Tomasz Szurmik[1], Paweł Lizis[2], Ewa Puszczałowska-Lizis[3]
[1]Orto-Med. Bielsko-Biała
[2]Świętokrzyska Higher School in Kielce, Faculty of Health Care
[3]University of Rzeszów, Faculty of Medicine, Institute of Physiotherapy

ASSESSMENT OF THE EFFECTS OF BODY POSTURE CORRECTION IN THE SAGITTAL PLANE IN RURAL GIRLS AGED 7-12 WITH I° SCOLIOSIS

Abstract

Postural defects of children and youth constitute a serious social problem. It indicates the need for taking up efficient diagnostic and rehabilitation activities with regard to all children and youth in Poland with a particular focus on children from small towns and rural areas. The aim of the work was to assess the efficiency of corrective exercises done by girls with I° scoliosis and concurrent spinal defects in the sagittal plane. Additionally, an attempt was made to assess whether the level of anterior-posterior curvatures of the spine determines the quality of the body posture and whether there exists a relation between selected morphological features and the body posture of the examined girls. Two tests carried out 10 months apart included a group of 22 girls with spinal defects in the sagittal plane aged 7 to 12. Girls lived in the rural area of Żywiec commune. They participated in the authors' programme of corrective exercises conducted in the Specialist Centre for Postural Defects Correction Orto-Med in Żywiec. The levels of anterior-posterior curvatures of the spine were measured with the use of photogrammetric method. The types of body posture were defined on the basis of Wolanski's silhouette method modified by Zeyland-Malawka. The quantitative and percentage distribution of body posture types was calculated before and after the applied correction. In order to assess the dependencies between the level of anterior-posterior curvatures of the spine and the quality of the body posture, a non-parametric Chi² (χ^2) test was used. To assess the relations of body posture with morphological features, Pearson's linear correlation was used. A beneficial influence of the applied corrective exercises on the shape of the anterior-posterior curvatures of the spine of the examined girls was noted. A body mass and height correlate with the body posture of the examined girls. A 10-month programme of corrective exercises improves the shape of anterior-posterior curvatures of the spine and the posture of girls aged 7-12 with I° scoliosis. The shape of the curvatures of the spine determines the quality of the body posture of the examined girls.

Key words: body posture, photogrammetric method, anterior-posterior curvatures of the spine, girls

Introduction

A body posture is an individual way of a human to hold a standing position or a casual body position influenced by morphological and functional factors. One of the most significant features of a body posture is its changeability occurring during phylo- and ontogenesis. These changes, especially during ontogenesis, influence the quality of the posture and represent the specificity of the body statics in successive development periods.

Postural defects of children and youth constitute a significant social problem. Their frequency of occurrence is to a large extent influenced by the civilisation progress which limits the natural need for physical activity. A sedentary lifestyle contributes to a faster decrease in joint mobility than it is assumed in the evolutionary process of the aging of the body. A sedentary position is usually connected with inclining the head and trunk forward, which brings about the pressure on abdominal organs, difficulties with digestive system functioning as well as immobilising and flattening the chest. The lack of physical activity improper hygienic habits and bad living conditions are only a few factors which, when interrelated, may threaten the proper development of children and youth.

In the literature regarding the issue of body posture assessment numerous evaluation methods are recommended. Their number and variety prove that no ideal method has been found so far. The most common methods include Kasperczyk's point method [6], inclinometric method [7, 12, 19] and photogrammetric method [9].

In numerous cases the major criterion taken into consideration while assessing body posture of children and youth is the frequency of occurrence of postural defects. Numbers and assessments of the scale of this phenomenon provided by various authors range from 36% to 76% [5, 8, 11, 15, 17, 18]. Research shows that changes in the musculoskeletal system more frequently regard urban children between 6 and 14 years of age and 18-year-old rural youth [3]. Deviations from the features of a proper posture occurring in the period of development flexibility which are not compensated in the developmental period may lead to the musculoskeletal system failure and to the systemic failure, which in further periods of ontogenesis may exert a negative influence on the state of health, well-being, and as a consequence, on the quality and length of life. All this indicates the need for taking up efficient diagnostic and rehabilitation activities with regard to all children and youth in Poland with a particular focus on children from small towns and rural areas. It means promoting widespread screening diagnostics in an early detection of irregularities in body posture as well as increasing accessibility to treatment and rehabilitation for children and youth requiring specialist medical care.

The aim of the work was to assess the efficiency of corrective exercises done by girls with I° scoliosis and concurrent spinal defects in the sagittal plane. Additionally, an attempt was made to assess whether the level of anterior-posterior curvatures of the spine

determines the quality of the body posture and whether there exists a relation between selected morphological features and the body posture. The following research questions have been formulated:

1. Do the applied corrective exercises improve the body posture of girls with spinal defects in the sagittal plane?
2. Does the level of anterior-posterior curvatures of the spine determine the quality of the body posture of the girls?
3. Are there any relations between body mass, body height, BMI and the body posture of the girls?

Material and methods

Two tests carried out 10 months apart (September 2009 – June 2010) included a group of 22 girls aged 7 to 12 with I° scoliosis and concurring spinal defects in the sagittal plane. The mean age in the examined group was $\bar{\chi} = 9.54 \pm 2.1$ years. The girls lived in the rural area of Żywiec commune. They participated in the authors' programme of corrective exercises conducted in the Specialist Centre for Postural Defects Correction Orto-Med in Żywiec. Children participating in the research manifested average physical activity and did not attend any extra-curricular sports and recreation activities. The children's parents were informed about the aim of the research and signed a written consent. On the grounds of a specialist medical diagnosis the cases of I° scoliosis were noted in the examined group. A functional assessment of the musculoskeletal system was performed and the anterior-posterior curvatures of the spine were measured. After detailed assessment of the body posture each person was provided with a set of exercises depending on the type of the curvature and the concurring spinal defect in the sagittal plane. The girls attended 45-minute correction classes regularly twice a week in the period of 10 months.

Examples of special exercises used in the individual programmes:

- *an exercise with the use of Asymmetric Set of Rehabilitation Blocks (ASRB) with a kyphotic addition*: A patient kneels supporting the trunk on the support piece with a kyphotic addition and grabs weighted lines with both upper limbs. Course of the exercise: A patient pulls lines while simultaneously stretching upper limbs alternately depending on the type and direction of the curvature of the spine. A precise exercise affects the peak of the curvature through properly selected arm positioning. Number of repetitions - 5, the duration of each exercise – 30 seconds (fig. 1).

- *an asymmetric exercise of the lumbar segment in the kyphotic position*: A patient supports the trunk with the device in such a way that the pelvis is set on its edge. The course of the exercise: A patient raises and supports lower limbs with a slight movement to the sides on a gymnastic ladder in the direction of a lumbar curvature arch. Number of repetitions: 10, with 20-second holds. The selection of an asymmetric initial position and the course of the exercise depends on the type and direction of the curvature of the spine, rotation and concurring defects in the sagittal plane (fig. 2).

- *an exercise strengthening abdominal muscles*: performed with the back to the wall bars supporting forearms on the apparatus. The course of the exercise: A patient raises lower limbs bent in knees and hip joints upwards and rotates them to the right and left with a hold, and then comes back to the initial position. Number of repetitions – 30, the duration of each exercise - 5 seconds (fig. 3).

- *a corrective-kyphotic exercise in Scoliosis De-rotator and Corrector (SDC)*: A patient kneels with front support in an apparatus with the stabilisation of shoulder and pelvic girdle. Corrective-redressing heads are placed on arch peaks depending on the course of the curvature. The course of the exercise: a patient takes a deep breath and makes a movement called a "cat stretch". At the peak of the bend the air is exhaled and the position is held for about 8 seconds and then the patient comes back to the initial position (fig. 4).

- *an elongating exercise with the use of an "elongator with a kneeling chair"*: A patient sits on a special kneeling chair that enables her to assume a proper position of pelvis. The top of the head touches the extension arm with a mobile knob. The patient pushes the knob of the extension with her head upwards holding the maximum elongation position. The apparatus informs about the improper course of the exercise with a signal, which makes it possible to correct the position. The number of repetitions - 15-20, with 15- to 20-second holds of the maximum elongation position (fig. 5).

Figure 1. An exercise with the use of Asymmetric Set of Rehabilitation Blocks (ASRB) with a kyphotic addition [16]

Figure 2. An asymmetric exercise of the lumbar segment in the kyphotic position [16]

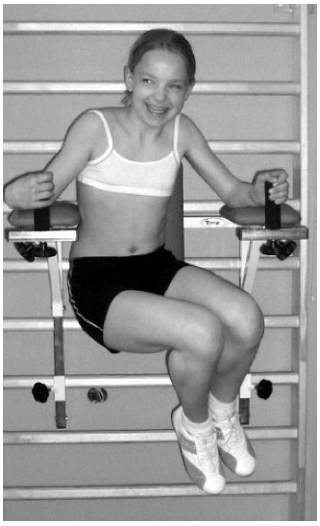

Figure 3. An exercise strengthening abdominal muscles [16]

Figure 4. A corrective-kyphotic exercise in Scoliosis De-rotator and Corrector (SDC) [16]

Figure 5. An elongating exercise with the use of an elongator with a kneeling chair [16]

The following morphological features were measured:

1. Body mass – using a doctor's scales with an accuracy of 0.5 kg.
2. Body height – using an anthropometer, with Martin's technique with an accuracy of 0.1 cm.

On the basis of the measurements of body mass and body height, BMI (Body Mass Index) was calculated according to the following formula:

$$\text{BMI} = \frac{\text{body mass}\,[\text{kg}]}{\text{body height}^2\,[\text{m}]}$$

Basic descriptive statistics of the examined morphological features are included in table I.

Table 1. Basic descriptive statistics of selected morphological features of the examined girls

Feature	min - max	$\overline{x}$	s	V
Body mass	20.3 - 45.9	32.5	8.8	27.1
Body height	121.0 - 163.0	142.3	14.7	10.3
BMI	13.20 - 17.88	15.67	1.36	8.68

The measurements of anterior-posterior curvatures of the spine were made with the use of a set for diagnosing postural defects with photogrammetric method designed and built by the employees of Warsaw University of Technology [9].

The measuring station for body posture examination included:

- measuring device (with a built-in video camera),
- digital camera,
- computer-electronic system,
- software (fig. 6).

Figure 6. A measuring station for body posture examination [13]

A computer system for body posture examination with a projection moiré technique includes the software which makes it possible to measure and analyse the registered object. On the basis of the suggested parameters the type of posture may be defined and the existing defects may be observed. With regard to the fact that the spine and its position is the axis of the whole body, and the fact that its shape exerts a significant influence on the body posture, the software makes it possible to define various parameters connected with the level, length and angle that provide information concerning the spatial shape of the back, the whole spine and its particular segments (fig. 7).

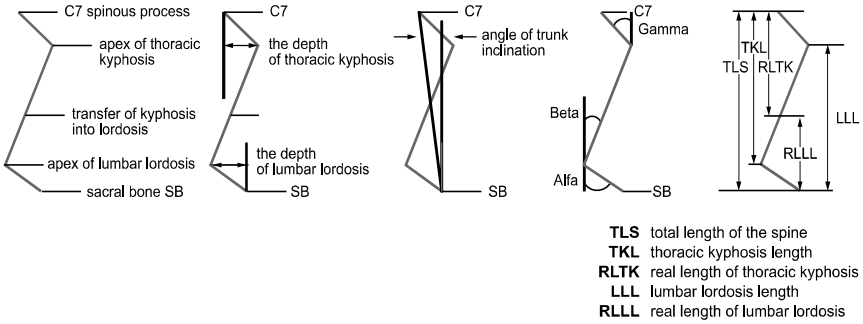

Figure 7. Selected parameters set in the sagittal plane [13]

The quality of the body posture in the sagittal plane was assessed on the basis of the angles of anterior-posterior curvatures of the spine, where the sum of angles β and γ was deducted from the sum of angles α and β and the compensation index $\mu = (\alpha \text{ angle} + \beta \text{ angle}) - (\beta \text{ angle} + \gamma \text{ angle})$ was calculated (fig. 8).

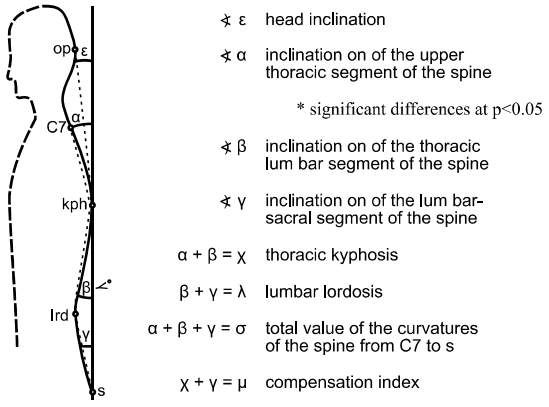

Figure 8. Angles of anterior-posterior curvatures of the spine [21]

On the basis of Wolanski's criterion modified by Zeyland-Malawka, three types of posture were defined, i.e. kyphotic, balanced and lordotic posture. Within each type three sub-types were distinguished. The typology is as follows:

1. Kyphotic types: if $\mu > 4^o$: $\chi = \beta + g$
   K I – $\chi < 28^o$; K II – $29^o \leq \chi \leq 31^o$; K III – $\chi > 32^o$
2. Balanced types: if $(-3^o) \leq \mu \leq 3^o$: $\sigma = \alpha + \beta + g$
   B I – $\sigma < 32^o$; B II – $33^o \leq \sigma \leq 41^o$; B III – $\sigma > 42^o$
3. Lordotic types: if $\mu < (-4)$: $\lambda = \alpha + \beta$
   L I – $\lambda < 24^o$; L II – $25^o \leq \lambda \leq 29^o$; L III – $\lambda > 30^o$

Afterwards, body posture types wwere classified into:

- proper postures – kyphotic type KI, balanced types BI, BII, lordotic type LI,
- improper postures – kyphotic types KII, KIII, lordotic types LII, LIII, balanced type BIII [20].

In order to analyse the gathered material, the quantitative and percentage distribution of body posture types was calculated before and after the applied correction. In order to assess dependencies between the level of anterior-posterior curvatures of the spine and the quality of the body posture, a non-parametric Chi² (χ^2) test was used. For the evaluation of the relations between body posture and selected morphological features Pearson's linear correlation was applied.

Results

The primary aim of the work was to assess the efficiency of the correction of spinal defects in the sagittal plane in the examined girls. In the analysis of results a quantitative and percentage distribution of the types and categories of body posture types before and after the applied correction was presented. The results indicate that in the first test the most common type was an improper lordotic type since it was noted in 10 girls. An improper balanced type was observed in 4 girls and an improper kyphotic type in 3 girls. In the second test no improper kyphotic type was noted, whereas a proper kyphotic type was observed in 3 girls. Moreover, the number of girls with an improper lordotic type decreased to 7. Nonetheless, the number of subjects with an improper balanced type did not change. Taking everything into consideration, the biggest improvement was observed among girls with a kyphotic and lordotic posture. In total, in the second test improper anterior-posterior curvatures of the spine were noted in 12 girls (tab. II, fig. 9). These results indicate that after a 10-month correction procedure the number of people with improper anterior-posterior curvatures of the spine decreased, while the number of people with proper anterior-posterior curvatures increased, which proves a positive influence of the applied correction programme on the quality of the body posture of the examined girls (table II, fig. 9).

Table 2. The efficiency of the spinal deformity correction in the sagittal plane

Body posture type / Body posture category	Kyphotic				Lordotic				Balanced				Total			
	exam. I		exam. II		exam. I		exam. II		exam. I		exam. II		exam. I		exam. II	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Proper	0	0.0	3	13.6	0	0.0	3	13.6	5	22.7	5	22.7	5	22.7	10	45.5
Improper	3	13.6	0	0.0	10	45.4	7	31.8	4	18.2	4	18.2	17	77.3	12	54.5
Total	3	13.6	3	13.6	10	45.5	10	45.5	9	40.9	9	40.9	22	100	22	100

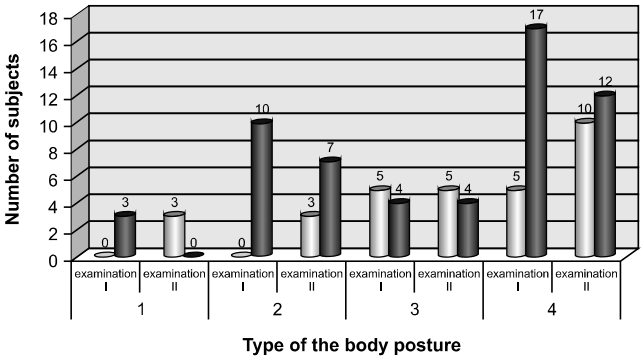

Figure 9. The effectiveness of the correction of spinal deformity in the sagittal plane: 1) kyphotic type, 2) lordotic type, 3) balanced type

The next aim of the analysis was to verify the thesis that the shape of the anterior-posterior curvatures of the spine conditions the quality of the body posture. Therefore, types of body posture were divided into kyphotic, lordotic and balanced types and each of them was assigned with two categories of posture, i.e. a proper and improper type, which were created on the basis of stemplots. In order to look for dependencies, a non-parametric χ^2 (stem and leaf diagrams) test was applied. A statistical critical value for V=2 (degrees of freedom) of all coefficients is χ^2=9.488; $p<0.05$. It was assumed that an increase or a decrease in physiological curvatures of the spine in the sagittal plane is connected with an improper body posture of the examined girls. A calculated coefficient of correlation (χ^2) between the shape of anterior-posterior curvatures of the spine and the quality of the body posture of the girls showed statistical significance at the level of $p<0.05$; χ^2= 7.244 (table III). The research showed that the deepening or flattening of thoracic kyphosis and lumbar lordosis determines an improper body posture of girls. The

authors' own research indirectly confirms the usefulness of Wolanski's silhouette method modified by Zeyland-Malawka concerning a detailed and reliable assessment of the quality of the body posture of children and youth (table III).

Table 3. Correlation between a body posture type and its quality

Body posture type / Body posture category	Kyphotic	Lordotic	Balanced	Total
	n			
Proper	0	0	5	5
Improper	3	10	4	17
Total	3	10	9	22
χ^2	7.244			

Table 4. Coefficients of Pearson's linear correlation between morphological features and a body posture of the girls

Feature	Body posture
	r
Body mass	- 0.658***
Body height	- 0.453*
BMI	-0.022

Discussion

In the research on body posture various research methods were applied. Therefore, research results published by various authors are difficult to compare. Regardless of the application of various research methods, huge discrepancies of results are brought about by the environmental conditions, selection of the examined groups and period of observation. In the research on 302 children aged 8-13 carried out with the use of photogrammetric method Grabara [4] observed that the most frequently occurring types in girls were type BIII and LIII. Drzał-Grabiec et al. [2] in their research on 159 children from the years I-III of primary school carried out with the use of photogrammetric method concluded that a dominating type of body posture was a lordotic type (47%), while a kyphotic type occurred less frequently (39%) and a balanced type was the least common (15). Also, Wojna et al. [20] observed that in the group of children aged 6-7 a dominating type of body posture is a lordotic type. Proper subtypes occurred more frequently among older children, while improper subtypes among younger children.

Prętkiewicz-Abacjew [11] analysed the shape of the curvatures of the spine in the sagittal plane and the angle of pelvis anteversion on the basis of the research conducted with the use of peg apparatus and Wiles' calliper. Types of body posture were defined according to Wolanski's method. In the pubertal period the occurrence of body posture defects in the sagittal plane is more common than before this period. In the case of the angle of the lumbar lordosis curvature in girls before the period of puberty, the most commonly represented angles included small angles of the spine inclination in the thoracic-lumbar segment. Over half of the girls in the puberty period had big inclination angles of the lumbar-sacral segment. Balanced and kyphotic postures occurred frequently in the girls in this period. The author highlights the fact that the change of morphological conditions occurring in the period of puberty disturbs the feeling and habit of good posture and, therefore, body posture in this period requires special care from doctors, parents and PE teachers who should make sure that the posture deterioration which occurs in this period is not consolidated [11].

Experts in the field of scoliosis claim that flat back or deep lordosis are an initial point or a predisposing factor for the occurrence of idiopathic scoliosis. In the physiological anterior-posterior curvatures the body mass rests on relatively big surfaces of vertebral bodies which are protected by intervertebral discs. The flattening of the back makes the spine labile and there occurs a huge likelihood that flexibility and endurance which an anteflexed posture lacks in will be compensated by its lateral inclination [10]. An improper position of vertebrae favours an uneven growth of vertebral bodies and a progressing deformity of intervertebral discs whose accelerated growth is observed on the convex side of the curvature [1, 14]. It is worth highlighting that scoliosis in the initial stages of ontogenesis occurs in boys and girls in relation 1:1, while in the further stages of development this proportion changes for the benefit of boys and equals 1:7 [10]. This may be brought about by the fact that pelvic anteversion is in general observed more often in girls. This can lead to a deepened lumbar lordosis, and as a consequence, to a frequent occurrence of lumbar scoliosis. Additionally, girls are in general less active physically, which limits a preferable burdening and unburdening of three support points (nucleus pulposus and two intervertebral joints). They experience earlier pubertal spurt, and, therefore, their osseous system is more susceptible to deformations [10].

The results of the authors' own research indicate that in the group of 7-12-year-old girls with I° scoliosis a lordotic type of body posture occurs most often. Moreover, it was concluded that after a 10-month period of applying the authors' programme of corrective exercises the frequency of occurrence of proper subtypes increased, especially in the kyphotic and lordotic type of body posture. Furthermore, the correlation between the category of the body posture and its quality was revealed. The quality of the body posture is determined by the type of body posture. As a result, it can be concluded that the level of anterior-posterior curvatures of the spine influences a body posture. In this work an attempt was made at assessing the correlations between selected morphological features and a body posture. The results revealed that there exists a statistically significant correlation between body mass, height and posture of girls. Negative correlation

coefficients indicate that lighter and shorter individuals have better body postures than heavier and taller subjects. No correlations between BMI and body posture were found. The lack of statistically significant correlations may indicate that this index does not reflect body proportions accurately (relation of mass to height) in the period of somatic development, and, as a result, it is not the best way to measure the changeability of the body build of girls before and after the puberty spurt. It is possible that statistically significant correlations between the aforementioned features may occur in the further period, after the developmental processes are finished. The lack of statistically significant correlations may also result from heterogeneousness of the research group caused by a big age span of girls. Therefore, this problem requires further scientific research and verification of our own results in a bigger and more homogenous group. The presented scientific reports and our own research results indicate the need for diagnosing and elaborating programmes of corrective procedures with regard to all children and youth with postural defects, with a special consideration of children from small towns and rural areas.

Conclusions

1. The improvement of the shape of anterior-posterior curvatures of the spine in the examined girls was observed, which proves the effectiveness of the applied programme of corrective exercises.
2. The research revealed the correlation between the level of the anterior-posterior curvatures of the spine and body posture, which leads to the conclusion that the deepening or flattening of thoracic kyphosis and lumbar lordosis determine the quality of the body posture of girls aged 7-12.
3. Correlations between body mass, height and body posture were noted, which enables us to claim that lighter and shorter girls have better body posture than heavier and taller girls.

References

1. Antoniou J., Arlet V., Gosvami T., Aebi M., Alini M. Elevated synthetic activity in the convex side of scoliotic intervertebral disc end endplates compared with normal tissues. Spine 2002; 26 (10): 198-206.
2. Drzał-Grabiec J., Snela S., Bibrowicz K. Postawa ciała w płaszczyźnie strzałkowej u dzieci z trzech pierwszych klas szkoły podstawowej. Przegl Med UR 2009; 4: 363-366.
3. Górniak K. Rozwój biologiczny dzieci wiejskich z wadami postawy ciała. Studia i Monografie, AWF, Warszawa, 2006.
4. Grabara M. Wady postawy ciała u dzieci w wieku szkolnym. Wych Fiz i Zdrow 2004; 12 : 14-20.

5. Kania-Gudzio T., Wiercicka M. Ocena postawy ciała dzieci w wieku 7-15 lat na podstawie wybranej losowo szkoły podstawowej miasta Poznania. Nowiny Lekarskie 2002; 71 (2-3): 151-159.
6. Kasperczyk T. Wady postawy ciała. Diagnostyka i leczenie. Kasper, Kraków, 2004.
7. Kużdżał A., Szczygieł A., Ćwirlej A. Porównanie parametrów krzywizn kręgosłupa w płaszczyźnie strzałkowej mierzonych metodą antropostereometfigzną i inklinometfigzną. Post Rehab 2004; 18 (4): 11-14.
8. Lichota M. Zmiany kształtu przednio-tylnych krzywizn kręgosłupa u dzieci w wieku 6-7 lat. Fizjoter 2008; 5 (1): 13-16.
9. Nowotny J., Podlasiak P., Zawieska D. System analizy wad postawy. Politechnika Warszawska 2003.
10. Ociepka R., Wagner G.T. Leczenie skolioz. System aktywnej korekcji idiopatycznych skrzywień bocznych kręgosłupa SAKIS. Łódź 2008: 18-21.
11. Prętkiewicz-Abacjew E. Wybrane cechy postawy ciała w płaszczyźnie strzałkowej u chłopców i dziewcząt w okresie dojrzewania płciowego. [in:] Nowotny J. (ed.): Dysfunkcje kręgosłupa, Diagnostyka i terapia. AWF Katowice, 1993: 225-238.
12. Saur P. Lumbar range of motion: Reliability and validity of the inclinometer technique in the clinical measurement of trunk flexibility. Spine1996; 12 (11): 1332.
13. Słonka K., Paluch P. Wykorzystanie techniki mory w ocenie postawy ciała człowieka. Materiały Konferencji Naukowo-Technicznej PPM 2005; 335-342.
14. Stokes W., Windisch E. Vertebral height growth predominates over intervertebral disc height growth in the adolescent spine. Spine 2006; 31(14):1600-1604.
15. Suder A., Kościuk T., Pałosz J. Częstość występowania wad postawy ciała u chłopców krakowskich w wieku od 4 do 18 lat-stan aktualny i zmiany w ostatnim trzydziestoleciu. Pediatr Pol 2003, LXXVIII (2): 123-129.
16. Szurmik T., Szczygieł A., Sitarz J. Wielofunkcyjny Zestaw do Profilaktyki i Leczenia Wad Postawy /OPIW-01 Plus/ do wykorzystania w szkołach, ośrodkach specjalistycznych. [in:] K. Górniak K. (ed.): Korektywa i kompensacja zaburzeń w rozwoju fizycznym dzieci i młodzieży. ZWWF Biała Podlaska 2005; 334-341.
17. Śliwa W., Mieszała W. Ocena krzywizn kręgosłupa metodą elongacyjną z wykorzystaniem „Posturometru-S". [in:] Nowotny J. (ed.): Dysfunkcje kręgosłupa, Diagnostyka i terapia. AWF Katowice, 1993: 25-30.
18. Walicka-Cupryś K., Ćwirlej A. Ocena wielkości krzywizn przednio-tylnych kręgosłupa u dzieci w wieku dziesięciu lat z pomocą pomiaru inklinometfigznego. Młoda Sportowa Nauka Ukrainy 2006; 10 (2): 263-266.
19. Walicka-Cupryś K., Puszczałowska-Lizis E., Maziarz K. Kształtowanie się przednio-tylnych krzywizn kręgosłupa u uczniów z klas gimnazjalnych i licealnych. Rebab Med 2008; 24 (4): 28-36.
20. Wojna D., Anwajler J., Hawrylak A., Barczyk K. Ocena postawy ciała dzieci w młodszym wieku szkolnym. Post Rehab 2009; 23 (2): 128.
21. Zeyland-Malawka E. Badanie postawy ciała. AWF Gdańsk, 1997: 54-59.

22. Zeyland Malawka E. Klasyfikacja ocena postawy ciała w modyfikacjach metody Wolańskiego i Nowojorskiego Testu Klasyfikacyjnego. Fizjoter 1999; 7 (4): 52-55.