# COMPUTERISED SYSTEM FOR EVALUATION OF ASYMMETRY OF POSTURAL PARAMETER COEFFICIENTS IN SCOLIOSES

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Abstract:     The work presents a clinical outline of stature defects and scoliosis as well as the contemporary methodology behind the thorax, spine and leg bone radiogram measurements. In order to increase the repeatability of the results and to create computer records which support monitoring records of scoliosis, an algorithm for the process of radiological image was developed. It automatises the time consuming process of measuring and processing data by the doctor. The image processing is initiated by an interactive procedure where key points of biological structures are marked with a cursor. Other measurements are done automatically. The algorithm is also an attempt to use the author's modification for measuring the geometry of the spine and thorax, which increases precision when compared to the methods by Cobb, Fergusson and Gruca. Results of radioplan-metric investigations compared with a system for analysing the trajectory of respiratory motion and the asymmetry weight distribution system in the foot have been presented. A mathematical analysis of thorax and bone radiogram geometry combined with the results of thorax trajectory movement enable the creation of individual patient symmetry indices with a description of the monitoring process of the disease.

## 1 INTRODUCTION

Side curvatures of the spine are a huge individual and social problem. The frequency in which this problem occurs is different in various populations and alternates between 3-15% of children and young people. During the last several years there has been a clearly increasing tendency in the number of people suffering from this disease. Scoliosis is a severe impediment of posture, which is accompanied by secondary alterations in the blood circulation and in the respiratory system. The alteration of the aforementioned systems leads to the limitation of the general efficiency of the patient. Finally it can cause early disabilities and can also shorten one's life.

Be advised that papers in a technically unsuitable form will be returned for retyping. After returned the manuscript must be appropriately modified. The three-dimensional body system in the standing position, which functions as a biomechanism with a wide range of freedom, protects against gravitation in the conditions of unstable equilibrium, and it should be considered in a dynamic sense. As a starting point it is necessary to consider the degree in which the body's physiology in terms of bones, joints and ligaments has been fulfilled. The correct build of the skeleton, passive stabilisation and proper movement in the range of individual elements, are essential. These elements create merely potential possibilities of taking on and maintaining the correct posture, however its image depends on the function and efficiency of the central nervous system. Currently it is claimed that assuming and sustaining the correct position is the same motion task as any other movement activity.

Producing and establishing a proper unconditioned co-ordination reflex requires even millions of conditions to be fulfilled; however the quality of created habits depends on conscious action and inborn predispositions. Gradually worked out, more simple movement abilities create a base for the following predispositions, which are built-in into more complex movement patterns. An established system of individual segments of the body, as well as balance do not form a static condition, but one that oscillates around the balance point, with a tendency to optimisation. Secondary disturbance of posture control is caused by a slightly different mechanism. It is probable that as a result of disturbance of brain functions, deviation of posture from the pattern recognised as a correct can occur. It should be noticed that while comparing the results of the application of advanced technology with a system of a few relatively connected simple methods supplemented by computer techniques, a significantly higher acuteness and peculiarity, than in the case of expensive novelties is achieved. Taking into account the unfavourable financial realities of Polish science there is a growing interest concerning the low-outlay adaptations of more simple methods. A system of mathematical correlation between different methods, which describe a chosen phenomenon, uncovers a new multidimensional space of description, characterised by a higher level of specificity.

One of the methods used in many centres as a parameter, which monitors the development of scoliosis, is the spirometer experiment. Unfortunately, from the bioengineering point of view it can be noticed that the two lung spaces coupled by an angle of scoliosis are the source of an averaged volumetric parameter and can be described as a compensatory structure. The increase in the value of the angle of scoliosis leads to a decrease of volumetric space on the chord site and a proportional increase of volume on the curve site. Proportions are preserved best with a slight scoliosis, which does not exceed 15-18$^0$. In such a situation equilibrium is established. The pressure of the lung is compensated by the emphysema of the second lung. During the increase in the angle of scoliosis the summative volumetric parameter decreases. Therefore, cases where a spirometric parameter represents an angle of scoliosis the case is usually so advanced that it should be treated surgically. The non-invasive character of simple postural-metric methods and precision of planimetric radiography are connected by a method, which consists of a multi-segmental system for evaluating the trajectory of thorax movement. A system of tapes and transducers braiding the thorax enables the estimation of movement in all of its areas. Based on the knowledge of motion biomechanics' index values which are dependant on the scoliosis angle, rib movement and activity of respiration muscles, a quantified body symmetry image can be obtained. Clinical cases linked with the occurrence of certain movement asymmetries can be induced through various illness mechanisms such as limb shortening, shoulder syndrome and the like. The application of an integrated system, which evaluates the basic parameters of geometry of the thorax by the planimetric method and repeated bio-engineering (Dyszkiewicz at all 1999) and spirometry provide effective and credible supervision in every stage of the disease. The image is made at the beginning of research. An analysis of the images of a patient's body carried out by means of a neural net implemented into the computer provides geometry (mainly symmetry) indicators of selected parameters. Based on these parameters the parameters of a three-dimensional trajectory of the respiratory system are compared. Monitoring the capacity of expiration in scoliosis is of a particular diagnostic importance when the parameter values fail to increase proportionally to age. This happens when a limiting value of scoliosis is achieved which is qualified to surgical treatment.

## 2 THE AIM OF THE STUDY

The aim of this compilation is to find a practical application of contemporary measurement methods of the side curvature of the spine to construct a practical algorithm and easy to use multipart software. The following questions were posed:

1. Does using methods (LAF, PAF, FAF, CA, FA, GA, LCC) make it possible to differentiate between the parameters of healthy and scoliotic people ?
2. Are the new, planimetric coefficients LAF, PAF, FAF (in scoliosis) well correlated with the traditional, measurement systems CA, FA, GA (Cobb, Fergusson, Gruca) ?
3. Are the planimetric coefficients LAF, PAF, FAF, CA, FA, GA (in scoliosis) better correlated with the traditional, spirometry test LCC or breath asymmetry analysing system (produces breath asymmetry factor BAF) ?

## 2.1 Group of Patients

Patients suffering from thorax and spine trauma, hypertension, collagen and asthmatic disease, diabetes, taking vascular medication, having frostbites and after injury to upper extremity were excluded from the study. The examinations were carried out in the following group of patients: (1) <u>Examined group (A)</u> - consisted of 16 women, average age 32,9±4,6 years and 9 men aged 34,7±6,3 years, with right-thorax scoliosis. (2) <u>Control group (B)</u> - consisted of patients with normal spine (treated in hospital for gastric illness), 15 women and 9 men, average age 35,7±5,8 years

## 2.2 Methods

In the first part the measurement algorithm conducts geometrical measurements according to Cobb's and Ferguson's recommendation. In the second part the author's own modification of the process is used. It is based on measuring the torsion and angle of scoliosis on the level of every vertebra with results projected on two vertical charts placed on both sides of the radiogram (Dyszkiewicz at all. 2001) The proposed method enables a partial observation of scoliosis on the background of averaging parameters. The analyser of the radiograms works with a spirometer and a device to evaluate the trajectory of the respiratory system in the thorax. The obtained multi-parameter of patients after long-term observations significantly helps to achieve a more accurate evaluation of the progression or regression of a disease (fig. 2, 3).
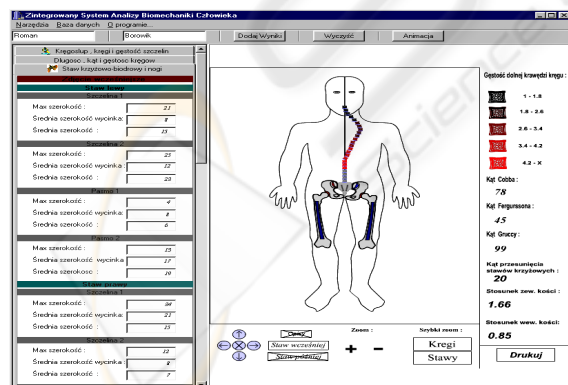


Figure 1: Expert program automatically detecting bone modification in scoliosis: (1) vertebrae torsion angle modo Gruca, Cobb, Fergusson, (2) cuneiform vertebrae deformations, (3) geometry and bone density distribution, (4) hip geometry, (5) sacro-iliac joint geometry.

The researchers used a prototypical diagnostic device, consisting of 4 elastic tapes embracing the chest, connected with converters of the path and an analogue-digital converter enabling the transmission of data through a parallel port to the "respiratory path" software which made it possible to monitor the oscillatory motion of the right and left lungs.

## 2.3 Results

Results of investigations (asymmetry coefficients CA, FA, GA, LAF, BAF, PAF, FAF, LCC) included in tab. 1. Patients described by asymmetry coefficients CA, FA, GA, LAF, BAF, PAF, FAF, LCC) show completely different values in group of sick patients (A) and in control group (B). While analysing table 1 we can clearly notice that in scoliosis the level of asymmetry of newly inserted coefficients LAF, BAF, PAF and FAF is comparative with coefficients based on Cobb's, Fergusson's, and Gruca's methods and clearly higher than the coefficient based on the LCC breath volume of lungs. Moreover, it can be observed that LCC in group (A) is much different from the value in the group of healthy people (B).
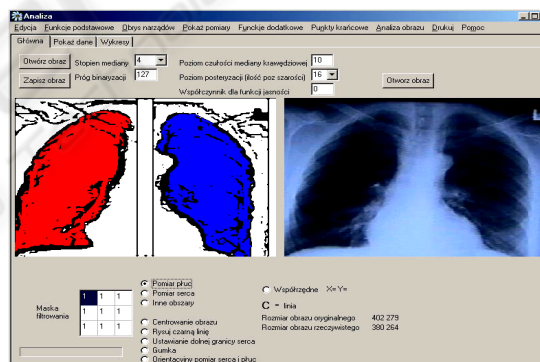


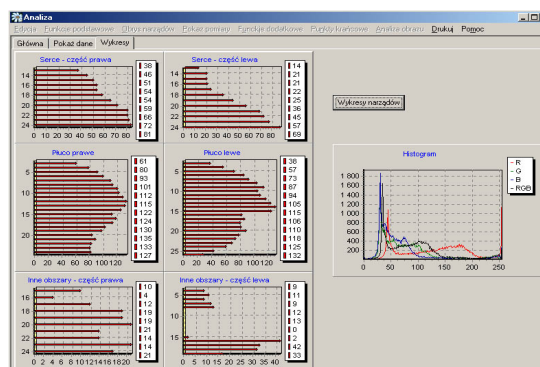Figure 2: Asymmetry area of lungs measurement.



Figure 3: Graphs of ungs area.

Table 1: Asymmetry coefficients.

| | Cobb angle CA | Fergusson angle FA | Gruca Angle GA | lung asymmetry factor LAF | breath asymmetry factor BAF | pelvic asymmetry factor PAF | foot asymmety factor FAF | lungs capacity coefficient LCC |
|---|---|---|---|---|---|---|---|---|
| Group A (n=25) | 0,684 ± 0,175 | 0,616 ± 0,168 | 0,651 ± 0,181 | 0,752 ± 0,121 | 0,711 ± 0,176 | 0,764 ± 0,193 | 0,694 ± 0,185 | 0,876 ± 0,214 |
| Grop B (n=24) | 0,973 ± 0,181 | 0,955 ± 0, 114 | 0,949 ± 0,136 | 0,813 ± 0,164 | 0,922 ± 0,178 | 0,875 ± 0,187 | 0,935 ± 0,135 | 0,821 ± 0,189 |
| CA (A - B) | | P < 0,01 | GA (A - B) | | P < o,o1 | BAF (A - B) | | P < 0,01 |
| FA (A - B) | | P < 0,01 | LAF (A - B) | | P < 0,05 | PAF (A – B) | | P < 0,05 |
| FAF (A – B) | | P < 0,01 | LCC (A – B) | | P < 0,5 | | | |

Table 2: Correlation table of Fergusson angle with Cobb angle, Gruca angle and FAF, BAF, PAF, LAF, LCC in decreasing relation.

| | FA/CA | FA/GA | FA/FAF | FA/BAF | FA/PAF | FA/LAF | FA/LCC |
|---|---|---|---|---|---|---|---|
| Gr. A (n=20) | 0,93 | 0,915 | 0,89 | 0,81 | 0,76 | 0,72 | 0,41 |

## 3 CONCLUSIONS

1. The methods $_{(LAF, PAF, FAF, CA, FA, GA, LCC)}$ used in this investigation make it possible to clearly differentiate between the parameters of healthy and scoliotic people
2. New, planimetric coefficients LAF., PAF, FAF (in scoliosis) have good correlations with traditional measurement systems CA, FA, GA $_{(Cobb, Fergusson, Gruca)(tab. 2)}$.
3. The planimetric coefficients LAF, PAF, FAF, CA, FA, GA (in scoliosis) have better correlations with breath asymmetry analysing factor BAF in comparison with traditional, spirometry test LCC $_{(tab. 2)}$.

## 4 DISCUSSION

The contemporary diagnosis and monitoring of the evolution of scoliosis in cheap screening evaluation is based on a physical test assisted with plumb-line, measure tape and a goniometer. Tests of averaged spirometric parameters, which have been administered for many years, have pointed to a phenomenon where the loss of capacity of one lung, which is the result of hypopnoe, is counteracted by hyperpnoea of the other lung often leading to tests producing normal values. It is often only after the angle of curvature passes the 30' mark that evident pathology is registered. Displaying a child on an x-ray, with the aim to determine a single angle of curvature seems very controversial. The main aim of this work was to expand the range of methods used for defining patients with scoliosis by adding to the already known methods CA, FA and GA – the new planimetric coefficients of the chest LAF, pelvis PAF, load decay of the foot test FAF and breathing track BAF. These tests were carried out on a small group of patients and have to be treated tentatively; nevertheless it is possible to notice a significant difference in the results between sick group (A) and control group (B). The correlation between CA, FA, GA / LAF, PAF and CA, FA, GA / FAF, BAF was also very good and clearly higher from the correlation with the traditional spirometric test which produced a result of only 0.41.The study results distinctly recommend inserting some extra LAF and PAF determinants to estimate standard radiological photos and to expand their range by a simple FAF podoscopic test and breath asymmetry analyses system estimating BAF. It can be clearly seen that an assessment of the breath asymmetry truck of the chest reveals more sensitivity than a traditional evaluation of the breath-volume.

## REFERENCES

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