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Incidence of scoliotic posture in school screening of urban children and adolescents: the case of Poznań, Poland

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Abstract: Postural defects including scoliotic posture constitute one of the most frequently observed health problems in school-aged children. The incidence of this multifactorial condition has been observed to increase recently. The aim of the study was to assess the incidence of scoliotic posture in primary and secondary school students living in a large city. The sample consisted of 1,325 boys and 1,355 girls, aged 6 to 18, living in the city of Poznań. Their postures were assessed through skilled visual inspection method based on the criteria delineated by Wiktor Dega. Additionally, measurements of scoliotic deformities were taken using the Bunnell's scoliometer. It was found that the incidence of scoliosis assessed on the basis of Dega's postural defect chart amounted in total to 14.6% in boys and 17% in girls. No substantial differences between boys and girls in particular age categories were found. Scoliometer examination appeared to be a more accurate method for screening scoliosis and revealed higher incidence of this condition in total and both in boys and girls as compared to the visual screening method. The contractures which may lead to scoliotic posture appeared most frequently in the knee joints, both in boys and in girls. The *incidence* of lateral spinal curvatures was related to age and increased with age. Scoliometer proved to be a more effective tool in detecting lateral spinal curvatures and should be more widely used in school healthcare.

Key words: postural defects, spinal curvature.

Introduction

Currently, one of the most frequently observed chronic health problems among children and adolescents are postural failures. This is confirmed not only by the results of epidemiological studies but also by the outcomes of preventive medical examinations performed among school children aged 7-18 (Krzyżaniak 2009). Also, the results obtained by the Polish Registry of Developmental Birth Defects (PRDBD) indicate that the osteo-articular disorders were ranked second, constituting 17.1% of all defects reported in Wielkopolska and 20.1% defects repor-

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ted in 10 provinces which are encompassed by PRDBD (Materna- Kiryluk 2014).

The studies performed in Europe and all over the world, devoted to the incidence of postural defects most often concern lateral spinal curvatures (Grivas 2007; Richards 2010).

There have been many studies conducted in Poland concerned with the assessment of lateral spinal curvatures among school children; however, there are no simple methods that could be applied to their diagnosis (Głowacki, Kotwicki and Pucher 2003; Kotwicki 2006, 2007).

Within the school environment, the studies devoted to the incidence of postural defects in children and adolescents are predominantly based on the results of screening tests performed by a school nurse on the basis of methodology specified by the Institute of Mother and Child (Jodkowska and Woynarowska 2002). According to the guidelines established by IMC, the assessment of lateral spinal curvatures should be performed at the age of 6, 8, 10, 12, 14 and 18. Due to the fact that the so-called scoliotic posture, described in detail in methodology, may be an early onset of scoliosis, its detection may give an opportunity to implement effective prevention and therapeutic measures, as well as to introduce corrective treatment in school conditions.

Sedentary life style, characterised by little physical activity, carrying heavy school backpacks, spending leisure time in front of a computer screen or TV, may contribute to increasing incidence of postural defects both among children and school youth (Krzyżaniak 2009).

Among the methods of subjective posture assessments, one should mention the Wolański silhouette assessment method. This method refers only to spinal curvatures in the sagittal plane and distinguishes three types of body posture: kyphotic, lordotic and balanced (Wolański 2012). Posture assessment from the orthopaedic point of view requires a more detailed indication of errors in particular body sections than it has been presented in Wolański's method (Dega 1964). At present, there is a need for a simple and objective assessment of body posture, especially because school children, apart from the screening tests performed by school nurses, may be primarily assessed by physical education teachers.

Professor Wiktor Dega suggested a simple and useful tool for body posture assessment which may be used during physical exercises classes in school environment (Dega 1964).

The method based on the postural error chart by Dega helps analyse particular elements of body posture by specifying the existing irregularities (errors) and determining the diversity resulting from individual body posture (Dega 1986; Dega and Milanowska 1994). The study takes into account the assessment of tension of selected postural muscles which might have a significant impact on a correct body posture (Kwolek 2013). The formula of the applied tool has been presented in Table 2.

Postural errors are single deviations from the correct body posture acquired as a result of incorrect daily habits of a child (Nowotny 1993). Very often they may be enhanced by eyesight defects, poor sense of hearing, disorders of the respiratory tract, as well as bad mental condition (e.g. stress). Through the application of appropriate strengthening, stretching, corrective and compensatory exercises, movement and learning how to take a proper body posture, postural errors

can be easily corrected (Nowotny 1993; Kasperczyk 2000).

Among the lateral spinal curvatures, we distinguish two types of scoliosis: structural and functional. Scoliosis is a lateral spinal curvature which consists in multifaceted deviation of the spine from the proper condition (Kotwicki et al. 2006; Kotwicki, Lorkowska and Szulc 2007; Chowańska et al. 2011). Based on the experts' opinion, the term 'scoliotic posture' was introduced, which in literature operates as functional scoliosis (Marciniak and Schulz 2003). The scoliotic posture is characterised by asymmetric positioning of shoulders and shoulder blades, which may be accompanied by asymmetry of waistline triangles. The lateral spinal curvature does not occur or is very small. During diagnosis, one must pay attention to the fact that this curvature disappears in the sitting position. Orthopaedic consultation shall help determine whether it is a scoliotic posture requiring corrective and compensatory exercises or scoliosis. By using selected corrective exercises and applying appropriate positioning of the joints in legs one can obtain a complete posture correction.

An objective method of assessing the incidence of lateral spinal curvature is the application of a tool called Bunnell's Scoliometer. This method has a high degree of reproducibility and is simple to use (Kotwicki, Lorkowska and Szulc 2007).

The aim of the study was to assess the incidence of scoliotic posture in primary school pupils and secondary school students, based on the amended Dega's chart of posture defects and an examination performed with the use of Bunnell's scoliometer. The study also aimed to compare results obtained using these two methods.

Material and Methods

The population subjected to our study was composed of children aged 6 to 18 permanently resident in Poznań. Population was randomly selected and the sampling frame consisted of primary and secondary schools in particular residential districts. The study encompassed 1,325 boys and 1,355 girls. A detailed specification of the study population indicating the numbers, age and sex is presented in Table 1.

Table 1. Study population stratified by sex and age

Age (years)	Boys n	Girls n	Total n
6	80	74	154
7	76	64	140
8	90	113	203
9	125	96	221
10	110	115	225
11	92	93	185
12	102	100	202
13	103	88	191
14	101	99	200
15	98	99	197
16	92	107	199
17	85	88	173
18	171	219	309
Total	1325	1355	2680

The assessment of scoliotic posture was performed on the basis of two methods. One of them is the method suggested by Dega (1964) and presented in Table 2.

The very term of 'scoliotic posture' was introduced in order to modify this method. Scoliotic posture is a lateral spinal curvature, functional scoliosis, in which no permanent structural changes can be seen, the lateral spinal curvature is totally reversible and can be actively

Table. 2. The chart of postural errors subjected to assessment based on criteria by Wiktor Dega

Postural errors											Contractures						
Head	Shoulders	Pigeon chest	Sunken chest	Hyperkyphosis	Scoliotic posture	Scoliosis	Hyperlordosis	Pelvis	Abdomen	Dorsum plenum	Knee varus	Knee valgus	Platypodia	Foot valgus	Shoulder joint	Hip joint	Knee joint
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

or passively corrected. The irregularity consists in the lateral bending of the spine in the frontal plane. A crucial factor in this phenomenon is the incorrect tension of postural muscles which may be the reason for asymmetric setting of particular body elements, e.g. shoulders, shoulder blades, waistline triangles, hips. Postural error in orthopaedic methodology denotes a minor, single deviation of one aspect of body posture, which may be corrected with appropriate exercises. The researcher working with this chart records every irregularity related to particular body elements in the table (Table 2), filling a separate box for every individual patient. While assessing the lateral spinal curvature, the scoliotic posture was subject to an analysis. The presence of this disorder was confirmed when there was an asymmetry of the shoulders, shoulder blades, waistline triangles and pelvis. In the case when the lateral curvature was diagnosed on many different planes, the irregularity was classified as scoliosis. Appropriate functional tests were used to assess the presence of contractures in the shoulder joints (contracture of pectoral muscles), hip joints (contracture of ilio-lumbar muscles), knee joints (contracture of sciatic-tibial muscles). He evaluation of the tensions observed in the pectoral, ilio-lumbar and sciatic-tibial muscles was performed in compliance with the principles of methodology applied in orthopaedics and rehabilitation (Dega 1964, 1986). In the case when the Thomas test turned out to be positive, the lateral spinal curvatures in the child were reassessed, this time in a sitting position (Dega 1964; Kasperczyk 2000). All the students were examined by a rehabilitation specialist.

During the study, the authors also paid attention to the length of lower limbs. If any inequalities were found, a correct setting of hip joints was achieved by putting a small wooden chip under the foot of the shorter leg. Every irregularity was marked in the table as "1". An advantage of point marking is that it enables to indicate specific body sections in which the irregularity is observed and is reversible. This has helped to establish a rational programme for correcting postural errors.

The exclusion criteria for the study were inborn skeletal disorders. In view of the fact that, currently, the incidence of lateral spinal curvatures is very often

observed in school environment, the scoliotic posture and scoliosis have been subject to a very meticulous analysis (Wilczyński 2000; Kotwicki, Lorkowska and Schulz 2007; Chowańska 2011).

The other method used to assess the lateral spinal curvatures was the scoliometer examination performed according to the methodology specified by Bunnell (1993, 2005). It is an objective assessment method of structural and functional scoliosis. Bunnell's Scoliometer measures the angle of trunk rotation (ATR) which allows an objective assessment of trunk asymmetry. The examination is characterised by high sensitivity (according to Bunnell, there are 0.1% false negative results), is not harmful for the child, and the result is available at the time of examination. Scoliometer detected every instance of trunk asymmetry; however, it was not always the proof of an existing scoliosis. In order to avoid false positive results, a threshold ATR value was established to determine a further course of action. The measured ATR value was interpreted according to Bunnell's recommendations. The following breakpoint ATR values were taken into account:

From 0 to 3 – physiological trunk asymmetry

From 4 to 6 – the examination must be retaken after 3-4 months

7 or more is an indication that the child must be referred to a specialist doctor and undergo radiological examination.

In the case when a high value of ATR (7 and >) was detected, and additional examination in a seated position was performed in order to offset the contractures of the ilio-lumbar muscles. During the test, the child was seated on a stool, with the trunk bent forward, the arms hanging loose along the shanks, and both feet placed on the ground. The results of scoliometer tests in which the ATR was 7 and more were qualified as scoliosis cases (this group of children was referred to the rehabilitation or orthopaedic clinic), whereas when the threshold ATR values were 4 – 6, the cases were qualified as scoliotic postures.

During the tests assessing the incorrect posture, all the pupils were dressed in sports clothes. Examination results were processed based on data from Excel, and the calculations were performed by means of STATISTICA 12 software.

Results

In the whole study population, the incidence of scoliotic posture assessed according to the chart of postural errors by Dega amounted to 14.6% in boys and 17% in girls and there were no significant differences between the boys and the girls in particular age groups (Table 3).

It was found that scoliotic posture both in boys and girls ($p<0.05$) is associated with age (the correlation is significantly different from zero, positive), and the proportions of students with scoliotic posture rise with age.

Scoliometer examination revealed that the incidence of scoliotic posture is more frequent among girls (25.7%) than among boys (22.2%). The differences were statistically significant - table 3. The results of scoliotic posture examination tested with a scoliometer indicated a dependence on age. The boys subjected to the study showed a correlation ($r=0.12$) significantly different from zero and positive, whereas in the group of tested girls, the correlation ($r=0.14$) was significantly different from zero and positive.

The comparison of significant differences between the test performed with

Table 3. Percentage incidence of scoliotic posture assessed on the basis of Wiktor Dega's criteria and using Bunnell's scoliometer and according to sex and age (percentage in parentheses)

Age (years)	Scoliotic posture assessed on the basis of Wiktor Dega's criteria			Scoliotic posture measured on scoliometer		
	Boys	Girls		Boys	Girls	
	n (%)	n (%)	*p*-value	n (%)	n (%)	*p*-value
6	15 (18.7)	12 (16.2)	0.681	9 (11.2)	9 (12.2)	0.860
7	10 (13.2)	15 (23.4)	0.116	18 (23.7)	22 (34.4)	0.165
8	9 (10.0)	16 (14.2)	0.371	12 (13.3)	19 (16.8)	0.494
9	14 (11.2)	11 (11.5)	0.952	21 (16.8)	14 (14.6)	0.655
10	16 (14.5)	15 (13.0)	0.744	16 (14.5)	19 (16.5)	0.683
11	6 (6.5)	11 (11.8)	0.213	13 (14.3)	16 (17.2)	0.566
12	7 (6.9)	10 (10.0)	0.423	16 (15.7)	21 (21.0)	0.330
13	15 (14.6)	15 (17.0)	0.639	22 (21.4)	21 (23.9)	0.680
14	16 (15.8)	19 (19.2)	0.534	38 (37.6)	30 (30.3)	0.275
15	19 (19.4)	23 (23.2)	0.511	39 (39.8)	40 (40.4)	0.930
16	18 (19.6)	25 (23.4)	0.517	25 (27.2)	42 (39.2)	0.073
17	21 (24.7)	22 (25.0)	0.964	28 (32.9)	33 (37.5)	0.531
18	27 (15.8)	37 (16.9)	0.770	37 (21.6)	62 (28.3)	0.133
Total	193 (14.6)	231 (17.0)	0.078	294 (22.2)	348 (25.7)	0.034
p=0.013 Pearson's Chi^2		p=0.038 Pearson's Chi^2		p<0.001 Pearson's Chi^2		p<0.001 Pearson's Chi^2
R=0.064		R=0.055		R=0.124		R=0.141
p=0.019		p=0.042		p<0.001		p<0.001

p* value – significance of the differences between boys and girls

the use of scoliometer and that performed with the use of postural error chart by Dega in both boys and girls showed that the scoliometer indicated scoliotic posture significantly more frequently than the postural error chart (Table 4).

The contractures which may have an impact on the incidence of scoliotic posture both in boys and in girls appeared more frequently in the knee joint than in shoulder or hip joints. The occurrence of shoulder, hip and knee joints is presented in Table 5. There were no significant differences in their incidence between boys and girls, whereas the biggest number of contractures was diagnosed both in boys (42.7%) and in girls (44.3%). The crucial differences in the incidence of shoulder joint contractures between boys and girls were found in students aged 9, 14, 15 and 18.

The hip joint contracture occurred significantly more frequently among boys than among girls only in the 17-year-olds.

The knee-joint contracture occurred significantly more often among boys than among girls aged 11 and 14.

Discussion

Majority of postural irregularities start occurring in childhood and adolescence and early diagnosis should allow "stop-

Table 4. Comparison of incidence of scoliotic posture assessed using Wiktor Dega criteria and measured by scoliometer in boys and girls

Boys				*p*-level	Girls				*p*-level
Wiktor Dega criteria		Measured by scoliometer			Wiktor Dega criteria		Measured by scoliometer		
N	%	N	%		N	%	N	%	
193	14.6	294	22.2	<0.001	231	17.0	348	25.7	<0.001

Table 5. Percentage incidence of shoulder, hip and knee joint contracture stratified by age and sex

Age (years)	Shoulder joint		Hip joint		Knee joint	
	Boys	Girls	Boys	Girls	Boys	Girls
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
6	29 (36.2)	18 (24.3)	23 (28.7)	32 (43.2)	50 (62.5)	52 (70.3)
7	23 (30.3)	24 (37.5)	20 (26.3)	21 (32.8)	37 (48.7)	32 (50.0)
8	31 (34.4)	40 (35.4)	27 (30.0)	33 (29.2)	29 (32.2)	51 (45.1)
9	42 (11.2)	16 (16.7)**	48 (38.4)	28 (29.2)	46 (36.8)	39 (45.1)
10	22 (20.0)	28 (24.3)	27 (24.5)	34 (29.6)	41 (37.3)	54 (46.9)
11	17 (18.5)	25 (26.9)	27 (29.3)	18 (19.3)	47 (51.1)	32 (34.4)*
12	15 (14.7)	19 (19.0)	22 (21.6)	20 (20.0)	44 (43.1)	35 (35.0)
13	16 (15.5)	14 915.9)	24 (23.3)	19 (21.6)	39 (37.9)	39 (44.3)
14	8 (7.9)	23 (23.2)**	20 (19.8)	22 (22.2)	29 (28.7)	53 (53.5)
15	24 (24.5)	13 913.1)*	30 (30.6)	26 (26.3)	48 (48.9)	47 (47.5)
16	16 (17.4)	20 (18.7)	28 (30.4)	27 (25.2)	40 (43.4)	48 (44.9)
17	24 (28.2)	11 (12.5)*	36 (42.3)	24 (27.3)*	43 (50.6)	37 (42.0)
18	25 (20.5)	26 (11.9)*	44 (25.7)	45 (20.5)	73 (42.7)	82 (37,4)
Total	302 (22.8)	277 (20.4)	376 (28.4)	349 (25.8)	566 (42.7)	601 (44.3)

Difference between boys and girls statistically significant at *$p<0.05$ and **$p<0.01$ levels

ping the disease process" or eliminating it altogether. A decline in the circulatory--respiratory capacity, as well as the vital lung capacity, bone degenerative changes, low back pain, the displacement of internal organs, bronchial asthma are only some of the effects of untreated postural defects.

On the basis of numerous scientific research studies one can assume that the number of children with locomotor system disorders will increase in the years to come, and the problem will become even more crucial (Żychowicz 2004; Fazal and Edgar 2006; Grivas et al. 2007; Thilagaratnam 2007; Janiszewska et al. 2009; Chowańska et al. 2012). Even though recently the topic has been often discussed, there are no concrete solutions with respect to prevention. Practice shows that the standard, simple methods aiming at revealing the postural irregularities among children and adolescents are scarce and their development poses a problem. Promoting physical activity, mobility, and active ways of spending leisure time may have a positive impact on the future of children and adolescents. Regular easy

exercises may protect children from the need to undergo treatment in their adult age, since postural defects in grown-ups may not only hurdle their normal functioning but also exert tremendous influence on their overall health and physical fitness.

The "postural errors" discussed above were assessed by means of a simple tool, that is the modified chart of postural errors created by Wiktor Dega. The chart may be treated as a screening test tool, because it is simple, handy and useful in detecting minor irregularities in posture as well as postural defects. It is worth noticing that the chart also contains the assessment of muscular contractures in selected joints, which may significantly influence the child's posture.

As has been shown by our studies, the scoliometer is a very effective tool in detecting the lateral spinal curvatures and, when combined with screening tests performed with the use of postural error chart by Dega, it may permit a thorough assessment of a young individual's body. It also seems to be reasonable to introduce an examination tool such as Bunnell's Scoliometer, to the compulsory screening tests affected in the school environment. It is worth stressing here that the application of selected functional tests may greatly contribute to the objective assessment of body posture.

At the moment, a change in the incidence of postural defects has been observed, as there is an increase in the number of children with minor irregularities and postural errors even among kindergartners. According to Jodkowska and Woynorawska (2002), the percentage of school children with postural defects amounts to 57%. Numerous authors, based on the studies conducted among children and adolescents aged 3 – 19, have pinpointed the incidence of high number of postural defects of a functional nature. They stress the need for the introduction of corrective gymnastics, especially the kind specifically designed to adjust head and shoulder position as well as the shape of spinal curvatures, which has been confirmed by the results of our study.

Some archival data indicate that this is a growing problem in schoolchildren. Jankowiak (1962) having examined health condition and osteo-articular disorders, recognized postural defects in 3.97% of the population. The incidence of postural defects was more frequent in boys than in girls (Oblacińska 1996).

In Europe and in the world there are few data related to the incidence of postural defects in children and adolescents. Postural assessment studies conducted in Macedonia in 2005 among 9,525 students (4,418 girls and 5,106 boys) aged 7-25, revealed a high percentage (96.5%) of children and adolescents with deviations from the correct shape of the spine, with scoliosis in 6.4%, and hyperkyphosis in 8.2% of them (Karovska et al. 2005). Well scheduled and appropriately conducted corrective gymnastics classes contributed to a reduction in the number of patients with incorrect spine shape by 35%, scoliosis at the level of 4.1%, and kyphosis 5.4%.

Screening tests have been widely discussed in many countries (Fazal and Edgar 2006; Grivas at al. 2007; Thilagaratnam 2007). American Academy of Orthopaedic Surgeons, American Academy of Paediatrics, Scoliosis Research Society, Society on Scoliosis Orthopaedic and Rehabilitation Treatment are only some of the selected facilities which deal with the problem of screening tests, among others, in the domain of scoliosis detection (Richard and Vitale 2010).

It is worth starting the tests in younger age, because early detection of any deviations from correct body posture should allow to undertake appropriate actions aimed at correction or compensation of mobility deficit at the right time.

Conclusions

Scoliometer examination revealed substantially higher percentage of students with scoliotic posture than the examination performed with the use of Dega's posture defect chart. Higher percentage of students with scoliotic posture was diagnosed with the use of scoliometer than with the application of Dega's posture defect chart. As the population ages, the incidence of lateral spinal curvatures increases. Scoliometer proved to be a more effective tool in detecting lateral spinal curvatures and should be more widely used in school healthcare.

Acknowledgements

This study has been approved by Poznań University of Medical Sciences Ethics Committee and been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. All parents and their children gave informed consent prior to their inclusion in the study.

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Authors' contributions

KM-P was the project manager, conceived the study design; AK coordinated the research, conceived the paper, analyzed and interpreted the data presented here; JD supported data analysis and interpretation; KM–P, JD, AK drafted the manuscript; statistical analysis of the data was executed by BS-W. All authors were involved in drafting the paper and in approval of the final manuscript.

Conflict of interest

The authors declare that there is no conflict of interest regarding publication of this work.

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