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CORRECTION AND COMPENSATION OF PHYSICAL DEVELOPMENT DISORDERS IN CHILDREN AND YOUTH

edited by

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Biała Podlaska 2009

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MONOGRAPHY

ISBN 978-83-61509-07-3

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Zamiejscowy Wydział Wychowania Fizycznego w Białej Podlaskiej
ul. Akademicka 2; 21-500 Biała Podlaska, tel. (83) 342-87-87

Translation and proofreading:
Marzena Jankowska-Buszta, Mariusz Buszta

PRINTED AND BOUND:
Usługowy Zakład Poligraficzny „INTERGRAF" s.c.
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SPINAL RANGES OF MOTION IN BOYS WITH PECTUS EXCAVATUM

Abstract

Aim. The lack of comparative research into the spinal ranges of motion and somatic features of children with pectus excavatum and healthy children was the reason for taking up this topic. The aim of this work was to compare the spinal ranges of motion and basic somatic features of boys with pectus excavatum with healthy children.

Material and methods. The study included 30 boys from Sucha Beskidzka commune. Fifteen subjects had pectus excavatum, whereas the remaining 15 boys were healthy and they constituted the control group. The mean age of the subjects was 13.3 ± 0.4 and 13.5 ± 0.7. The study was carried out in 2008. The spinal range of motion was measured with the use of the SFTR method. Also, body height, body mass as well as chest inspiratory and expiratory volume were measured.

Results. Smaller ranges of motion of the spine were observed in boys with pectus excavatum. Significant differences concerned lateral flexions of thoracolumbar spine, the flexion of the lumbar spine as well as the flexion of the whole spine. Significant differences between the groups were found in chest circumference.

Conclusions. Significant differences in some ranges of motion of the spine between the groups are caused by rachitis. Statistically significant differences in chest circumference indicate that rachitis exerts negative influence on the range of motion of the chest and on the respiratory system.

Key words: boys, spine, range of motion, somatic features.

1. Introduction

Body posture is a characteristic feature of human beings. It helps to maintain an erect bipedal position. It is an individual feature of every human and it is labile and changeable in ontogeny. The developmental age is particularly important for postural development. It consists of two critical periods. The first one is connected with commencing school education and changing an active lifestyle into a sedentary one. The other period is the pubertal spurt during which there occurs intensive growth of bones as well as the weakening of postural and deep muscles of the spine.

Acquired postural defects of children in developmental age usually result from improper motor habits while those inborn may be caused by rachitis. Pectus excavatum (after rachitis) is not genetically based. It is characterised by the funnel-shaped sinking of the sternum and adjacent ribs. If the "funnel" covers the centre of the sternum, post-rachitic changes are symmetrical; if it is moved to one side, changes are asymmetrical [2, 3, 10, 12]. Children with pectus excavatum have worse circulatory-respiratory efficiency and demonstrate worse somatic development. They are smaller, lighter and their ranges of motion and circumference of the chest are lower than those of their healthy counterparts. Another characteristic feature of asthenic body build is flaccidity and considerable weakening of postural muscles of the back and abdomen as well as gluteal muscles. Muscles become more weakened together with an increase in deformity values [5, 11].

In scientific publications there is no comparative research into the spinal ranges of motion in children with chest deformities in relation to healthy children. Therefore, the authors examined the spinal ranges of motion in children with pectus excavatum whereupon they compared the data obtained with the results of healthy boys. The data presented form the basis for further research assessing the influence of chest deformity on the spinal range of motion. The authors' own results and conclusions may point to the need for implementing exercises that maintain and stimulate sectional range of motion of the spine in children with chest defects.

2. Aim

The spine is a central axis of the body. Its proper build ensures optimal static-dynamic efficiency of the musculoskeletal system. Rachitis leads to a deformity of the chest and to changes within the internal structure of vertebrae. As a result, the spinal range of motion in children with pectus excavatum may decrease in comparison to healthy individuals. The lack of comparative research into the spinal ranges of motion of children with pectus excavatum and healthy children was the direct reason for taking up this topic. In addition, basic somatic features of boys with pectus excavatum were compared to those of healthy boys. Therefore, research questions and hypotheses were formulated.

Research questions:

1. Are there any differences in the spinal ranges of motion between boys with pectus excavatum and healthy boys?
2. Are there any differences in basic somatic features between boys with pectus excavatum and healthy boys?

Research hypotheses:

1. Boys with pectus excavatum demonstrate smaller ranges of motion of the spine than the healthy ones.
2. Boys with pectus excavatum demonstrate worse physical development than the healthy ones.

3. Material and methods

3.1. Material

The study included 30 boys from Sucha Beskidzka commune. Fifteen subjects had pectus excavatum, whereas the remaining 15 boys were healthy and they constituted the control group. The study was carried out in 2008. The mean age of the subjects was 13.3 ± 0.4 and 13.5 ± 0.7. The study included children who declared no previous injuries and lesions of the musculoskeletal system.

3.2. Methods

The spinal ranges of motion were evaluated with the use of a measuring tape according to the SFTR method. The measurements were made from selected osseous points to an accuracy of 0.5 cm (in an initial position and after performing a maximal range of motion). The difference between the final and initial measurement was the range of motion. Ten spinal ranges of motion were taken into account:

1. **Flexion of cervical spine in a sitting position.** The distance between external occipital protuberance and the spinous process of the 7th cervical vertebra was measured.
2. **Extension of cervical spine in a sitting position.** The distance between the top of the chin and jugular incisure of the episternum.
3. **Left- and right-side flexion of cervical spine in a sitting position.** The distance between the mastoid process of the temporal bone and the acromion of the scapula was measured on the right side. In the case of the right-side flexion, the measurement was made on the left side.
4. **Left- and right-side rotation of cervical spine in a sitting position.** The distance between the top of the chin and the acromion of the scapula was measured on the right side. In the case of the right-side rotation, the measurement was made on the left side.
5. **Flexion of thoracic spine in a standing position.** The distance between the spinous process of the 1st thoracic vertebra and the spinous process of the 12th thoracic vertebra was measured.
6. **Left- and right-side flexion of thoracolumbar spine in a standing position.** The distance between the top of the axilla and the crista iliaca was measured on the right side (with right upper limb on the nape). In the case of the right-side flexion (left upper limb on the nape), the measurement was made on the left side.
7. **Left- and right-side rotation of thoracolumbar spine in a standing position.** The distance between the xiphoid process of the sternum and the anterior superior iliac spine was measured on the right side. In the case of the right-side rotation, the measurement was made on the left side.
8. **Flexion of lumbar spine in a standing position.** The distance between the spinous process of the 1st lumbar vertebra and the spinous process of the 5th lumbar vertebra was measured.
9. **Extension of lumbar spine in a standing position.** The distance between the xiphoid process of the sternum and the pubic tubercles was measured.
10. **Flexion of the whole spine in a standing position.** The distance between external occipital protuberance and the base of the sacral bone was measured.

In addition, 4 somatic features were measured:

1. **Body mass** measured with the use of scales to an accuracy of 100 g.
2. **Body height** measured with the use of anthropometer to an accuracy of 1 mm.
3. **Chest circumference during expiration** measured at the height of nipples with the use of a measuring tape to an accuracy of 1 mm.
4. **Chest circumference during inspiration** measured at the height of nipples with the use of a measuring tape to an accuracy of 1 mm.

3.3. Statistical methods

Basic descriptive statistics were used in the analysis. Arithmetic means ($\bar{x}$), standard deviations (s) and coefficients of variation (V) were calculated for every feature in boys with pectus excavatum and the healthy ones. To assess the differences between arithmetic means of spinal ranges of motion and somatic features of boys with pectus excavatum and the healthy ones the Student's t-test was used [6].

4. Results

Ranges of motion in flexions, extensions, lateral flexions, rotations of cervical spine, flexions of thoracic spine, rotations of thoracolumbar spine and extensions of lumbar spine are similar in the examined groups. The flexion of cervical spine in boys with pectus excavatum is 2.5 cm, while in healthy boys it is approximately 3 cm (t = -0.909, p>0.05). The extension of cervical spine is similar in both groups, i.e. about 7 cm (t = -0.133, p>0.05). Left- and right-side flexions of cervical spine reach 4 cm in both groups (t = -1.379 and t = - 0.909, p>0.05), while rotations are equal to approximately 6 cm and 7 cm (t = -1.515 and t = -1.724, p>0.05). Similar values of flexions of thoracic spine were registered in the groups under investigation, i.e. about 4 cm (t = -0.732, p>0.05) (table I, fig. 1). Left-side rotations of thoracolumbar spine are equal to approximately 4 cm in both groups (t = -1.315, p>0.05); in the case of right-side rotations the boys with pectus excavatum reached about 3 cm, whereas the healthy ones had the values of 4 cm (t = -1.395, p>0.05). The extension of lumbar spine in boys with pectus excavatum reached 6.5 cm, while that of healthy boys reached approximately 7 cm (t = -1.272, p>0.05) (table I, fig. 2).

Significant differences in the ranges of motion of lateral flexions of thoracolumbar spine, flexions of lumbar spine and flexions of the whole spine were observed between the examined groups. Left- and right-side flexions of thoracolumbar spine are smaller in boys with pectus excavatum than in the healthy ones, i.e. 6.5 cm and about 8 cm respectively (t = -4.146, p<0.001 and t = -3.191, p<0.01) (table I, fig. 2). Boys with pectus excavatum demonstrate a smaller flexion of lumbar spine than healthy boys, i.e. approximately 4 cm and 5.5 cm (t = -2.600, p<0.05) and a smaller flexion of the whole spine, which is equal 9.5 cm and 12 cm respectively (t = -3.561, p<0.01). The results indicate that these are the most significant differences in the spinal ranges of motion between the groups under examination. It must be highlighted that the chest deformity known as pectus excavatum limits the ranges of motion of thoracolumbar spine in the coronal plane as well as lumbar spine and the flexion of the whole spine in the sagittal plane to the highest degree (table I, fig. 2).

Table I. Comparison of spinal ranges of motion in boys with pectus excavatum and in healthy boys

Range of motion (cm)	Boys with pectus excavatum			Boys from the control group			Value t
	$\bar{x}$	s	V	$\bar{x}$	s	V	
Flexion of cervical spine (cm)	2.5	0.8	32.0	2.7	0.7	25.9	-0.909
Extension of cervical spine (cm)	7.1	1.9	26.8	7.2	2.0	27.8	-0.133
Left-side flexion of cervical spine (cm)	4.0	0.8	20.0	4.4	0.7	15.9	-1.379
Right-side flexion of cervical spine (cm)	4.0	0.8	20.0	4.3	0.7	16.3	-0.909
Left-side rotation of cervical spine (cm)	6.4	1.9	29.7	7.4	1.5	20.3	-1.515
Right-side rotation of cervical spine (cm)	6.0	1.6	26.7	7.0	1.4	20.0	-1.724
Flexion of thoracic spine (cm)	3.7	1.2	32.4	4.0	0.9	22.5	-0.732
Left-side flexion of thoracolumbar spine (cm)	6.5	1.2	18.5	8.2	0.9	11.2	**-4.146**
Right-side flexion of thoracolumbar spine (cm)	6.5	1.3	20.0	8.0	1.2	15.0	***-3.191***
Left-side rotation of thoracolumbar spine (cm)	3.7	1.2	32.4	4.2	0.7	16.7	-1.315
Right-side rotation of thoracolumbar spine (cm)	3.4	1.4	41.2	4.0	0.8	20.0	-1.395
Flexion of lumbar spine (cm)	4.2	1.4	33.3	5.5	1.2	21.8	**-2.600**
Extension of lumbar spine (cm)	6.5	0.9	13.8	7.2	1.8	25.0	-1.272
Flexion of the whole spine (cm)	9.5	1.8	18.9	12.1	2.0	16.5	***-3.561***

Student's t-test (t) significant at the level of p<0.001 is presented in bold type, while at the level of p<0.01 it is in bold type and italics; at the level of p<0.05 it is presented in bold type and is underlined

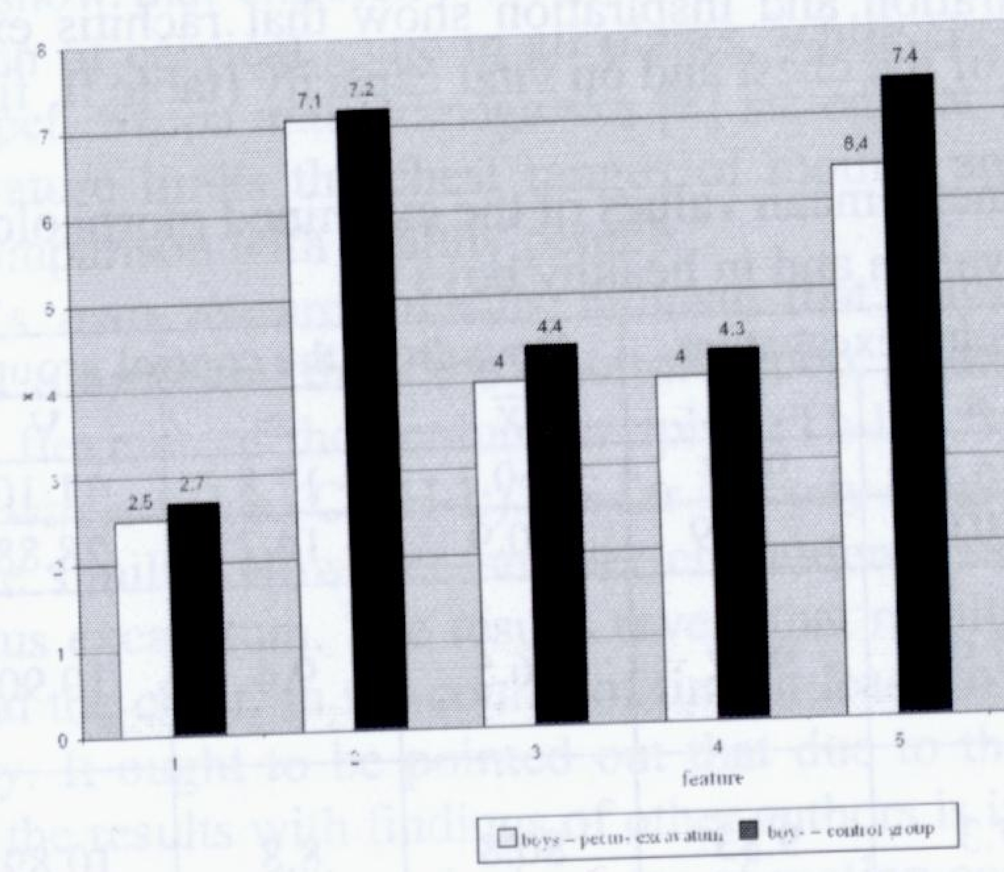

Fig. 1. Arithmetic means of the ranges of motion of cervical and thoracic spine in boys with pectus excavatum and healthy boys: 1 – flexion C, 2 – extension C, 3 – left-side flexion C, 4 – right-side flexion C, 5 – left-side rotation C, 6 – right-side rotation C, 7- flexion Th

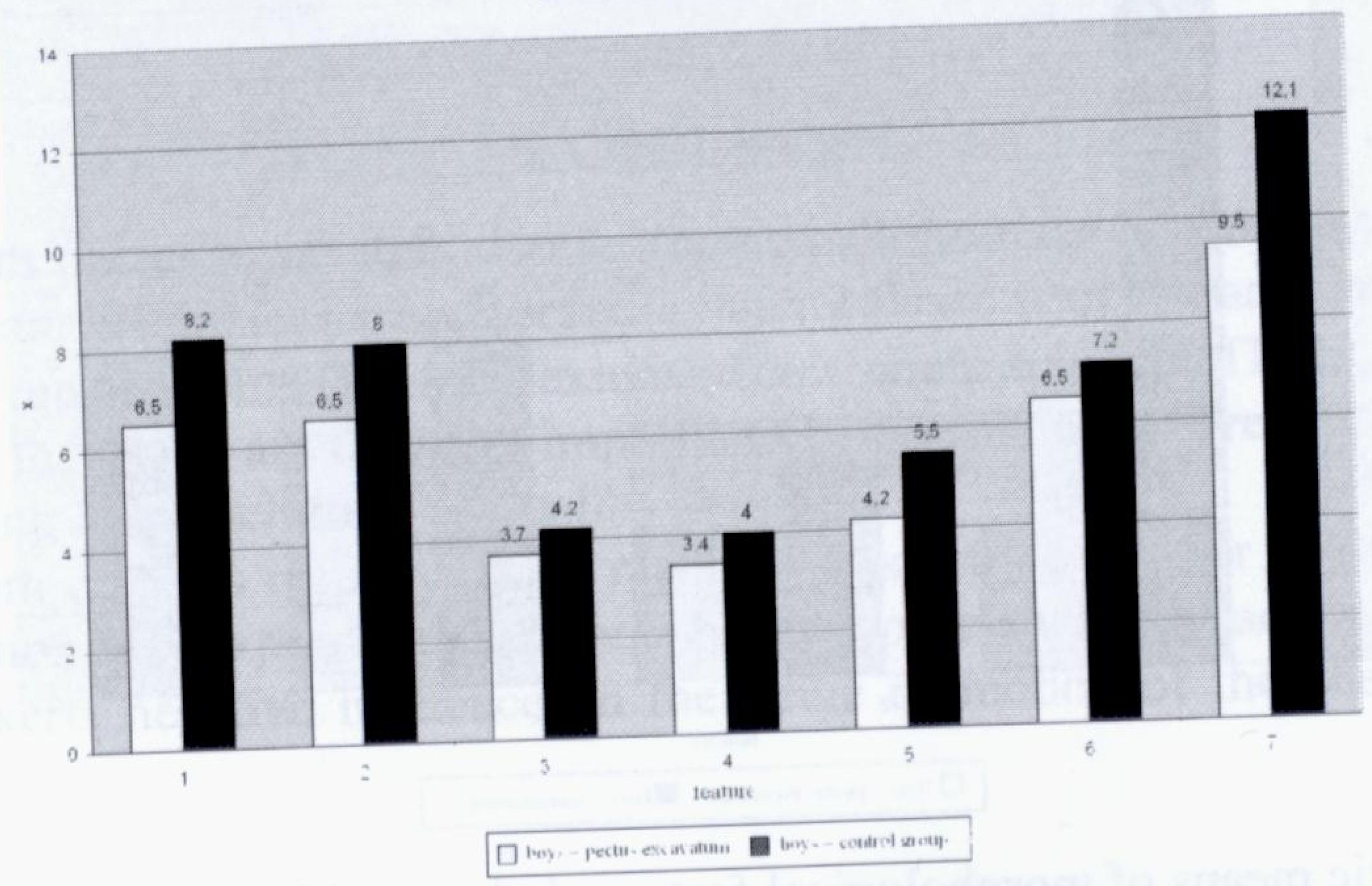

Fig. 2. Arithmetic means of the ranges of motion of thoracolumbar spine, lumbar spine and of the whole spine in boys with pectus excavatum and healthy boys: 1 – left-side flexion Th-L, 2 – right-side flexion Th-L, 3 – left-side rotation Th-L, 4 – right-side rotation Th-L, 5 – flexion L, 6 – extension L, 7 – flexion C-Th-L

Boys with pectus excavatum are smaller and lighter than their healthy peers; however, these differences are statistically insignificant. Body height of boys with pectus excavatum is approximately 157 cm, while in the case of healthy boys it is about 160 cm ($t = -0.571$, $p>0.05$). Body mass of boys with pectus excavatum is around 46 kg, while that of the healthy ones is about 51 kg ($t = -0.997$, $p>0.05$). Significant differences were noted in circumferences of the chest between both groups. Chest circumference during expiration and inspiration in boys with deformities resulting from rachitis is smaller than in the case of healthy boys, i.e. approximately 80 cm and 86.5 cm as well as around 74 cm and 81 cm respectively ($t = -2.053$, $p<0.05$ and $t = -2.109$, $p<0.01$). Research results indicate that body height and body mass are similar in the examined groups. Significant differences in chest circumference during expiration and inspiration show that rachitis exerts negative influence on the range of motion of the chest and on vital capacity (table II, fig. 3).

Table II. Characteristics of arithmetic mean values of the examined morphological features in boys with pectus excavatum and in healthy boys

Feature	Boys with pectus excavatum			Boys from the control group			Value t
	$\overline{X}$	s	V	$\overline{X}$	s	V	
Body height (cm)	156.7	14.7	9.38	160.3	17.8	11.10	-0.571
Body mass (kg)	46.1	10.0	21.69	50.9	14.7	28.88	-0.997
Chest circumference during inspiration (cm)	79.6	7.9	9.92	86.5	9.4	10.90	**<u>-2.053</u>**
Chest circumference during expiration (cm)	74.2	7.3	9.83	80.8	8.8	10.89	**<u>-2.109</u>**

Student's t-test (t) significant at the level of $p<0.05$ is presented in bold type and is underlined

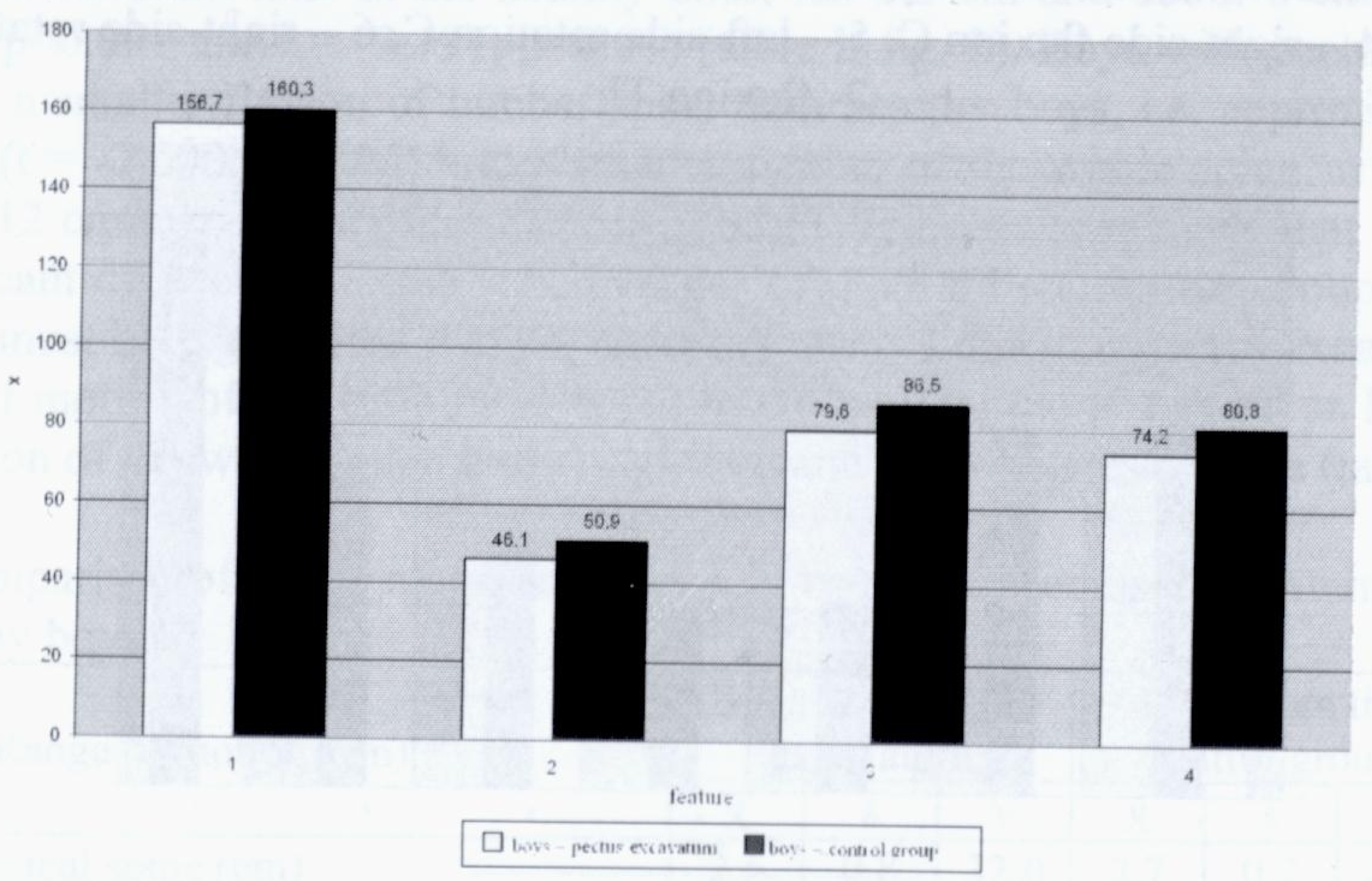

Fig. 3. Arithmetic means of morphological features in boys with pectus excavatum and healthy boys: 1 – body height, 2 – body mass, 3 – chest circumference during inspiration, 4 – chest circumference during expiration

5. Discussion

Body posture changes in ontogeny and depends on age, gender, genetic and socio-professional factors as well as on the lifestyle. Environmental pollution and improper nutrition negatively affect health status of children and often cause rachitis, which leads to spinal deformities and chest defects.

In scientific publications there is research into the influence of various sports on spinal ranges of motion. However, there are no studies concerning spinal ranges of motion in children with chest deformities [4, 7, 9]. Some authors studied the ranges of motion of the spine and the chest in children with chronic respiratory system disorders and scoliosis. Bieć et al. [1] show that children with chronic respiratory system disorders have limited ranges of motion of cervical spine in all planes, while chest and thoracic spine ranges of motion are proper. Szopa and Domagalska [8] stated that the progression of the angle of the spinal curvature limits the chest ranges of motion and leads to a decrease in body efficiency in comparison with healthy people.

The author's own research results indicate that boys with pectus excavatum have smaller ranges of motion than the control group. Statistically significant differences concern lateral flexions of thoracolumbar spine (Th-L), flexions of lumbar spine (L) and flexions of the whole spine (C-TH-L). As far as body height and body mass are concerned, both groups are similar. However, smaller circumferences of the chest were observed in boys with pectus excavatum. The results reveal that rachitis limits some ranges of motion of the spine and the chest. In the course of time it leads to a decrease in vital capacity and body efficiency. It ought to be pointed out that due to the lack of similar studies, direct comparison of the results with findings of other authors is impossible.

Linear measurements of the spinal ranges of motion confirm their usefulness for cross-sectional studies since they are neither time-consuming nor expensive. The author's own findings show that it is necessary to apply exercises aimed at stimulating the ranges of motion of the spine and the chest in children who suffered from rachitis in order to improve therapy.

6. Conclusions

1. Boys with pectus excavatum demonstrate smaller ranges of motion than the control group. Significant differences are observed in lateral flexions of thoracolumbar spine (TH-L), flexions of lumbar spine (L) and flexions of the whole spine (C-TH-L), which leads to the conclusion that these are the most important characteristics differentiating people with changes resulting from rachitis from healthy people.
2. Boys with changes resulting from rachitis demonstrate smaller chest circumference during inspiration and expiration than their healthy peers, which leads to the conclusion that rachitis exerts negative influence on the range of motion of the chest and on vital capacity.

7. References

1. Bieć E., Giemza Cz., Skolimowski T. Ruchomość kręgosłupa i klatki piersiowej u dzieci z przewlekłą niewydolnością układu oddechowego. Fizjoterapia, 2000; 8, 4: 7-10.
2. Brattberg G. The incidence of back pain and headache among Swedish schoolchildren. Q Life. Res. 1994; 3: 27.
3. Burton K. Low back pain in children and adolescence: to treat or not. Bull. Hosp. Jt Dis. 1996; 127.
4. Grabara M., Zając I. Gibkość kręgosłupa i ruchomość wybranych stawów kończyn u dzieci w wieku 8-13 lat. Wychowanie Fizyczne i Zdrowotne, 2003; 8-9: 19-21.
5. Lizis P. Ocena wytrzymałości siłowej mięśni posturalnych u chłopców ze skoliozą I stopnia i klatką piersiową szewską. Fizjoterapia, 2001; 9, 3: 20-25.
6. Ryłko A. Metody analizy statystycznej. Skrypt dla studentów Akademii Wychowania Fizycznego. Wydawnictwo Skryptowe, AWF, Kraków, 1989; 104.
7. Stasiak J., Nadolska-Ćwikła J. Wpływ pływania na zakres ruchów kręgosłupa w płaszczyźnie czołowej u dziewcząt. [In:] Ślężyński J. (ed.): Postawa ciała człowieka i metody jej oceny. AWF, Katowice, 1992; 131-133.
8. Szopa A., Domagalska M. Ruchomość klatki piersiowej a postawa ciała dzieci i młodzieży. [In:] Nowotny J. (ed.): Dysfunkcje kręgosłupa – diagnostyka i terapia. AWF, Katowice, 1993; 281-292.
9. Ślężyński J., Polechoński J. Ruchomość stawów kończyn i kręgosłupa polskich kulturystów. Wychowanie Fizyczne i Sport, 2000; 3: 61-69.
10. Veldhuizen A. G., Wever D. J., Webb P. J. The etiology of idiopatic scoliosis: biomechanical and neuromuscular factors. Eur. Spine J. 2000; 9: 178.
11. Walczak W. Zarys pediatrii. PZWL, Warszawa, 2004.
12. Wilczyński J. Korekcja wad postawy człowieka. Anthropos, Starachowice, 2001.