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True body length in patients with scoliosis

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Summary

Background: Norms for measurements effectuated, among others, in the field of physiotherapy, for example, Body Mass Index or Vital Capacity % are described with regard to height (body length) of examined patients. However, in scoliosis, normally measured body length is lowered, because of the fact that the trunk length is shortened as a result of lateral spinal curvature. Given these examples, we can say that using norms for lower height will result in mistaken recognition of obesity or not recognizing restrictive type of respiratory disorder. According to that, there is a need to correct height (body length) values in order not to relate the results of examinations to lowered or overstated norms. The aim of the study is presenting method of describing real height of patients with scoliosis.

Material and methods: 503 roentgenograms of patients with scoliosis were examined. Planimetric measurements method effectuated on roentgenograms with the help of curvometer was used in the studies.

Results: Obtained results show significant divergence of measurements results of spine length effectuated in a straight line and on a curve. They depend not only on curve angle size but also on a number of vertebrae creating curvature.

Conclusions:

1. Trunk length in people with scoliosis measured in a straight line is lowered, because it does not consider true spine length, in other words, arc length of a curvature.
2. Using planimetric method we can easily describe arc length and correct height dimension of a patient measured traditionally.

Key words: scoliosis, true body height, roentgenogram

BACKGROUND

Body length in scoliosis patients measured normally is lowered, because their trunk length is clearly shortened as a result of lateral spinal curvature. Norms for many measurements effectuated for, among others, physiotherapy, for example BMI (Body Mass Index) or VC% (Vital Capacity) are described with regard to height (body length) of examined people [1,2,3,4,5,6]. Given the above examples, we can say that using norms for lower height will result in mistaken recognition of obesity or not recognizing restrictive type of respiratory disorder.

According to that, there is a need to correct height (body length) values in order not to relate the results of examinations to lowered or overstated norms and not to take up any unnecessary treatment in order to correct false disorders or, on the contrary, to omit existing problems. In practice, it is often to effectuate linear measurements of trunk length and curve (arrow) depth and to describe the Cobb angle size, what anyway does not show the value of the trunk shortening. There were also attempts to describe trunk length indirectly from arm span [3,7,8,9], but this method is not precise and that is why it is not popular.

The aim of the study is presenting a method of describing real height of patients with lateral spinal curvature.

MATERIAL AND METHODS

We analysied 503 archive roentgenograms from patients with scoliosis (scale 1:1). There were 405 patients with a single curve and 98 patients with a double curve. The Cobb angle was typically described on these roentgenograms [10]. In the group of single curve patients the Cobb angle was ranging between 10 to 70° (x=19,61±12,71°) and in the group of a double curve the value of primary curvature was ranging between 12-70° (x=34,8±13,55°) and of secondary 10-45° (x=15,36±6,33°). In the analysied material there were 384 low degree curvatures of curve angle value ranging from 10° to 29° (x= 14,93±4,25). Angle values remaining 119 curves were ranging between 30° to 70° (x+43,61± 9,86).

Criteria including in the study: normal roentgenogram of scoliosis over 10°.

Chord length of every arc and length of arc were measured on the roentgenograms. Measurements were effectuated planimetrically with the help of curvometer exact to 5 milimeters. For double curve scoliosis, independently from each arc measurements, the spinal length in a straight line and the complete true spinal length were measured planimetrically – from the beginning of the upper curve to the end of the low one.

The results were at first described separately for single and double scoliosis and then for all the group in conjunction. In order to describe individual results of measurements a database was established in Excel 2007 and the further describing of results were effectuated using Statistica v. 8.0. In the statistical evaluation first of all we tried to answer the question how much the spinal length measured in a straight line differs from the true spinal length measured on a curve and on what do the obtained differences depend on.

According to blinding method, the measurements performed two independent persons and the results established in two separated databases.

RESULTS

In each case the difference between the arc length and its chord was noted, but individual results were diversified. The differences calculated from all the roentgenograms were ranging between 5 and 85 mm (x=13,55

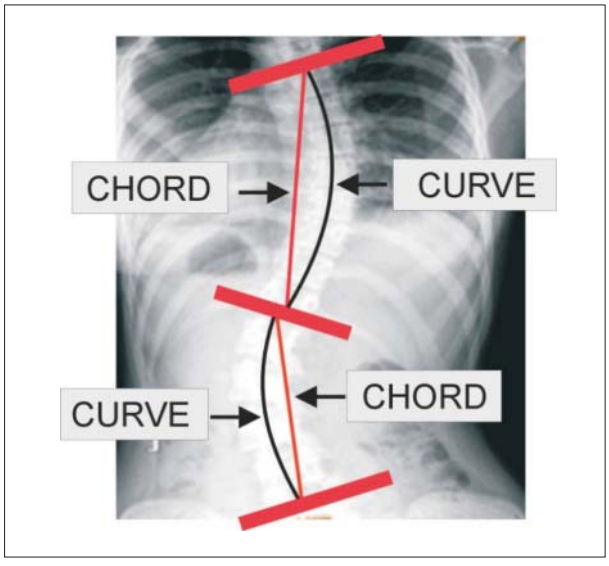

Fig. 1. Measurement method – in a straight line (red line), on a curve (black line)

Tab. 1. Mean values and standard deviations of considered parameters and statistical significance of differences between them (data concerning single arcs)

Parameter	Min-max	Mean	SD
Chord length of arc	80-320 mm	163,4	45,27
Arc length	100-325 mm	174,3	43,89
Statistical significance		**t = 19,70 p < 0,0001**	

Tab. 2. Mean values and standard deviations of considered parameters and statistical significance of the differences between them in double arc scoliosis

Parameter	Min-max	Mean	SD
Sum of chords lengths of both arcs	200-515mm	315,9	54,222
Sum of both arcs lengths	215-535mm	345,4	54,1
Statistical significance		**t = 20,75 p < 0,00001**	

±11,36 mm) and the difference between these parameters was statistically important (t= 26,70; p< 0, 00001). In practice we can say that in patients with scoliosis trunk length measured in a straight line (thus the complete body length) is significantly smaller than the true body length concerning arc length of a curvature.

Analysing double arc curvatures and comparing the complete spinal length measured in a straight line with the sum of both arcs lengths we obtained more visible differences. These differences were individually diversified, but in this group they were significant, because in many cases they had values of 85 mm (x=20,32±12,5).

It turned out that the presented above differences depend more on the curve angle size than on the length of its chord. Obtained correlation factors show that the difference between the arc length and its chord is significantly bigger, depending on how bigger is Cobb angle (simple dependance: r = 0,82; p<0, 0001). This difference is bigger when the arc is shorter, however it is less visible (negative correlation: r = - 0,23; p< 0, 0001). It also turned out that these differences depend on the number of vertebrae included in curvature (negative correlation: r = - 0,19; p<0,0001). In other words, in curvatures including a long segment of the spine the difference between measured and real trunk length is relatively small and in those curvatures including a short segment of the spine the difference is bigger.

Particular analysis of the obtained results showed that the differences noted in the group of low degree scoliosis (to 30^0) are relatively small (5 – 20 mm), whereas in scoliosis over 30^0 they are clear, especially in double arc scoliosis (10 – 85 mm).

Summarising, it can be said that the trunk length in scoliosis patients is smaller than it would be if the spine was straight, it is obvious. Nevertheless, this difference is big enough and statistically important to be considered in the situation, where it is necessary to know true height of patient. The noted differences depend mostly

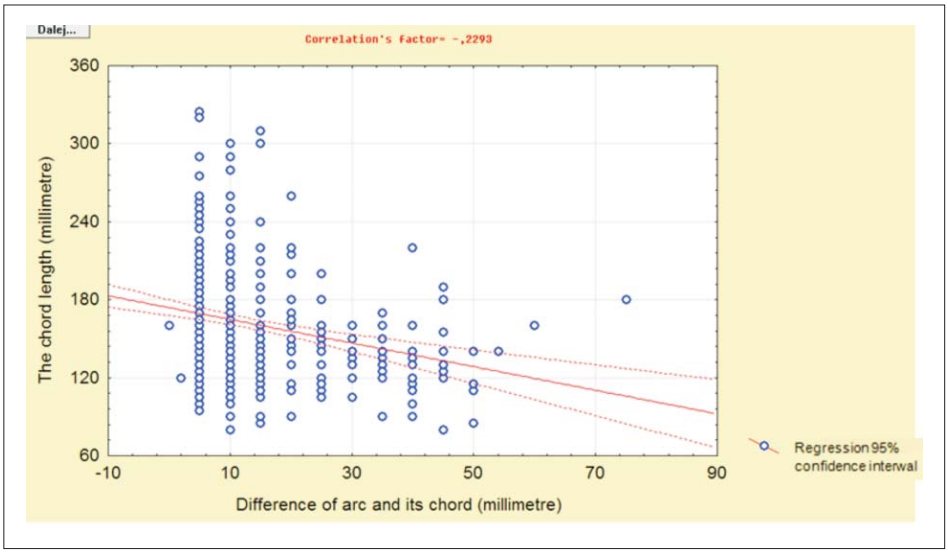

Fig. 2. Dependence between arc length difference and its chord and chord length

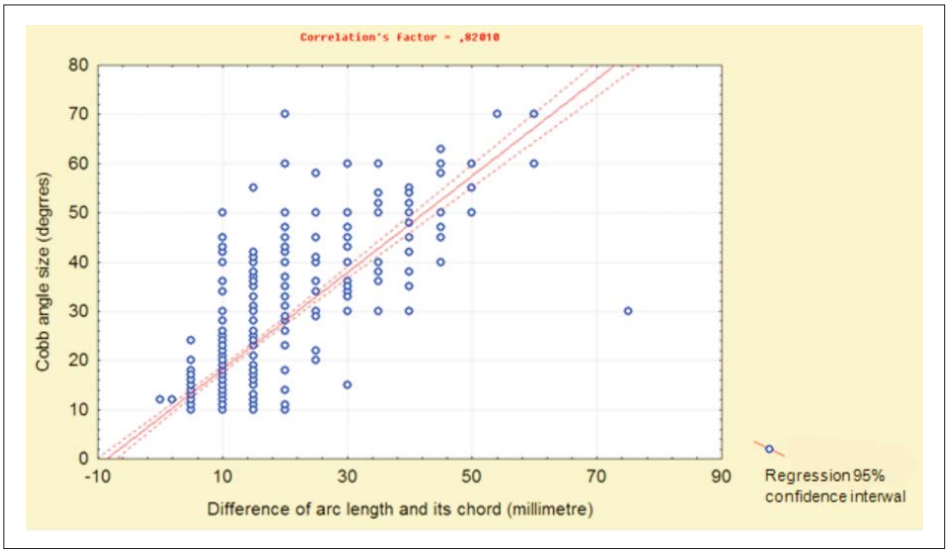

Fig. 3. Dependence between arc length and its chord and the Cobb angle size

on the curve angle size (simple dependence), and less (but also significantly) on the chord arc size and a number of vertebrae creating this arc (both correlations were negative).

DISCUSSION

It is obvious that in scoliosis trunk length is shortened, thus apparently the length of the body. Only a simple try of active correction of the curvature shows how much a patient with scoliosis would be taller if their spine was straight or a little straighter.

As the scoliosis develops in time possibilities of active correction of the curvature become smaller and in most cases completed correction is impossible. It results in a fact that measuring true body length is impossible. It is then necessary to find new methods of describing the height in scoliosis patients, because – as it was mentioned – standards for many examinations are described with reference to the body length of patients. In scoliosis, especially idiopathic scoliosis it is essential to describe a true dimension of so called pubertal growth spurt, what can be important for prognosis and the decision about further treatment [11].

Knowing the length of chord and size of curvature angle, at first we have tried calculated length of arc mathematically. Unfortunately, these trials gave us most differentiated and not credible results. Probably because it was that arc curvature does not part of the wheels which precludes mathematical calculations for its length. Because of that, we propose another, a simple method of describing the true spinal length. The difference calculated using this method, between the arc length of curvature and its chord length is the value of how many we should correct (enlarge) the body length measured using normal antropometric methods if proper height norms are needed. Using this method involves certainly a slight mistake connected with the spine rotation which is difficult to measure this way. But this mistake seems to have no importance at all.

The noted differences between true height and the height measured using normal methods are in contrary important. As example we can take spirometric examination in which height measurements are particularly

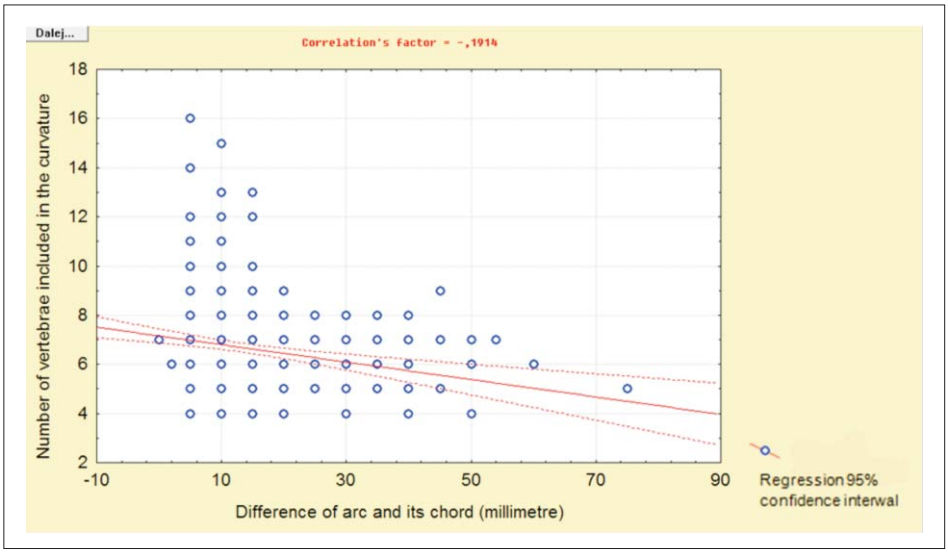

Fig. 4. Dependence between arc length difference and its chord and a number of vertebrae included in the curvature

Fig. 5. Roentgenogram of the patient with scoliosis (on the left) and their height measuring in free standing position (in the middle) and during the try of active correction of a curvature (on the right)

important for interpretation of the examination results. Formerly, to describe value VC% special tables were used with norms concerning age, sex and body length of patients. Spirometers of new generation norms, described for exemple by European Respiratory Society (ERS) or ECCS/ECSC and accepted by *Polish Society of Lungs Diseases,* have in their databases [12,13,14]. After telling the height, age and sex they automatically count VC% and FVC%. If in person with scoliosis the height is 9 cm lower, proportional values will be 30% bigger and may be admitted for normal despite evident restriction characteristics. The same problem is connected with BMI. Using the same example, the difference of calculated BMI is 3,0 – it can be important in patients who reach the limits of normal weight and overweight and overweight and obesity.

This aspect is often omitted by authors. First tries of height values correction are from 60s of 20th century when it was attempted to describe trunk length on a base of arm span [8]. However, this method was not very popular and as not precise in practice it is rather not used now. No other method was described to replace that one, what makes precise interpretation of spirometric examination difficult. In scoliosis, a precise method is particularly important because even with slight spinal curvatures there may be found some limits of lungs ventilation [7]. It is necessary to prevent development of these changes and then to effectuate a proper treatment but credible results of spirometric examination are essential. It seems that presented method fills the gap.

Given the fact that there are typical for scoliosis three-dimentional (3D) changes of the spine shape, the method presented above has probably a slight mistake. This mistake seems to be anyway not important, it does not influence the results of examinations.

CONCLUSIONS

1. In patients with scoliosis the trunk length measured in a straight line is lowered because it does not concern the true spine length, i. e. the arc length of the curvature.
2. Using the planimetric method we can easily describe arc length and correct height dimension of a patient measured with traditional method and thus to use proper norms VC and BMI.

Tab. 3. Dependence between arc length difference and its chord and the Cobb angle size considering curvature size

	N	Pearson's R	P
All of the examined persons	503	0,82	**< 0,001**
≤30 °	384	0,89	**< 0,001**
31° ≥	119	0,64	**< 0,0001**

Tab. 4. Dependence between arc length difference and its chord and chord length considering curvature size

	N	Pearson's R	P
All of the examined persons	503	**- 0,22**	**< 0,001**
≤30 °	384	- 0,18	> 0,001
31° ≥	119	- 0,21	< 0,02

Tab. 5. Dependence between arc length difference and its chord and relation between the Cobb angle size and the arc length considering curvature size

	N	Pearson's R	P
All of the examined persons	503	**0,71**	**< 0,001**
≤30 °	384	**0,79**	**< 0,001**
31° ≥	119	**0,48**	**< 0,0001**

Tab. 6. Dependence between arc length difference and its chord and a number of vertebrae creating curvature considering the curvature size

	N	Pearson's R	P
All of the examined persons	503	**-0,19**	**<0,0001**
≤30 °	384	**-0,15**	**<0,003**
31° ≥	119	**-0,24**	**<0,013**

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