

# **Does the gait pathology in scoliotic patients depend on the severity of spine deformity? Preliminary results**

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The gait pattern in scoliotic patients differed from the gait pattern of the healthy subjects. The aim of the present paper was to describe the dependence of the gait pathology on the severity of the spinal deformity. Thirty five patients with confirmed scoliosis participated in the study. All patients underwent the clinical examination (X-ray and anthropometric measurements) as well as the objective gait analysis. Based on clinical examination the patients were divided into subgroups according to six different criteria. The gait parameters were compared between these subgroups.

Most of the assessed variables do not depend on the clinical variables, describing the severity of the spinal deformity. The two gait parameters which depend on the clinical variables are pelvic obliquity and step length. The results show that the obliquity increases with the Cobb angle. The step length decreases with the increasing Cobb angle and with the sum of angles describing the spinal deformity in sagittal and frontal planes.

The evaluation of the gait pattern of scoliotic patients and the establishment of its dependence on the spinal deformity are of importance for the treatment of these subjects.

*Key words: gait pathology, scoliosis, spinal deformity*

## **1. Introduction**

Scoliosis is the most common orthopaedic problem among children and adolescents, with the frequency of occurrence between 1 and 4% [1]. Moreover, it is estimated that in over 60% of scoliotic patients the spinal deformity progresses with time [1].

Although scoliosis is the structural deformity of the spine it influences also the gait pattern. The data about the gait pathology in scoliotic patients is scarce and rather contradictory. CHEN and co-workers [2] found that although the scoliotic patients exhibit rather poor postural stability their gait pattern do not

differ from that of the normal healthy subjects. In another study, the only discrepancy in the gait pattern between scoliotic patients and healthy subjects was asymmetrical trunk movement in the transversal plane [3]. In one study, the researchers found that the scoliotic patients walked with normal speed and cadence, but with the step length reduced by 10% via increased range of pelvic motion transversal plane [4], while in another one the decreased cadence, decreased pelvic motion in transversal plane with normal step length were revealed [5].

One of the most comprehensive studies on the scoliotic gait was performed by MAHAUDENS and co-workers [6]. Its results show the marked reduction of

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the range of motion of the knee in sagittal plane, hip motion in frontal and transversal planes, and the diminished step length. Although the sample of patients was relatively large (41 patients) and could be divided into three subgroups according to the severity of the deformation, no dependence of the kinematic parameter on the severity of the deformation was found.

Our previous study [7] on the gait pathology in scoliotic patients was performed on strictly selected subjects, thus forming the homogeneous group. We found that the gait pattern in scoliotic patients differed from the gait pattern of the healthy subjects. The gait pathology in scoliotic patients was characterized by: decreased step length, decreased pelvic tilt, pelvic obliquity, increased pelvic range of motion in transversal plane, retracted pelvis in respect of the line of progression, diminished range of motion in hips in the sagittal plane, internal hip rotation at initial contact, increased knee flexion at initial contact, decreased range of knee motion, dorsiflexion of the feet in the swing phase, and internal rotation of the feet with respect to shank. Depending on the parameter, the changes were observed in 30 to 90% of the scoliotic patients. The question which arised from this study was the dependence of the gait pathology on the severity of the spinal deformation. This paper deals with the answer to this question.

## 2. Method

### 2.1. Patients

35 girls with scoliosis participated in the study. They were aged between 12 and 17 and selected from the patients treated in The Children's Memorial Health Institute (CMHI) in years 2008 and 2009. The inclusion criteria were as follows:

- patients were not previously treated neither surgically nor conservatively due to scoliosis;
- gait analysis was performed during the first visit at CMHI (i.e. before the start of the treatment);
- only patients with idiopathic scoliosis participated in the study;
- the spinal deformity was present both at thoracic and lumbar regions;
- the Cobb angle was equal or greater that 20 degrees;
- apart from deformities in sagittal and frontal planes also pathological rotation in transversal plane was observed.

The exclusion criteria were: any accompanying disease which could influence the gait pattern (cardio-pulmonary, diabetes, asthma, etc.), or fracture of the legs in the past.

The study was approved by the local ethical committee and the informed consent was obtained from patients and parents prior to the study.

### 2.2. Gait analysis

All patients underwent the objective gait analysis with VICON 460 system (ViconPeak). The Helen Hayes marker set with Plug-In-Gait model was used. Patients during data collection sessions were walking with self-selected, preferred speed. Six dynamic (gait) trials were collected in each session, using the Workstation (ViconPeak) software. Later the data was processed using Polygon (ViconPeak) software. The results from each session were averaged and presented with respect to gait cycle. Data for further analysis was extracted from the averaged data. Based on the previous study [7] the following data was analysed: pelvic tilt, pelvic obliquity, range of pelvic motion in the transversal plane, range of knee motion, dorsiflexion of the foot in the swing phase, and step length. As the patients were of different age and body stature the step length was expressed as the percent of the age and sex reference value.

### 2.3. Clinical assessment

All patients underwent the X-ray examination (AP-projection, in frontal plane). From the X-ray the deformity angles were measured according to Cobb's methodology. Also the degree of rotation was measured from X-rays according to Pedriolli's methodology [8].

The pelvic deformity was assessed based on anthropometric measurements: the distance between base and anterior and posterior, left and right iliac spines [9], [10].

Based on the above clinical assessment the six clinical variables were designed:

- the first described the severity of the spinal deformity in sagittal and frontal planes;
- the second described the degree of spinal rotation in transversal planes;
- the third was the sum of the thoracic and lumbar scoliotic angles;
- the fourth was the sum of the Cobb angle and rotation angle;

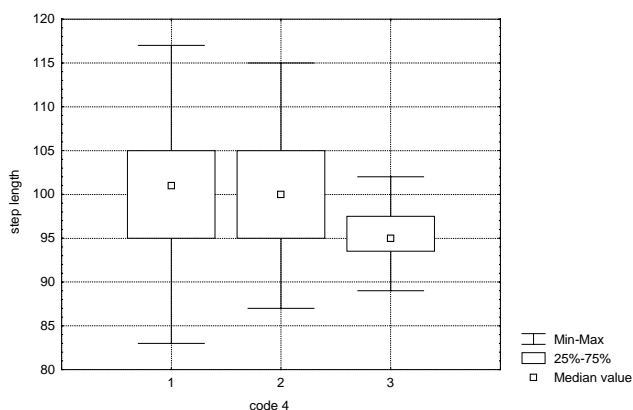
- the fifth was the type of pelvis, describing the orientation of the iliac bones with respect to each other (rotated, obliqued, normal, or mixed);
- the sixth was the type of deformity: higher in thoracic region, higher in lumbar region or equal in both.

## 2.4. Statistical analysis

The distribution of the numerical variables was checked using the Kolmogorov–Smirnov and Shapiro–Wilk’s tests. The dependence of the gait variables on the clinical categorical variables was assessed using analysis of variance or ANOVA Kruskal–Wallis (in the case of non-normally distributed variables, or variables with non-homogeneous variance). The dependence of the gait variables on the numerical clinical variables was assessed using the Spearman rank correlation test. The statistical significance was at the level of 0.05. All calculations were done using the Statistica (StatSoft) software.

## 3. Results

The statistical analysis revealed that pelvic tilt, pelvic rotation, knee range of motion, or foot dorsiflexion in swing did not depend on any clinical variable. The pelvic obliquity depends on the fourth clinical variable (the sum of the Cobb and rotation angles:  $F = 3.352$ ,  $p = 0.048$ ) and is correlated with the Cobb angle ( $R = 0.352$ ,  $p = 0.049$ ). Step length depends on the degree of the spinal rotation ( $F = 3.520$ ,  $p = 0.032$ ) and is correlated with the Cobb angle ( $R = -0.387$ ,  $p = 0.002$ ) and sum of the angles describing the spinal deformity in sagittal and frontal planes ( $R = -0.304$ ,  $p = 0.018$ , the figure).



Dependence of the step length on the sum of the angles representing the spinal deformity in sagittal and frontal planes

## 4. Discussion

The contradictory results found in the literature about the gait pattern of the scoliotic patients are obtained due to several reasons. Some studies are performed on the low number of patients. In others, the patients examined are within a wide age range and represent different types of deformity. All these factors could influence the gait pattern. Therefore it is difficult to compare the results of our study with those found in the literature.

The number of gait parameters selected for this study were limited. Based on our previous study [7] the authors selected only these parameters which differed from the reference normal data in more than 50% of patients, thus could be characteristic of the gait pattern of scoliotic patients. These parameters could be regarded as a good representation of the scoliotic pathological gait, as they exhibit high inter-trial and test–retest reliability [11]. Most of these variables do not depend on the clinical variables, describing the amount of the spinal deformity.

The two gait parameters which depend on the clinical variables are pelvic obliquity and step length. The results show that the obliquity increases with the Cobb angle, thus suggesting that the orientation of the pelvis in scoliotic patients depends on the severity of the spinal deformity. The step length decreases with the increasing Cobb angle and with the sum of angles representing the spinal deformity in sagittal and frontal planes.

These results show that although spinal deformity occurs in the trunk, i.e. the upper part of the body, it influences the motion pattern of the legs and the orientation of the pelvis, i.e. the lower body. Moreover, some gait abnormalities depend on the severity of the spinal deformity. This means that the progression of the scoliosis with time (which is characteristic of the majority of patients [1]) leads to the progression of the gait pathology.

The patients examined in the study all were diagnosed with idiopathic scoliosis, i.e. any neurological problem was excluded. Therefore, the gait deviations could be attributed only to the spinal deformations. Thus, the results obtained show that the structure and function, to some extent, depend on each other.

Some of the gait parameters evaluated in the present study, although different from those in healthy subjects, do not depend on the severity of the spinal deformity. This is in agreement with other studies. SCHIZAS and co-workers [12] analysed the symmetry of the ground reaction force parameters in scoliotic

patients during walking. They found that the majority of patients exhibited marked asymmetry of these parameters, but no dependence on the spinal curve direction, magnitude or rotation was found.

Contrary to our findings, MAHAUDENS and co-workers [6] did not find any dependence of the abnormal gait kinematic parameters on the severity of the deformation. The age range and the type of scoliosis are similar in both studies. But as in our study we asked the subjects to walk with their normal, self-selected speed, Mahaudens et al. forced their patients to walk with constant speed of 4 km/h. For some of their subjects this speed could be equal or close to their comfortable speed, but for others was too slow or fast. Patients had to concentrate on keeping the desired speed, thus their walking pattern could be slightly artificial and did not represent their every day type of gait.

The evaluation of the gait pattern of scoliotic patients and the establishment of its dependence on the spinal deformity are of importance for the treatment of these subjects. In one of the studies [13], it was found that the energy cost and the oxygen intake during walking were increased by approximately 30% in comparison with healthy subjects. This finding proves that although the gait changes in the scoliotic patients are small, their overall effect on the cost effectiveness is high. The increased energy consumption during gait in scoliotic patients does not depend solely on the abnormal gait pattern, but in more severe deformations depends also on the decreased lung capacity and decreased pulmonary efficiency [14], [15]. This last factor is well recognized and it was proven that the introduction of special rehabilitation protocol could improve the pulmonary function in scoliotic patients [15]. The gait pathology characteristic of all scoliotic patients should also be addressed as it influences the overall functional efficacy of these patients.

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