla, et al.	1985	Singapore	FBT	110,744	6-7 y.	girls	0,15%
						boys	0,1%
					11-12 y.	girls	1,67%
						boys	0,44%
					16-17 y.	girls	3,12%
Morais, et al.	1985	Canada	FBT	29,195	8-15 y.	girls	5,19%
						boys	3,2%
Ohtsuka, et al.	1988	Japan	Moire topography (MT)	1,246,798	Primary sch.	girls	0,44%
						boys	0,07%
					Secondary sch.	girls	1,77%
						boys	0,25%
Nissinen, et al.	1993	Finland	FBT, MT	1060	10,8-13,8 y.	9,2%	
Koukourakis, et al.	1997	Greece, Crete	FBT	21,220	6-12 y.	1,7%	
Soucacos, et al.	1997	Greece	FBT	82,901	-	1,7%	
Huang	1997	China	FBT	33,596	11-14y.	girls	1,47%
Yawn. et al.	1999	USA	FBT	2242	3-19 y.	3,2%	
Sugita	2000	Japan	Radiographs	3,299	14-15 y.	boys	1,38%
						girls	4,93%
Wong, et al.	2005	Singapore	FBT	72,699	6-14 y.	girls	0,93%
						boys	0,25%
Kamtsiuris, et al.	2007	Germany	Clinical evaluation	17,641	0-17 y.	5,2%	
Yong, et al.	2009	Singapore	FBT	93,626	9-13 y.	girls 9	0,27%
						girls10	0,64%
						girls11	1,58%
						girls12	2,22%
						girls13	2,49%
Cilli, et al.	2009	Turkey	FBT	3,175	10-15 y.	0,47%	
Nery, et al.	2010	Brazil	FBT	1340	10-15 y.	1,4%	
Suh, et al.	2011	South Korea	FBT	1,134,890	10-14 y.	girls	4,65%
						boys	1,97%
Yamamoto, et al.	2015	Japan	MT	195,149	11-14 y.	0,26%	

The international consensus defined the scoliosis as a deformity of the spine ≥10° of Cobb angle (Grivas, et al., 2007), therefore we analyze only those studies which used the same criteria. The prevalence rate varies in large scale too, depending on many variables. The male ratio shows at all cases lower indices. The elder (13-15 years) girls have a much higher prevalence of sever scoliosis. In the studies mentioned above for the girls shows a prevalence from 1,77% to 5,19%, but in some cases we find just the over-all incidence of scoliosis, and probably that in these publications the prevalence rate of the girls is much higher (Kamtsiuris, et al., 2007). Based on the investigations we can conclude that the over-all prevalence for the age group 10 to 14 years varies

between 0,47% and 5,2%. Two extreme cases were found. One of them is from Japan, where prevalence rates were quite low in two studies (Ohtsuka, et al., 1988; Yamamoto, et al., 2015). The second study is from Finland, where a relatively high prevalence rate, 9,2% was found by Nissinen, et al. (1993).

Currently in Romania there has not been any consistent or centralized preoccupation for deficiencies school screening. In the 1950-60's a periodical physical evaluation of the children was mandated by law and performed at the beginning of the school year (Ionescu, 1961). The deficiencies are often discovered through casual medical examinations, and in many cases the curves are far-gone progressed, so it is not possible to apply a conservative treatment, like physiotherapy and bracing.

In the last two decades private and state associations organized some minor screenings, but not so expansive like in the other countries presented in the Table 1.

In Timișoara (second largest city in Romania) Avramescu-Oprițoiu (2008) performed a study on a group of 308 pupil. She found the following interesting results: among the evaluated pupils: 7,79% were with scoliotic posture and with clinical scoliosis 14,94% of them. She mentioned an increased incidence of the deficient postures and the proper deficiencies of the vertebral column.

An other study in Oradea was performed where 201, 10 to 14 years children were examined. At the 32,3% of them was found different types of deformity, but these deformities were not detailed in that study (Maroti, Antal, Indrieș, Costea, & Dragoș, 2001).

A third study from Cluj-Napoca, investigated whether there was a connection between the incidence of physical deficiencies and body weight among 11-12 year old children or not. The results reveal that of 149 evaluated subjects, 64 subjects had physical deficiencies, that means 42,9%. Clinical signs of scoliosis was found in 13,4% (Câmpeanu, Vădan, Crișan, Nemeti, & Varga, 2013)

Every single study published in this topic in Romania transmits the same observations and similar results, that the prevalence of different physical deficiencies is very high among the Romanian schoolchildren. We found just a few studies published in school screening topic, and the greater part of those used the somatoscopic method to detect the affected children. The only problem with this method is that is partly subjective and in most of the cases does not use any metric tool, like the scoliometer.

CONCLUSIONS

- the most indicated school screening method is the FBT assisted by the scoliometer measurement;
- the over-all prevalence rate of AIS varies from 0,5% to 5,2%, depending on the screened area;
- the girls are more affected by AIS than the boys;
- the risk of progression is higher in girls as compared with boys;
- association between the age of girls and the severity of the curve was observed in almost every study;
- optimal age for scoliosis screening seemed to be 11 to 12 years;

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