

# Gait pattern and spinal movement in walking - A therapeutic approach in juvenile scoliosis

H. Fleiss\*\*, O. Fleiss\*\*, P. Holzer\*\*, G. Ritter\*\*\*, V. P. Stokes\*  
*University of Graz\*\* , Medical University of Graz\*\*\*, Austria,  
Uppsala University, Sweden\**

## **Abstract**

*Background:* In many cases of juvenile scoliosis there is - besides of the spinal curvature and the rotation of the spine - a deficiency in body awareness and physical fitness. Avoiding sports activities leads to muscular weakness and sometimes to bad posture. In addition some motor activities, as walking and running can enhance scoliotic curvatures as in moving the amplitude of pelvis tilt or sideways movement of the spine is larger than in standing or sitting.

Therefore therapy includes at least three goals: First to work on the overall physical fitness, especially in training trunc muscles to achieve the ability to hold a corrected posture. The next step is to correct scoliotic curvature and to derotation scoliotic rotation by specific exercises. Then it is necessary to define those movement patterns - in first case walking and running - that enhance the scoliotic curvature and train the subject to learn a movement pattern that works against the scoliotic curve in a way like a therapy. In this case study the walking pattern is modified to have an effect like a therapeutic exercise.

*Methods:* A young girl with juvenile scoliosis undergoes an intensive training program including strength and mobilizing exercises and changes in her walking pattern.

Videos are taken before, while and after the training program, documenting posture, mobility and motor patterns as walking and therapeutic exercises.

*Programs:* SMA for analyzing pelvis and lumbar spine data, SAS for evaluation of posture, spine function and walking; *Wirbel-med* for therapeutic programs.

*Result:* The therapeutic goal to achieve a better posture, to strengthen trunc muscles, mobilize scoliotic curvatures and to achieve a symmetric gait pattern by changing the coordination pattern could be realized.

*Key words:* Juvenile scoliosis, gait pattern, spinal movement.

## 1. Introduction

A case study of a girl with juvenile scoliosis shows, that within three months of intensive exercises a change in posture and gait pattern can be achieved.

A girl, 13:5 years of age, with a scoliosis of 35°/40° (Cobb) and rotation of the spine, was examined clinically and by video documentation. She was treated with an individual training program and trained to change her walking pattern as to avoid enhancing the scoliotic curvature of her spine when walking or running.

After three months the girl was reexamined, clinically and by video documentation. The results show a change in posture as well as in gait: The gait pattern had changed from enhancing the scoliotic curvature of her spine to a pattern, that reduces the scoliotic curvature. The pelvis movement had become more symmetrical, thus avoiding the extreme tilt to the scoliotic side. The lumbar spine movement had changed from swinging into the scoliotic curve on every step (right and left) to a softer curve closer to the vertical.

In spite of the „underlying“ scoliotic deviation of the spine, the more upright body posture and the ability to control the movement of the spine while walking can give an optimistic approach in the treatment of juvenile scoliosis.

## 2. Method

Girl, 13:5 years of age, thoracic scoliosis 35°, rot +; lumbar spine 40° rot ++, no leg length difference, very good compliance and willing to do the exercise program regularly. Training session: 3 months. Control examination 3 months after first examination.

### First examination

- Clinical orthopaedic examination.
- Video documentation (Video-screening - routine of the Graz Gait- and Back School) including panorama view, standing, bending, walking barefoot, with shoes and with shoes + inlays (1 cm left shoe), coordination (running, balance and jumping).
- Motor testing - strength, flexion of the spine.
- Discussing the video together with the girl and her mother.
- Selection of exercises for an individual training program.
- Practice under control.
- Gait training.

In Training sessions the girl is told to do her individual training program 6 times a week for about 45 minutes and to practise the instructed gait pattern several times a day.

### Control examination

After three months the clinical examination and the video-screening as in the first examination are repeated, the exercise program practised by the girl is documented.

### 3. Before training

#### Video documentation

Take 1: Panorama View: The girl in standing position on a plate slowly turning round.  
Take 2: The girl standing in the middle of the walk track, first in standing position, then bending forward and bending to both sides, after that she starts walking barefoot, then wearing shoes and wearing shoes + inlays.



Fig. 1. Panorama view, standing.



Fig. 2: Video documentation: Standing, bending, walking barefoot.

## Selection of Scoliosis Exercises

**Flexibility training**

- lateral flexibility
- rotatory flexibility



**Strength training**

- push ups
- sit ups
- back muscles



**Stretching**

- back muscles



Fig.3: Training program.

## Practising under supervision

- All exercises are practised with the girl, right and left side, some of them done differently. All exercises are documented by pictures and given to the girl as a training guide.



Fig.4: Strengthening the back muscles in X-large position.

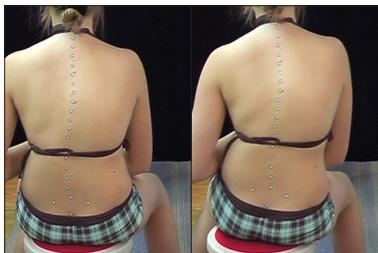


Fig.5: Lateral flexion of the lumbar spine.



Fig.6: Rotatory flexion of the spine.

## Gait training

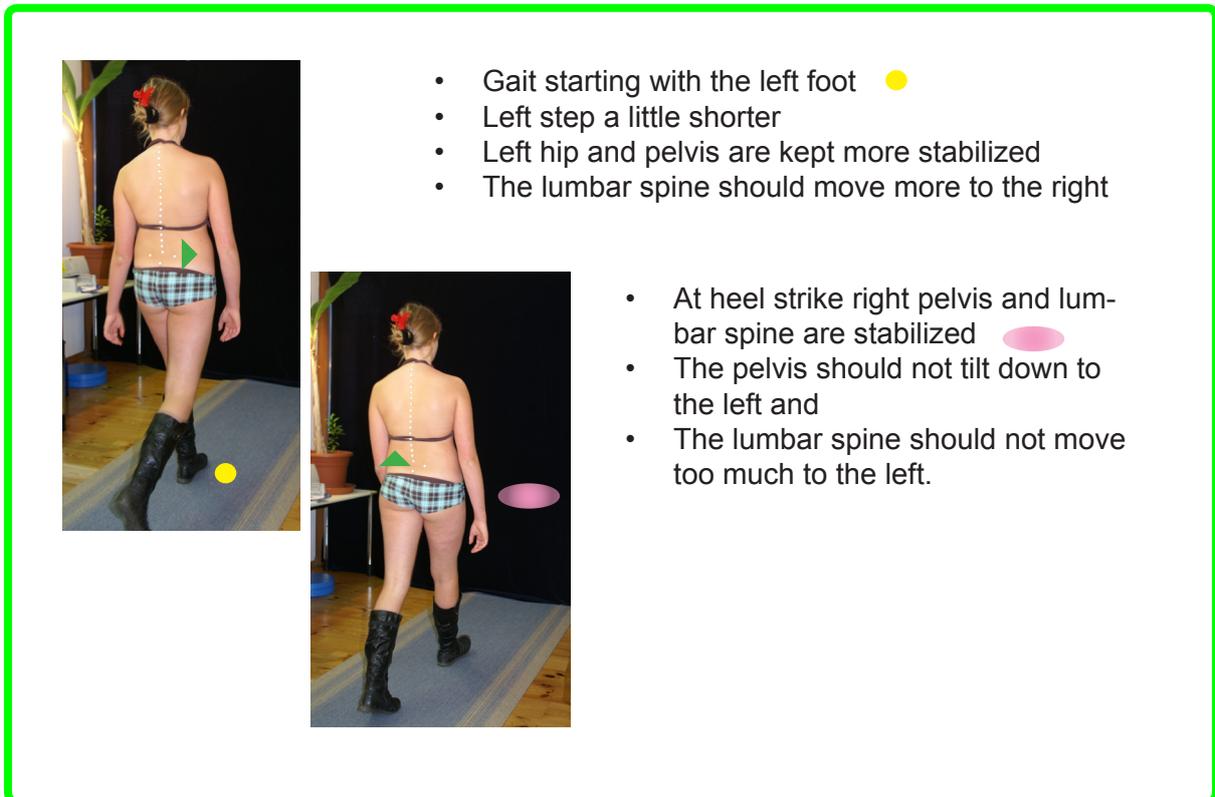


Fig.7: Gait training.

## 4. Results after training

### Selfconfidence and posture

At the end of a training period of 3 months the girl presented herself very selfconfident and with a remarkably changed back. The strong scoliotic curvature had changed to a smooth curve and the deviation of the low back curve to the left had disappeared at all.

This does not mean that the scoliosis had disappeared, but the girl had succeeded in straightening her upper body.

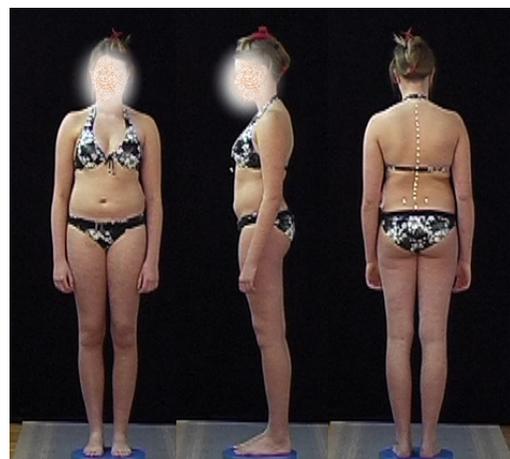


Fig.8: Standing postures.

### Work out

This improvement was primarily owed to an intensive workout the girl performed 6 times a week for about 45 minutes each. Video documentation of her workout showed that the girl had improved in her muscle strength and in mobilizing and correcting her scoliosis. She had gained a better body awareness and could precisely do her asymmetric strength and mobilizing exercises.

This can be seen for example in mobilizing exercises - combined with breathing (into the left chest) - with effect on correcting the scoliotic curvature to the right and to derotate scoliotic rotation.

The ability to precisely perform asymmetric exercises was especially necessary for gait training as the girl had to change from step to

step from free swinging of the lumbar spine to the right (at step left) and to stabilize her low back at step right to prevent pelvis and lumbar spine to swing into the scoliotic curvature. As she was able to do so she succeeded to use every single step as a therapy against her lumbar scoliosis.

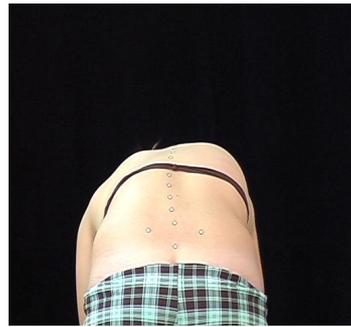


Fig.9: Asymmetric trunk „before“



Fig.10: Symmetric trunk in mobilizing exercise

Comparison of pelvis and spine position in standing upright and in gait before and after training

Pelvis tilt angle and the angle of the lumbar spine are compared before and after training. These two angles - in standing upright and in gait - are taken from the video. In gait the chosen frame to extract the angles is defined as the maximum pelvis tilt after heel strike (foot contact). In adult walking in moderate speed it is usually the fifth or sixth frame after heel strike. The comparison of angles include the angles for standing position to right and left step and considering „before“ and „after“.

Standing	before		after	
	pelvis	spine	pelvis	spine
	+ 1	+ 13	+ 2	0

Walking	before			after		
	frame	pelvis	spine	frame	pelvis	spine
right max	12	+ 6	+ 16	13	+ 2	0
left max	27	- 2	+ 12	28	- 6	- 3

Tab. 1: Pelvis and spine position in standing upright and in gait before and after training.

## Comparison of the upright position of the trunk „before“ and „after“

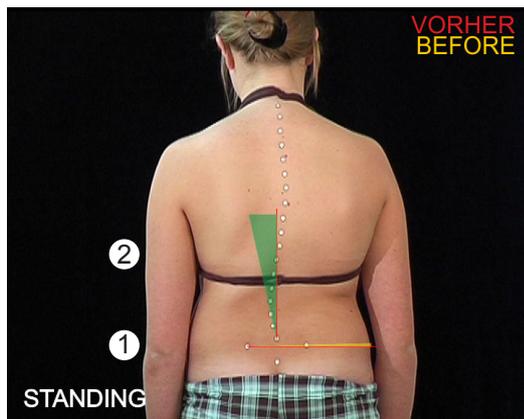


Fig.11: Posture „before“.

### Standing upright „before“:

The markers on the spinal processes show a right-left deviation which corresponds roughly to the X-ray results considering the rotation in thoracic and lumbar spine.

The upper body shows a slight rotation in the shoulder region, a difference in the curvature of the taille and a slight pelvis tilt to the left.

### Standing „before“:

Lumbar spine +13 °, pelvis +1°).



Fig.12: Posture „after“.

### Standing upright „after“:

The posture is more erect, there is no rotation in the shoulder part and the shoulders are further back. The spinal curvature shows less lateral deviation.

### Standing „after“:

Lumbar spine 0 °, pelvis + 2°.

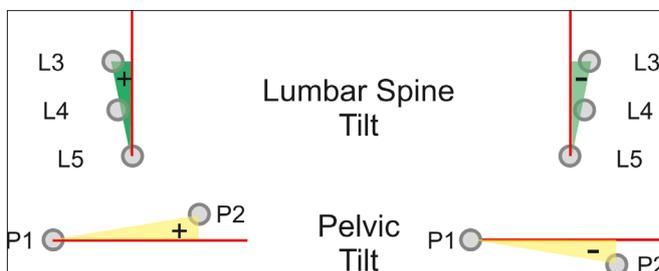


Fig.13: Definition of lumbar spine tilt and pelvis tilt.

## Comparison of pelvis and lumbar spine movement in walking

In order to compare the adequate gait phases of right and left step a „reference time“ is defined: It is at the beginning of single step, when the swinging leg passes the knee of the stance leg. At this time the pelvis comes to its first maximum tilt to the side of the swinging leg and the lumbar spine shows its maximum curvature (At this time the pelvis is nearly 90° to the camera axis).

In the video the foot contact can be found by looking at the pelvis tilt and at the pelvis marker on the side of heel contact. There is a change of movement direction. Before heel strike the pelvis (marker) of the swinging side goes down. At heel strike it shortly remains at a certain level and then goes up until the stance leg takes up the whole body weight (= the highest position of the pelvis marker on the stance leg side). In normal walking the reference frame is the 4th, 5th or 6th frame after heel contact and is defined as first maximum pelvis tilt.

## Spine position and pelvis tilt in left step and right step before and after

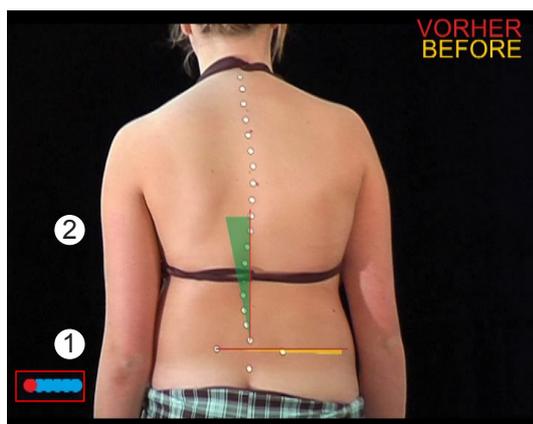


Fig. 14: Left step „before“: Spine position and pelvis tilt.

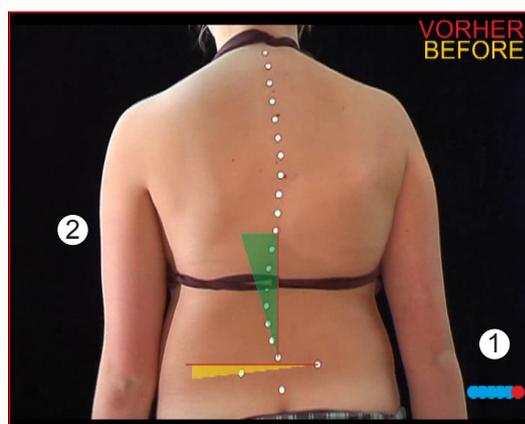


Fig. 15: Right step „before“: Spine position and pelvis tilt.

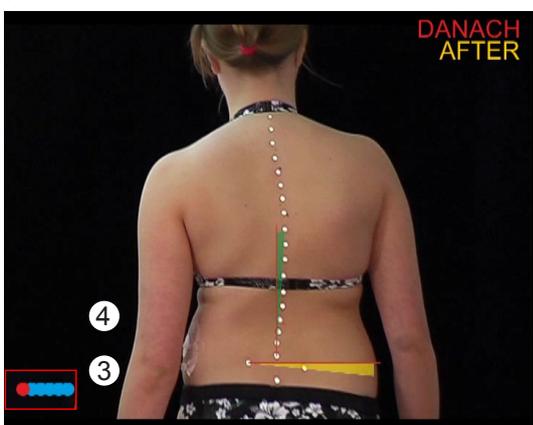


Fig. 16: Left step „after“: Spine position and pelvis tilt.

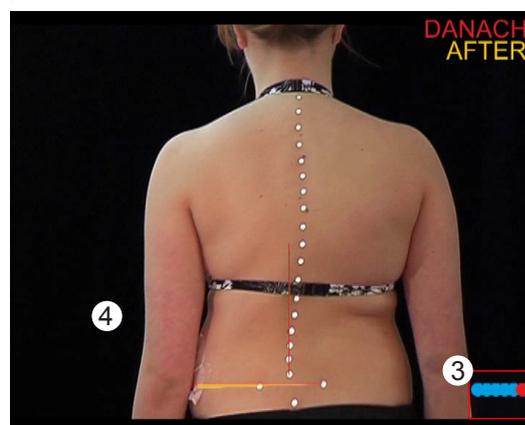


Fig. 17: Right step „after“: Spine position and pelvis tilt.

### Interpretation of differences in posture and gait

- ① Before: In standing position the pelvis is lower left  $1^\circ$ . In step right of walking this angle rises to  $6^\circ$  and in step left the pelvis is lower on the right side ( $2^\circ$ ).
- ② Before: In connection to the pelvis angles the lumbar spine deviation rises from  $13^\circ$  in standing position to  $16^\circ$  in the right step and  $12^\circ$  in the left step.  
  
!! At every right step the lumbar spine deviation rises from  $13^\circ$  in standing position to about  $16^\circ$ .
- ③ After training the pelvis in standing position is  $2^\circ$  lower at the left side. A change is seen in walking, as the tilt is minimized in the right step (which is of advantage for the scoliosis) from  $6^\circ$  to  $0^\circ$ . In the left step it rises from  $2^\circ$  to  $6^\circ$  which, too, is a favorable therapeutic effect for the lumbar scoliosis.
- ④ The greatest change is seen in the lumbar deviation: In standing position it is reduced from  $13^\circ$  to  $0^\circ$ . In walking (left step) the lumbar spine even moves about  $3^\circ$  to the right (which is an advantageous effect against the deviation of the spine there) and in the **right** step there is no more movement of the spine into the lumbar deviation ( $16^\circ$  before).

## **5. Video documentation before and after**

At first the video shows the upper body of the girl standing on a rotating platform (before and after) and then doing some mobilizing exercises and strength training, followed by the method used for gait training.

To demonstrate the walking pattern before and after the training period two files were chosen to show the walking cycles. The file „before“ starts 6 frames before foot contact right. The file „after“ starts 8 frames before contact. The foot contacts are shown in the video by a blue dot on the right side of the frame. On the following frame there are two dots and on the frame with the maximum pelvis tilt the dot is red. Pelvis and spine angles are shown in yellow and green and the horizontal/vertical lines are shown in red. At foot contact left and pelvis tilt maximum left the dots are on the left side of the video frame. The video file shows the following heel strike right with blue dots but without spine and pelvis angles.

## **6. Conclusion**

This case study shows, that exercise programs in combination with gait training can enable young persons with scoliosis for altering their posture and movement patterns. By intensive training (6 times a week) the girl, 13:5 years of age, succeeded in improving her posture and in modifying her walking pattern. Starting with a walking pattern which enhanced the scoliotic curvature especially in the lumbar region there is a change into a pattern that enables her to reduce the scoliotic deviation.

The study also demonstrates that standing, gait and running have a great influence on scoliosis, as a permanent asymmetric spinal posture or movement into the scoliotic curvature deteriorates the situation. Thus early attempts to a more symmetrical movement of spine and pelvis by altering the gait pattern in combination with an intensive training program can lead to more positive results.

Especially for young people who suffer from a bad posture and want to be physically more attractive and have more self confidence, this case study shows, that in a short period of time it is possible to gain muscular strength, to change a bad posture into a good one and to improve motor ability.

## **Background**

Between 1976 and 1990 five research programs by the Institute of Sports Sciences at the University of Graz and the Institute of Orthopaedic Surgery at the Medical University of Graz were focused on biomechanical gait analysis, walking patterns of children with cerebral palsy, alternative methods to diagnose and treat juvenile scolioses and postural problems and analysing spinal movement during gait. These research programs were supported by the Austrian Science Foundation (Fonds zur Förderung der Wissenschaftlichen Forschung).

Steirische Gesellschaft für Wirbelsäulenforschung - Grazer Gang- und Rückenschule  
8052 Graz, Herbersteinstrasse 76  
Kontakt: Univ.-Prof. Dr. Otto Fleiß  
Tel.: +43 316 584848, email: otto.fleiss@uni-graz.at, homepage: www.wirbelix.com