Gait pattern and spinal movement in walking
A therapeutic approach to low back pain
by training programs and changing gait pattern

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Abstract

Background: Spinal and pelvic movement in walking are codeterminating factors for the quality of gait and can be used to document therapeutic effects. In studies about motor therapy, prevention for school children and movements in sports the Graz Back School has used spinal and pelvic movement parameters in walking.
Objective: In this single case study a woman with permanent low back pain and an unsymmetric gait pattern is treated with a therapeutic program and trained to change her gait pattern.
Method: Simple video recording (one or two camera system) is used to document posture, spine function and walking. The video frames are used for further analysis.
Programs: SMA for analyzing pelvis and lumbar spine data, SAS for evaluation of posture, spine function and walking; W-med for therapeutic programs.
Results: The therapeutic goal to minimize pain and to achieve a symmetric gait pattern by changing the coordination pattern could be realized.
The comparison of gait before and after training shows the change from an unsymmetric to a symmetric gait pattern.
Conclusion: Asymmetric gait pattern can be found by simple video documentation. By specific gait training a change of gait pattern can be achieved. The parameters *pelvis and lumbar spine tilts in walking* are considered to define the quality of gait and to document therapeutic progress and effects.

Key words: Walking pattern, pelvis and lumbar spine tilt, video analysis, low back pain.

1. Introduction

Low back pain is sometimes associated with asymmetric pelvis and lumbar spine movement in walking. The asymmetric pelvis movement might be caused by pain, leg length difference or gait pattern. In the case of a 46 year old woman an asymmetric pelvis height and a restriction of neck and trunk flexibility (caused by a car accident) has led to an unsymmetric walking pattern and to servere low back pain.
After a preliminary therapy because of neck and shoulder problems a first video documentation of posture, spinal function and walking was done, followed by a special training program to mobilize and to strengthen the low back and pelvis area. In addition, regular gait training was initiated to achieve an equal balanced pelvis and symmetric lumbar spine movement.
After 8 1/2 months a second video documentation shows a regular and equal balanced pelvis movement and a symmetric lumbar spine movement. The woman reported that a few weeks after starting the gait training her low back pain had ceased.
A second result of the study is the fact, that analyzing pelvis and lumbar spine movement in walking by video documentation can be an easy tool for therapists to analize the effect of therapy on walking.

2. Methods and Materials

2.1 Subject

Young woman, 45:10 years old, pain and muscular tension in neck and shoulder region, severe low back pain, permanent pain while walking.
Case history:17 years ago car accident, wiplash injury, broken iliac crest at the right side (not operated). No documentations. Since then permanent unregular back pain and a strong feeling of asymmetry. Several therapeutic approaches, including unregularly used leg length correction of 7 mm in the left shoe (without effect).

2.2 Experimental Design

1. Therapeutic approach
2. First video documentation after two months
3. Gait training and strength training
4. Control examination after additional 81/2 months

2.3 Video-analysis and data acquisition

1. Clinical orthopaedic examination
2. Reflective markers are attached above the spinal processes from C7 to L5 and on three prominent areas on the pelvis (spin.il.sup.post. and beginning of rima ani)
3. Video documentation (Video-screening - routine of the Graz Gait and Back School) including panorama view (standing on a rotating platform), standing, bending, walking barefoot, with shoes and with shoes+inlay left
4. Motor testing - strength, flexibility
5. Discussion and analysis of the video together with the client
6. Selection of specific exercises for the training program
7. Exercise sessions with supervision

2.4. Data processing

Pelvic and lumbar spine angles in the frontal plane were calculated for each frame in the before and after videos with the software SMA (Spine Movement Analysis). The spine angles were estimated with total least squares (TLS) to account for digitizing errors in both horizontal (x) and vertical (y) coordinates. The pelvic angles were estimated from a straight line between the markers attached to the left and right side of the pelvis. The curvatures along the spine were estimated with two-dimensional parametric cubic smoothing splines that took into account errors x and y. Virtual markers were added to the ends of the spine (C7 and L5) to reduce account for boundary discontinuities. The curvatures were mapped onto a colorbar where red represents high curvature and green low curvature.

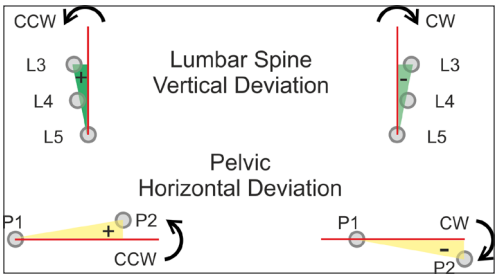


Fig. 1: Definition of lumbar spine and pelvic tilt.

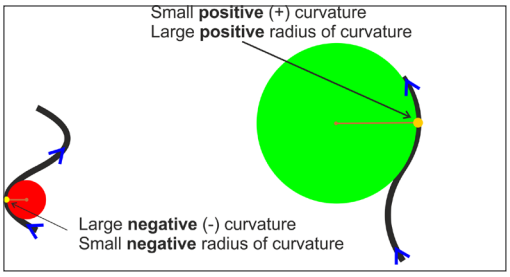


Fig. 2: Signed curvature and radius of curvature.

2.5 Parameter definition

2.5.1 Maximum pelvis and lumbar spine tilt in walking

These angles are measured in standing and in walking. In walking two positions in the walking cycle are defined and used for analysis: heel strike and maximum pelvis and lumbar spine tilt.

The main parameter considers pelvis and lumbar spine tilt at reference time: the result is seen in the comparison of right to left step and will be defined as symmetric or asymmetric.

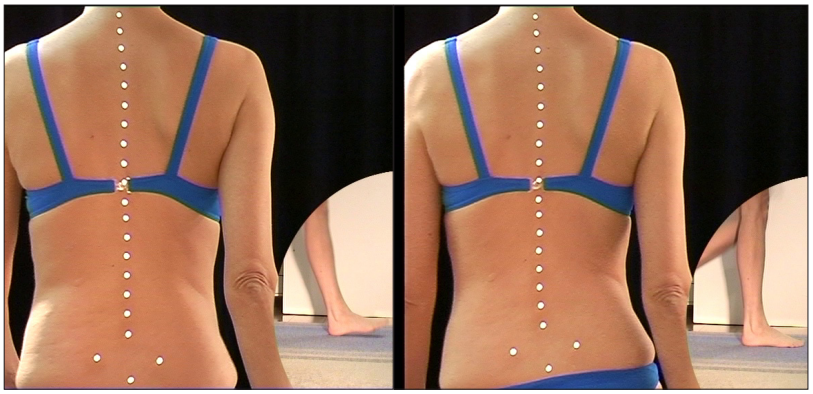


Fig. 3: Heel strike right foot.

Fig. 4: Beginning of single support phase right (reference time).

In the two camera version it is easy to define heel strike and first maximum pelvis tilt at reference time - which is the time, when both knees are at the same height.

At the beginning of single support phase right, the knees are at the same height (defined as first maximum pelvis and lumbar spine tilt = reference time). In this frame the pelvis is close to a 90 degree angle to the camera axis, so the angles are reliable. When there is no second camera the foot contact can be estimated by watching (or analysing) the markers P1 and P2 on the pelvis respectively to right or left heel contact.
Sometimes pelvis and lumbar spine angles are greater after reference time. But for comparision we stick to the angles at reference time.

2.5.2 Pelvis and lumbar spine movement after heelstrike

Between heel strike and maximum pelvis and lumbar spine tilt (reference frame) the movement of pelvis and lumbar spine is usually gradual, but sometimes there is an abrupt movement which should be paid attention to, especially if it occurs only at one side.

2.5.3 Right / left symmetry of pelvis and lumbar spine angles over the gait cycle

Although only those angles at the time when the pelvis is nearly in a 90 degrees angle to the camera axis are reliable, it is interesting to compare both angles during the whole gait cycle.

2.5.4 S- versus C-shaped curvature of the spine

The overall curvature of the spine in walking changes from a S-shaped curvature (usually at reference time) - to a C-shaped curvature before heel strike. If S- and C- curvatures occur symmetrical, the spine is moving freely and not restiricted by scoliosis or fixed areas. A not symmetrical movement of the curvature might indicate functional problems of the spinal column.

2.5.5 Spinal Curvatures in Standing and Walking - Splines

We used smoothing splines to estimate curvatures along the spine where the markers served as the knots for our splines. Curvatures were estimated for the 18 markers over all frames.

2.6 Software programs

For this movement analysis three programs are used:

(1) SAS - Spine Analysis System - is a complex program to analyse posture, flexibility, gait and coordination, based on video data.
(2) W-med is a collection of 300 exercises for children from 4 to 18 and for adults to select individual training programs and hand it to the client as printed program.
(3) SMA - Spine Movement Analysis - is a program to analyse pelvis and lumbar spine movement during gait.

3. Training programs and first results

3.1 Therapeutic approach

Because of the painful situation of the person, 5 sessions relaxing and soft mobilizing exercises are given to relax the painful neck and shoulder region, to mobilize and relax the low back area and to gain a more symmetric body feeling.
The exercises are printed (pictures and descriptions) and given to the person as a daily exercise program. They all could be performed without any pain. Eight weeks later the video documentation was done.

First training program

Fig. 5: First exercises for relaxation, mobilizing and symmetric head and shoulder movements.

3.2 First video documentation

Standing

The frontal plane view reveals asymmetries in shoulder heights, waist contour, pelvis position and shows the line of the spinal processes. The sagittal plane gives information about body and head posture.

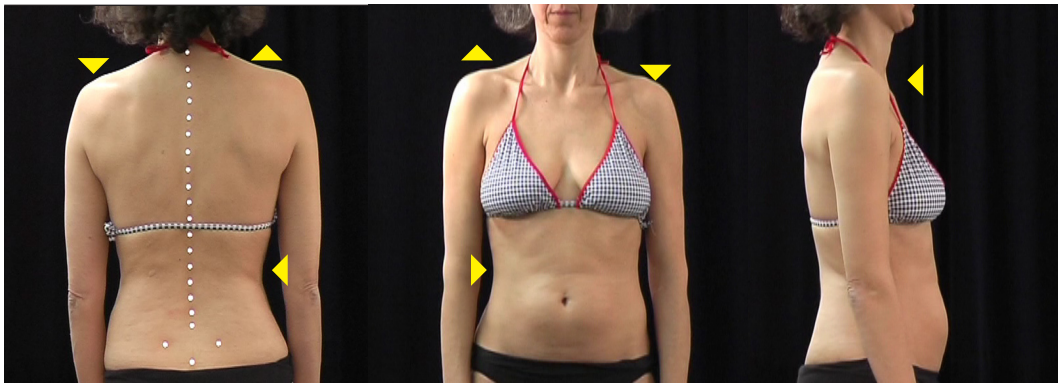


Fig. 6 Standing: Correct upright posture, a few irregularities (shoulder and waist asymmetry).

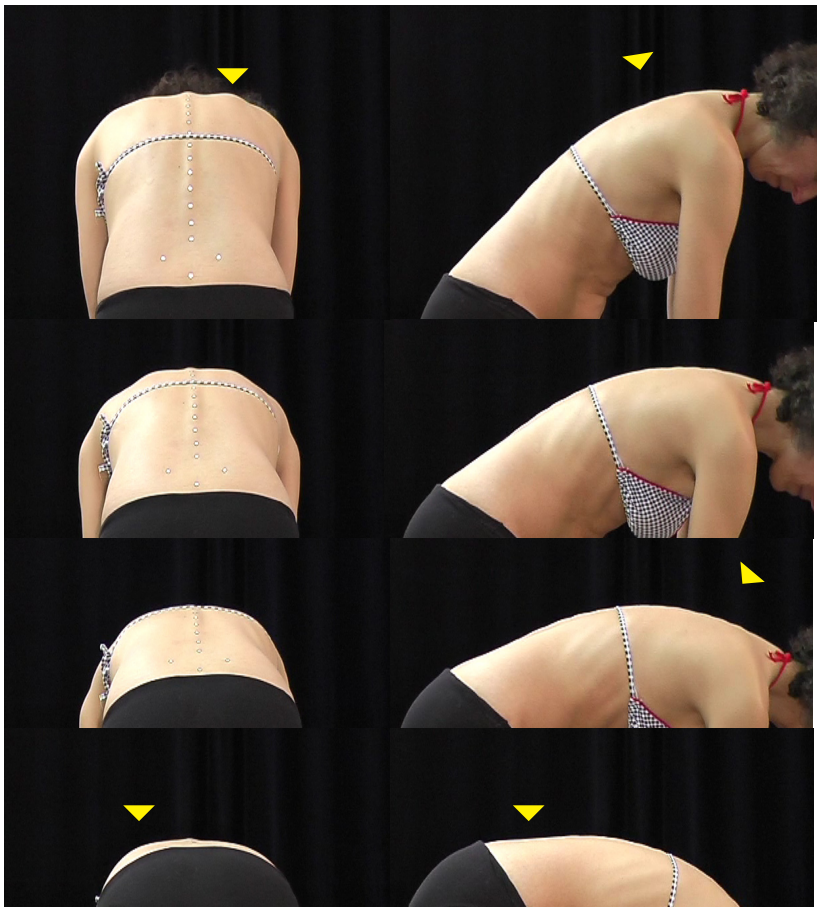


Fig. 7: Bending forward from behind: Minimal asymmetric contour in the upper and in the lowest position.

Fig. 8: Bending from the side: Minimal flat part in the upper spine region, the hollow back remains even in the lowest position.

The positions of bending forward from behind document symmetric or asymmetric contours of the back and also deviations in the line of the spinal processes.

In the lowest position an asymmetric height of the pelvis and the lumbar region can be found.

From the side one can see the flexibility of the spinal column during bending. Flat parts (plateaus) show regions with less flexibility.

Bending sidewards

Bending into a maximal sideward position shows the total range of flexibility and the flexibility or stiffness of different regions.

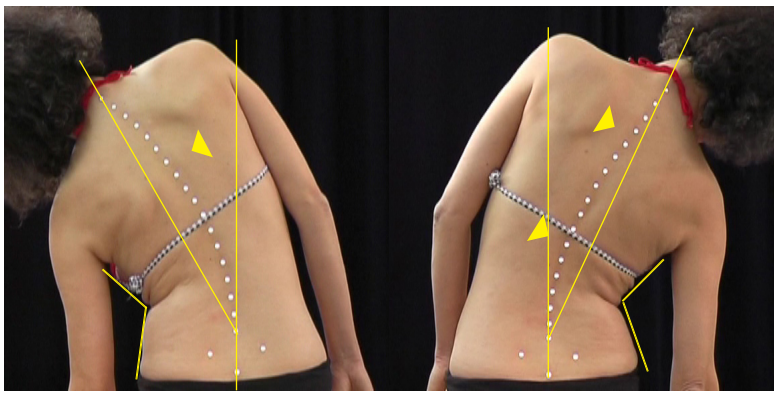


Fig. 9: Bending sidewards: Asymmetric curvature of the spine, stiff areas and slightly asymmetric overall flexibility.

Bending to the left is efficient (30 degrees), there is a stiff part in the upper thoratic spine. The range to the right is smaller (25 degrees), there are two stiff parts in the spine curvature.

Walking barefoot

To describe the symmetry of gait we compare right to left step at the time when the swinging leg has just left the floor and the knees are at the same level (reference frame). Parameters are pelvis and lumbar spine tilt (L3 to L5) in the frontal plane.

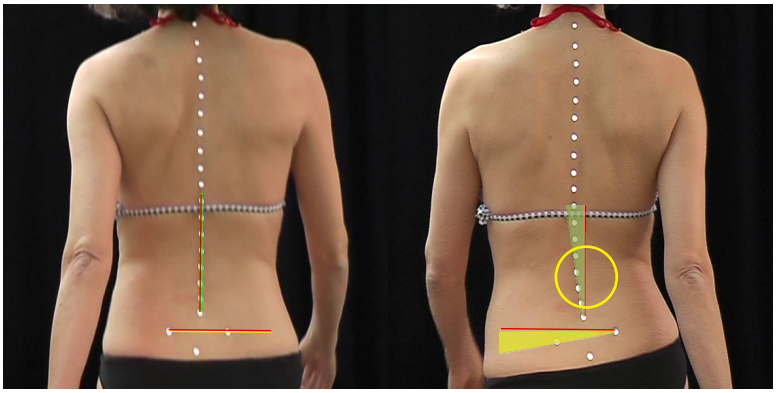


Fig. 10: Walking barefoot (reference frame): Step left (left picture), step right (right picture).

At step left there is a minimal tilt of the pelvis down right und a minimal tilt of the lumbar spine to the right. At step right (right picture) the pelvis tilts about 10 degrees down left and the lumbar spine tilts 10 degrees to the left. As the upper body moves to the right there occurs a lateral rotation of the pelvis of about 4 to 5 degrees in the crucial area at L3.

Walking with shoes

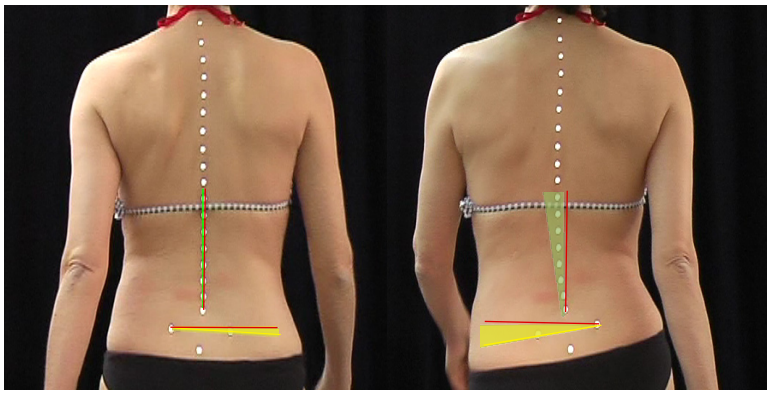


Fig. 11: Walking with shoes +7 mm in left shoe: Step left = left picture, step right = right picture

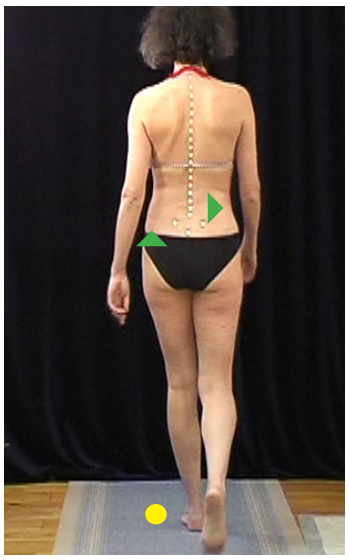
At right step (right picture) the pelvis tilts 10 degrees down left and the lumbar spine tilts about 8 degrees to the left. At step left (left picture) the pelvis tilts 3 degrees down right and the lumbar spine does not tilt to the right but stays vertical.
This pelvis and lumbar spine movement is nearly exact as in barefoot walking inspite of the fact that the shoe on the left foot is 7mm higher than the right shoe.

3.3. Second Training program

Fig. 12: Second training program

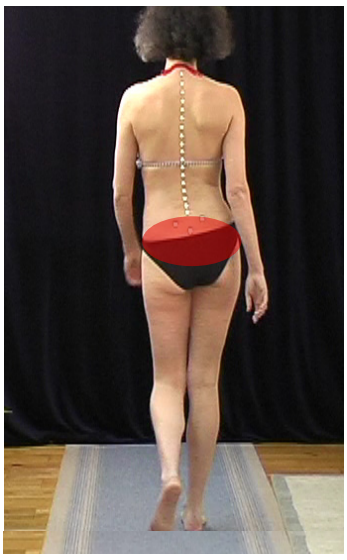
The second training program includes exercises to build up strength (trunk, back and buttocks) as well as lateral and rotatory mobilizing and exercises to regain a symmetric body feeling.

Gait Training



(1) Start walking with the left foot.
(2) Reduce length of the first left step.
(3) Try to hold the left hip as high as possible.
(4) Increase the lateral movement of the lumbar spine to the right.
(5) Swing freely to the right.

Fig. 13: Gait training left step.



(1) Stabilize pelvis and lumbar spine at right heel contact.
(2) Reduce the rotation of the pelvis.
(3) Decrease the lateral movement of the lumbar spine to the left.

Fig. 14: Gait training right step.

Gait training was started to reduce the asymmetric pelvis and lumbar spine tilt in walking. In combination with strength exercises for back and buttock muscles a symmetric pelvis and lumbar spine movement was supposed to reduce back pain and enable the client to perform a symmetric walking pattern even without leg length correction.

3.4. Second video documentation

Standing

There is no remarkable change in posture exept the fact that the waist contour is more symmetric than before and that the shoulders are a little more kept back. The right shoulder is still higher.

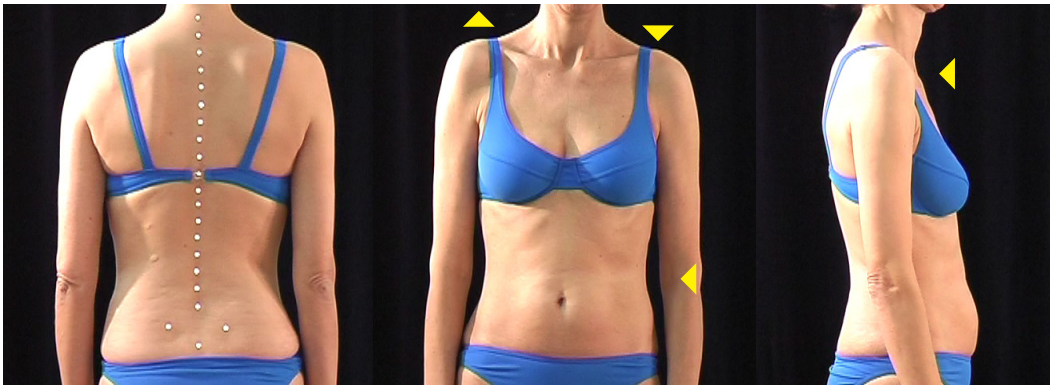


Fig. 15 Standing position: Correct upright posture, irregularities: right shoulder higher, asymmetric waist contour.

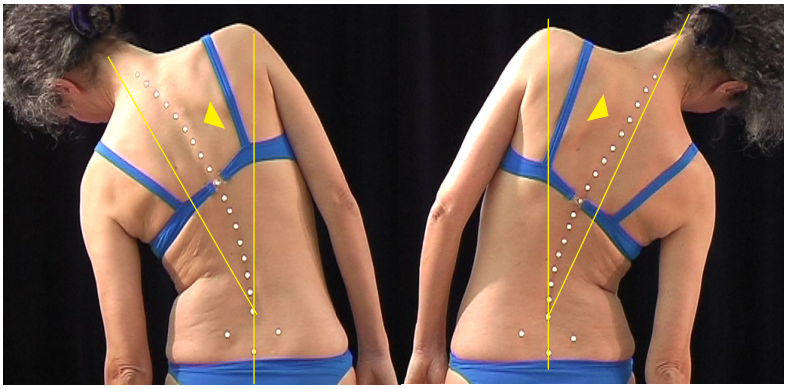
Bending

Fig. 16: Bending from behind: No irregularities in the upper position, in the lowest position left contour higher.

Fig. 17: Bending from the side: Good flexibility in the upper spine, the hollow back remains.

In bending especially in the throratic region the flexibility has enhanced.

Bending sidewards



In bending sidewards there is nearly no change in flexibility before and after. Especially the right curvature in the thoratic spine remains unchanged.

Fig. 18: Sideward bending: Moderate flexibility to both sides, stiff area in the upper thoratic spine.

Walking

At the beginning of single support phase right, the knees are at the same height (defined as first maximum pelvis and lumbar spine tilt = reference time). In this frame the pelvis is close to a 90° angle to the camera axis, so the angles are reliable.
When there is no second camera the foot contact can be estimated by watching (or analysing) the markers P1 and P2 on the pelvis respectively to right or left heel contact.

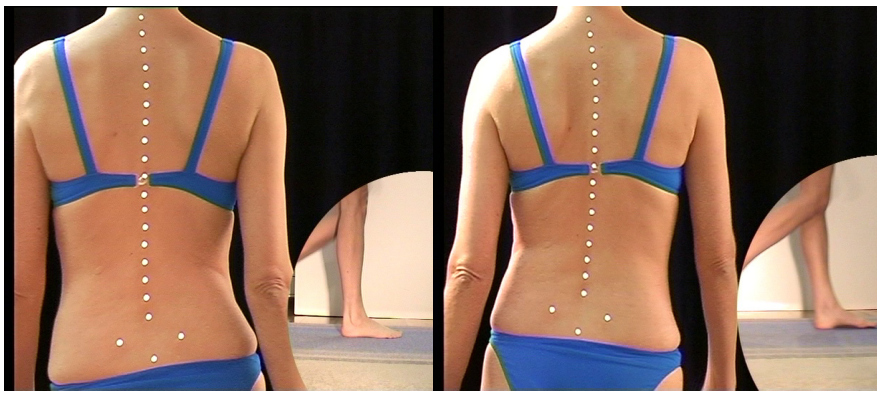


Fig. 19: Walking after, step right and step left (at reference frames). Almost symmetric movement of the spine.

Barefoot walking was analysed and showed a clear pattern change to a nearly symmetrical pelvis and lumbar spine tilt.
There was no more low back pain and only when walking for a longer period the subject used an inlay of 2-3 mm in her left shoe.
In walking she still kept aware the main items of the new walking pattern as to start with the left foot, keeping the left hip high and stabilizing pelvis and lumbar spine in the right step. (*The detailed comparison of before and after is given in „results“*).

4. Results

The results are split into general aspects as posture, spine function and strength and into special aspects of walking, including pelvis and lumbar spine tilt.

4.1 Comparison of posture, bending, strength and initiation of gait before and after

Posture has not changed very much. The asymmetric waist curvature after (prominent right) is not as strong as it was. This might be due to the more symmetric walking pattern after gait training.

Bending
Bending in the sagittal plane has changed. Before training the thoratic spine was stiff and did not bend very much. After training the thoratic spine bent into a smooth curve. The hollow back did not change.

Fig. 20: Bending from the side before (left) and after (right): Minimal stiffness of the whole spine (before) has changed to more flexibility in the middle thorac region.

Muscular strength
The muscular strength of back and buttock muscles has increased as the woman kept on her strengthening program.

Initiation of gait
We observe this parameter when the person gets to the end of the gait way, turns and starts walking towards the camera. Concerning posture our points of interest are: position of the upper body, position of the head, behavioural pattern when starting walking.
Before gait training the person turns with slightly twisted head and without interruption right out of the turning movement (turning around).

After gait training there is a clear change in her turning pattern. She turns with her head slightly bent but not twisted - then stops - raises her head and straightens her body and then she starts to walk. She has this **„pause of awareness“** at each start of walking and each turning. So she has automized the initiation of first step (high hip left, short step, swinging the spine to the right, etc). This habit of concentrating on the new walking pattern during her gait training might be the reason why she finally could change her walking pattern so effectively.
(This pause of awareness is essential in many situations when one has to concentrate on a specific posture or movement pattern, as for example on activating the muscles before lifting).

Fig.21: Turning before: Turning to the left, her head is bent and slightly twisted, then the head twists more to the left and the walking starts without any interruption. Here she starts with her right leg.

The green dots symbolize the temporal aspect of the turning - movement. Continuous movement before and with „pause of awareness“ (double dots) after.

Fig. 22 : Turning after: Turning to the right, her head is bent but not twisted (1st picture), then she raises her head (2nd picture) and stops for a moment - straightens her body and controls her head (3rd picture) - and starts walking with her left leg (4th picture).

Selfconfident posture in walking.
After gait training her gait is more controlled and especially at first step she has changed her walking habit. Before she starts to walk, she straightens her body to an upright posture, straightens her neck and then starts the first step - nearly always with her left foot as it was trained.
This „selfconfident walking“ may be due to the fact, that walking is no longer painful for her, that she has gained a good body awareness and that she feels good. She reported, that within the training period she got the feeling of being more symmetric than before.

4.2 Results: Comparison of standing and walking before and after training

For the comparison of before and after we use different parameters and figures. At first we compare the angles of pelvis and lumbar spine in standing position to the same angles in walking. In walking the reference frame is chosen at the maximum pelvis tilt just after double support phase. In normal gait speed it is the second or third frame of the swing phase and is defined as the moment when the knee of the swinging leg passes the knee of the supporting leg.

For the positions of pelvis and spine in standing and walking the angular rotations of the pelvis and lumbar spine in the frontal plane were measured before and after 8 1/2 months of training. We found that these angles were good indicators of changes in gait pattern. These angles were calculated for each frame in the before and after videos using the software package SMA-VOX.

Standing before and after

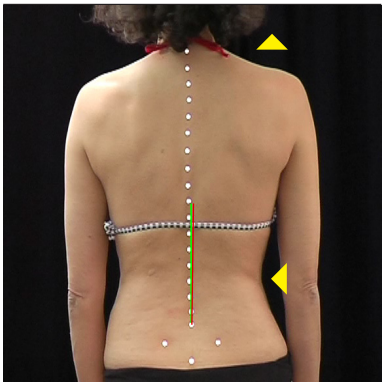


Fig. 23: Standing before

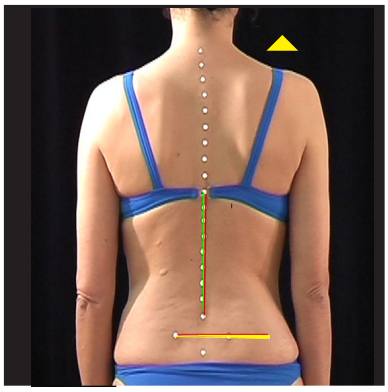


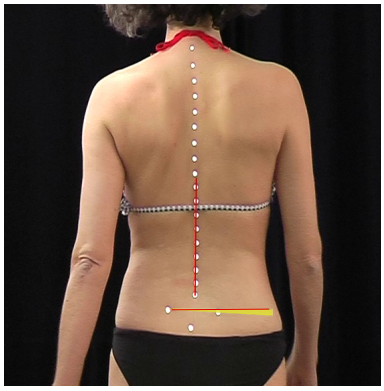
Fig. 24: Standing after

The pelvis and spine position in standing upright before and after training shows, that the posture is nearly the same, the lumbar spine after however is vertical.

Walking before and after

Walking Parameter 1: Maximum pelvis and lumbar spine tilt at reference time

Fig. 25 and 26 show the pelvis and spine position in walking before at reference time. In the right step (right picture) the pelvis and lumbar spine tilt 10/8 degrees to the left. In the left step (left picture) the pelvis tilts only 2 degrees to the right and the lumbar spine does not swing to the right at all.



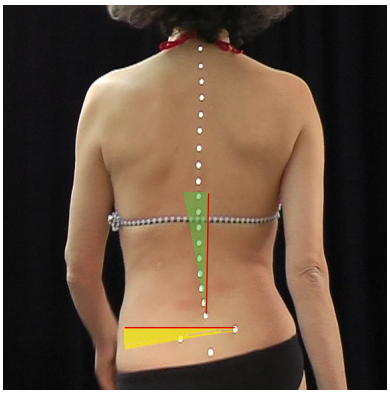


Fig. 25: Walking before, step left *Fig. 26: Walking before, step right*

In walking after in the right step (right picture) the pelvis and lumbar spine tilt 4 degrees to 6-8 degrees to the left and about the same amount to the left (left picture). Pelvis and lumbar spine movement is symmetric.

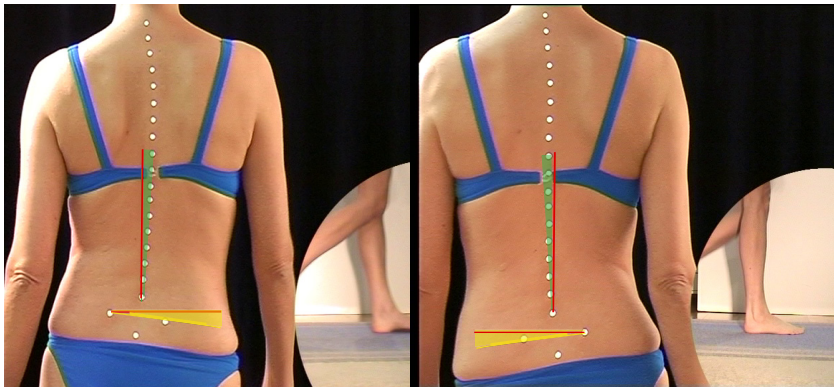


Fig. 27: Pelvis and spine position in walking after training at reference time.

Pelvis and lumbar spine angles in standing and walking before and after *(Tab. 1)*

Standing	before			after		
		pelvis	spine		pelvis	spine
		+ 1,5	+ 4		- 2	0

Walking	before			after		
	frame	pelvis	spine	frame	pelvis	spine
right max	11	+10	+ 10	15	+ 5,5	+ 4,5
left max	27	- 3,5	- 1,0	30	- 6	- 4,5

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

The main difference is seen in the walking cycle. In the walking cycle before there is a great difference between right and left step. In the right step the pelvis tilts about 10 degrees down left and parallel to it the lumbar spine tilts also about 10 degrees to the left. In the left step the pelvis moves only 3,5 degrees to the right and the lumbar spine is nearly vertical, which means that it does not swing to the right.
After gait training the movement of the pelvis and lumbar spine is nearly symmetric. The pelvis tilts to both sides about 4 to 5 degrees and the lumbar spine swings to both sides, up to 5 to 6 degrees.
It must be mentioned, that this happens in barefoot walking without a length correction and only in a special walking pattern.

Walking Parameter 2: Pelvis and lumbar spine movement after heelstrike

Before and at the beginning of single support phase (right step) the pelvis tilts within 4 frames about 10 degrees down left and the lower lumbar spine (L3 - L5) moves with it. Then the upper body moves back to the right and so a rotary movement occurs around L3 in a range of about four to five degrees. This rotational movement occurs only in the right step before training. As this dynamic pelvis and lumbar spine movement is located in the area of the low back pain it may be argumented that this asymmetric spinal movement might have some influence on low back pain in this client.

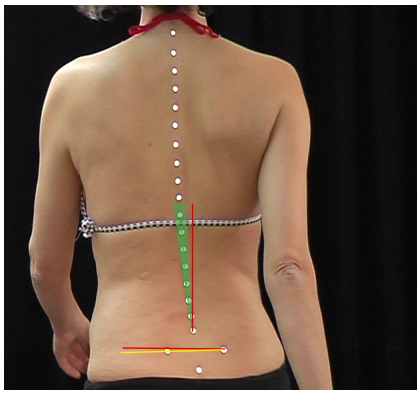


Fig. 28: Step right before, 2 frames after heel contact.

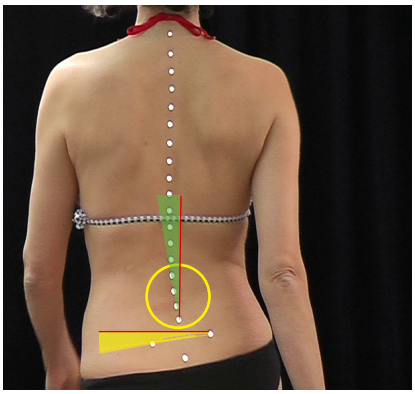


Fig. 29: Step right before, reference frame.

In walking before heel contact occurs in frame 6. There is no pelvis or spinal movement up to frame 8 (left picture). In the next three frames the pelvis tilts about 3 degrees each frame down left. In the 11th frame (reference frame - right picture) the upper body has moved to the right thus causing the rotary movement around L 3.
After training this movement is more regular and does not show the asymmetric pattern as before.

Walking Parameter 3: Right / left symmetry of pelvis and lumbar spine angles over the gait cycle

Although only those angles at the times when the pelvis is nearly in a 90 degrees angle to the camera axis are relieable, it is interesting to compare both angles over the whole gait cycle (One has to take into consideration that most of the angles change when the pelvis rotates strongly in the horizontal plane before heel strike).

The chronogram (before training) shows the pelvis and lumbar spine angles over 43 frames (video clip before). The red line give the pelvis rotation and the blue the lumbar spine angles. 0 line shows the horizontal (pelvis) and the vertical (lumbar spine).

Both curves are in the upper side of the diagram which means that the movements of pelvis and lumbar spine are only on the left side when walking: the pelvis tilts down left and the lumbar spine moves to the left.

After gait training the curves show a quite different form. Primarily both curves are symmetric in regard to the 0 line, which means that pelvis and lumbar spine tilt about the same amount to the right and to the left side.

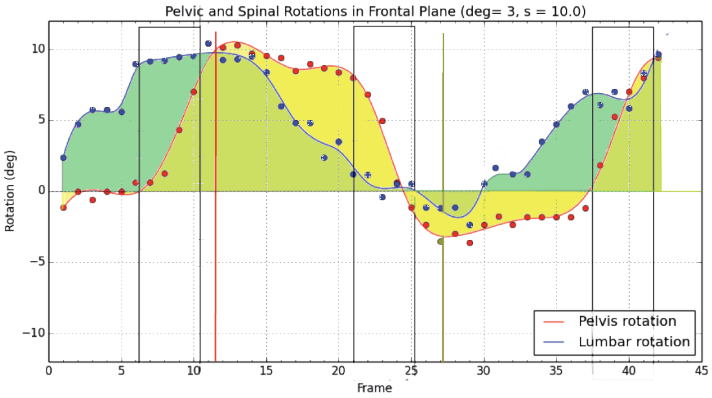


Fig. 30: Pelvis and lumbar spine angles over more than a stride. This chronogram is based on 43 frames of one stride (before). The video clip starts 5 frames before heel strike. The rectangles define double support phase. The red line is the reference time = 5th or 6th frame after heel strike - and first maximum of pelvis tilt.

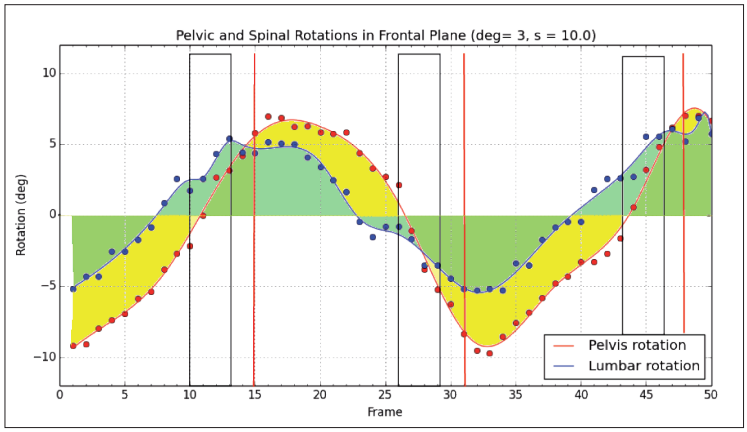


Fig. 31: Pelvis and lumbar spine angles over more than a stride. This chronogram is based on 50 frames of one stride (after). The video clip starts 10 frames before heel strike. The rectangles define double support phase. The red line is the reference time = 5th or 6th frame after heel strike - and first maximum of pelvis tilt.

Walking Parameter 4: S versus C - curvature of the spine in normal walking

In normal walking the spine shows two curvatures: a S-curved line at about reference time - when the pelvis tilts to the swinging leg and the upper body starts to rotate backwards - and a C- formed curvature before and at heel strike. These curvatures can be found only when there is no functional inhibition and the spine is swinging „freely“. Thus by observing the curvatures in walking we can get indications about functional disorders of the spine.

In our case at foot contact right (first picture) the spline line shows a good C-curvature. When we look closer, there is a deviation of the line to the markers in the upper thorac region.

The C-curvature at reference time corresponds to the underlying spinal problems: a right deviation at upper thorac and a left deviation in the lumbar region. So this curvature follows the underlying problem and the gait cycle. In the next picture (third picture) we expect a great C curvature (open to the left) at foot contact left. The lower lumbar spine however does not follow the C-curve. That means that the lower lumbar spine can not move freely into this C-shaped curve.

In the last picture we should expect the mirrow symmetrical curvature of picture two. But we find something close to a straight line: In the pelvic region there is not enough pelvis tilt to enable the lumbar spine to swing to the right and in the upper thorac region the underlying right-shaped curve prevents a swinging to the left

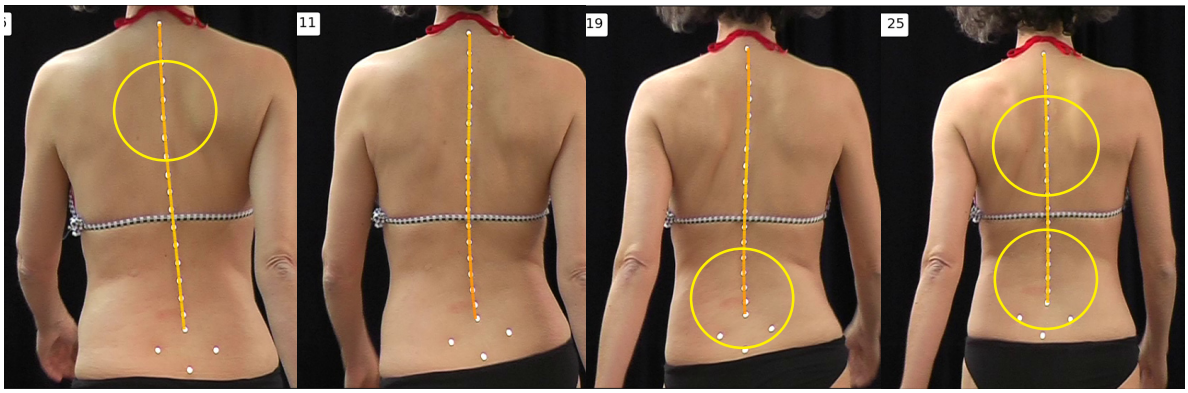


Fig. 32: Spine curvature before: a) Heel strike right, b) reference time right, c) heel strike left, d) reference time left. The circles define areas which do not move freely in these phases.

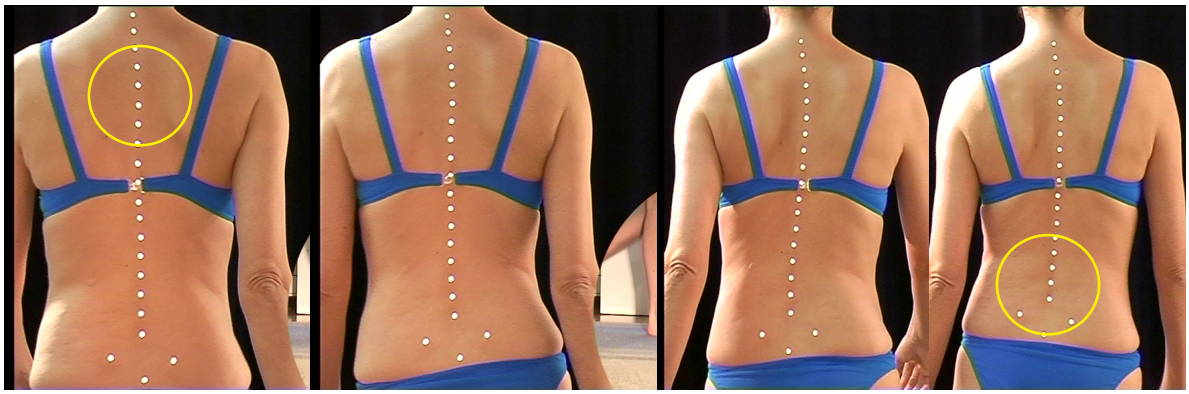


Fig. 33: Spine curvature after: a) Heel strike right, b) reference time right, c) heel strike left, d) reference time left. The circles define areas which do not move freely in these phases.

The curvatures at the chosen intervals (*after, Fig. 33*) correspond closely to the curvatures before (*before, Fig. 32*). If there had been any underlying problems - functional impedments - they would not have changed within a short period of some months. The question was if the newly reached tilt of the pelvis down right at reference time (left step) could force the upper thorac spine into a left oriented curve - which it does not. This means the upper thorac spine is rather stable in a right oriented curvature (which could be a next therapeutic goal).

Spinal curvature in walking (Splines)
We used smoothing splines to estimate curvatures along the spine where the markers served as the knots for our splines. Curvatures were estimated for the 18 markers over all frames.

Walking

In Walking before (reference time) we find large curvatures in the lumbar segment during right step and only small deviation during left step.

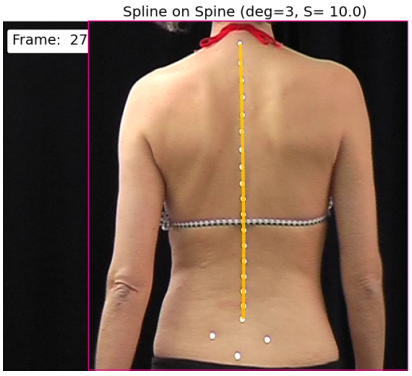


Fig. 36: Spine curvature in step left before.

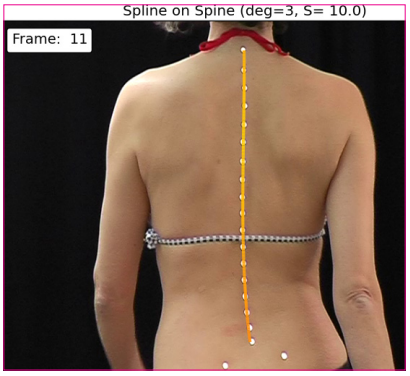


Fig. 37: Spine curvature in step right before.

In Walking after (reference time) we find smaller curvature along the spine during right step and more deviation in the thoratic area during left step.

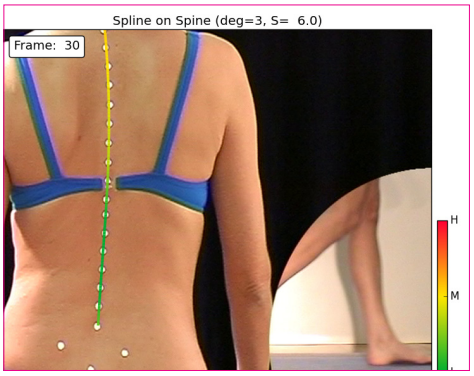


Fig. 38: Spine curvature in step left after.

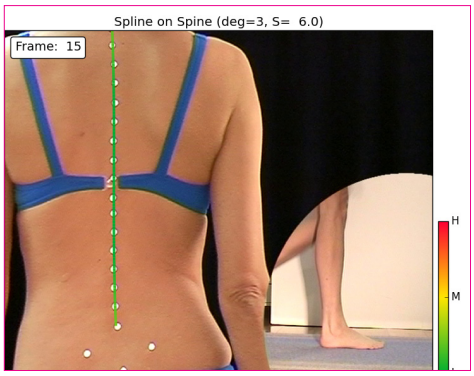


Fig. 39 : Spine curvature in step right after.

The colours of the splines change from green (no deviation) or yellow (small deviation) to orange and red (great deviation).

5. Video File including Spine and Pelvis Angles

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 10 frames before contact. The foot contact right is 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 are shown as red lines. The same happens at foot down left and maximum left, having the dots on the left side of the picture. The video file includes also the following heel strike right and a few more frames, but without any markers.

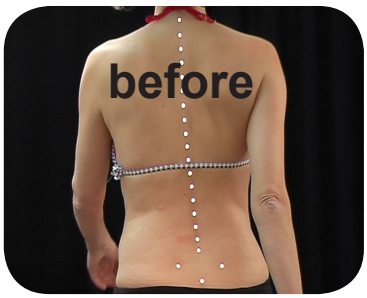


Fig. 40: Video file, gait before.

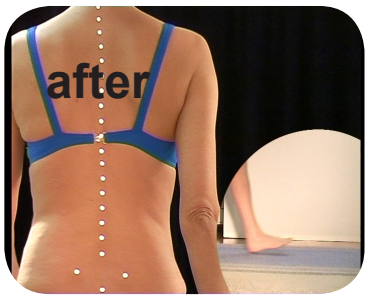


Fig. 41: Video file, gait after.

The reason why we start the video files with additional frames before heel strike is to give a user the opportunity to find heel strike (in a single camera version) by watching the pelvis tilt forward and down before heel strike.
At heel strike this movement ends and the pelvis tilts to the other side.

The video file includes also a gait pattern of a woman with nearly normal walking. Pelvis and spinal movement are comparable to the walking pattern of the woman discussed here,

6. Interpretation of results

The main results of this study consider the change of gait pattern in following a gait training. As the gait pattern before training showed an unsymmetric pattern - in step right the pelvis and lumbar spine moved much more to the lleft and left down than it happened in the left step to the right - and after training the gait pattern was symmetric with the same movement to both sides in right and left step.
Parallel to this pattern change the back pain ceased and the woman had no more pain in daily life and in walking.

Whatever might have caused the good result in regard to back pain - if it was the exercise program, the gait pattern change or just time - there still remains the fact the is was possible to alter an unsymmetrical gait pattern to a symmetrical just by coordination training and without leg length correction.
Before gait training the woman underwent a training program to help her with neck and shoulder problems and with the gait training special exercises were given to strengthen back and buttock muscels.

7. Summary

This case study shows a video based approach to document a therapeutic training and the effect that it might have on posture and walking. The method used follows the routine of the Grazer back school, with a preliminary video documentation of posture, spine function and walking, the description of the therapeutic training process and the results after two months.

The results presented concentrate on the comparison of right to left step, taking into account pelvis and lumbar spine tilt in order to define right-to-left symmetry in walking. This symmetry is suggested to be a prominent parameter in evaluating the quality of gait.

Besides the documentation of the different parameters before and after training, video files of a walking cycle before and after training give the opportunity to evaluate and observe the change of walking pattern before and after.
The results of this study - documenting the change of walking pattern and at the same time getting rid of back pain - should give an example that it is possilble to change an unsymmetric walking pattern within a reasonable period of time into a symmetric walking pattern and that a simple method as video documentation can give sufficient information to define the change in a walking pattern and the quality of walking.

Between 1976 and 1990 five reseach 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 childern with cerebral palsy, alternative methods to diagnose and treat juvenil 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).

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Anhang bzw. Kommentar zum Video

Das Video zeigt jeweils drei Schritte vor und nach der Therapie. Die Serien beginnen einige Bildern vor dem Bodenkontakt rechts, zeigen dann den Verlauf über den Bodenkontakt links und rechts und enden mit einigen Bildern nach dem dritten Bodenkontakt **rechts.** Damit kann die Becken- und Wirbelsäulenbewegung bei Beginn der einzelnen Takes bereits vor dem Bodenkontakt rechts, am Ende der Schwungphase rechts und zu Beginn der Stützphase rechts beobachtet werden, sowie auch noch der weitere Verlauf nach dem dritten Schritt.
Für die Beurteilung der Becken- und Wirbelsäulenbewegung beim Gehen werden - wie im Artikel ausgeführt - der Beckenwinkel zur Horizontalen und der Winkel L3/L5 zur Vertikalen zu den Zeitpunkten des ersten Bodenkontakts und der maximalen Beckenkippung 3-6 Bilder nach dem Bodenkontakt erfasst; weiters die Bewegung von Becken und Lendenwirbelsäule vom ersten Bodenkontakt bis zum Maximum und außerdem die Form der Wirbelsäulenkrümmung in der Frontalebene - in Annäherung an eine S- bzw. C-Form.
Die Zeitpunkte zur Beurteilung der Becken- und Wirbelsäulenstellung sind der erste Bodenkontakt (foot contact) und der Referenzzeitpunkt (reference time or reference frame), wenn beide Knie auf selber Höhe sind, das Schwungbein also am Stützbein vorbeischwingt.
Zu diesem Zeitpunkt ist in den meisten Fällen die größte Abkippung des Beckens erreicht und das Becken steht senkrecht zur Kameraebene. Dies stellt einen günstigen Beobachtungszeitpunkt dar. Mit der Beckenabkippung schwingt auch die Lendenwirbelsäule nach derselben Seite und erreicht die erste maximale Seitschwingung. Der Vergleich der Becken- und Wirbelsäulenbewegung zwischen dem Schritt rechts und dem Schritt links gibt Auskunft über die Symmetrie des Ganges, über Beinlängendifferenzen und über die Beweglichkeit der Lendenwirbelsäule bzw. etwaige Skoliosen. Jede Asymmetrie des Ganges - Hinken, asymmetrische Schrittlängen usw. - ist im Rechts-links-Vergleich der Becken- und Wirbelsäulenbewegung dokumentierbar. Ebenso können - dies wird im vorliegenden Beitrag versucht - Therapieerfolge an der Symmetrie des Ganges dargestellt werden.

Vergleichsdemo: Normaler, fast symmetrischer Gang
Um die Becken- und Wirbelsäulenbewegung im vorliegenden Beitrag besser einschätzen zu können, wird vorweg ein Doppelschritt einer fast gleichaltrigen Frau mit ähnlichem Gangmuster vorgestellt.

In der ersten Reihe (Abb.1,2) ist die Becken- und Wirbelsäulenposition zum Zeitpunkt des ersten Bodenkontakts dargestellt. Die Beckenstellung ist rechts und links fast horizontal und auch die Stellung der Lendenwirbelsäule ist nahezu gleich.
Zum Referenzzeitpunkt (1. Maximum) kippt das Becken deutlich ab (6-7°) und auch die Seitbewegung der Wirbelsäule ist eindeutig (3-4°).
Während sich bei den Becken- und WS-Winkeln eine gute Symmetrie zeigt, sind die Kurvenformen der WS unterschiedlich, was auf eine „Funktionsschwäche“ der Wirbelsäule bzw. eine Skoliosierung hinweist.

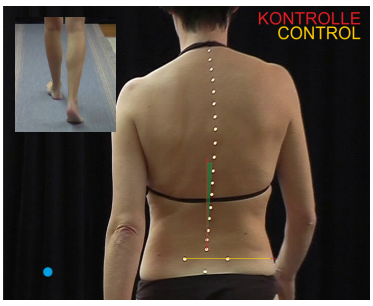

Abb. 1: Aufsetzen links.

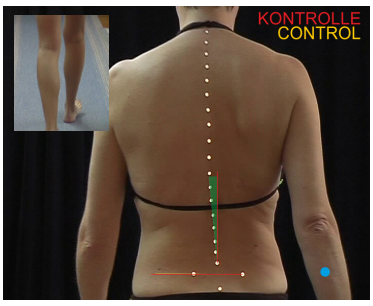

Abb. 2: Aufsetzen rechts.

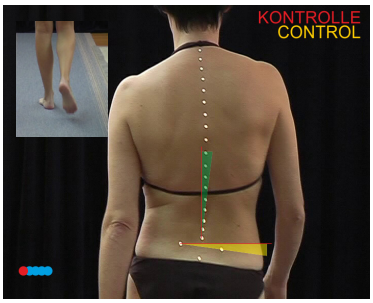

Abb. 3: 1. Maximum Schritt links

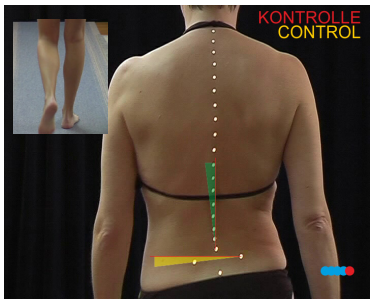

Abb. 4: 1. Maximum Schritt rechts

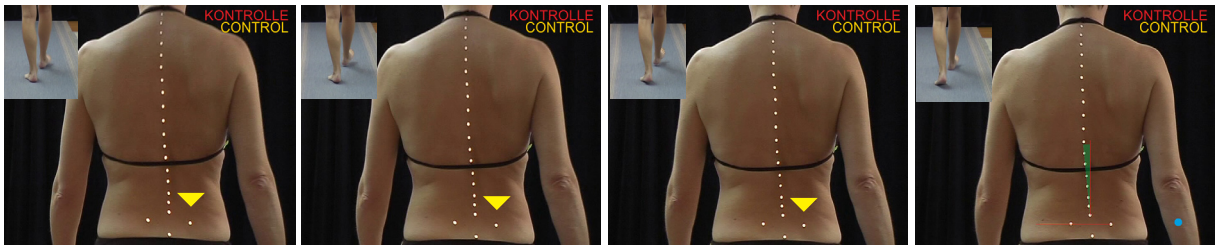

Abb. 5: 3. Bild vor dem Aufsetzen, 2. Bild vor dem Aufsetzen, Bild vor dem Aufsetzen, Aufsetzen rechts

Die Bestimmung des Referenzzeitpunktes kann mit einer Seitkamera erfolgen oder mit Winkelmessung der Beckenstellung, aber auch durch eine genaue Beobachtung der Beckenpunkte: Bis zum Aufsetzen der Ferse senkt sich die Beckenseite des aufsetzenden Fußes. In Abb. 5 zeigen die gelben Pfeile auf der Schwungbeinseite nach unten. Mit dem Bodenkontakt (Aufsetzen rechts) bewegt sich der rechte Beckenpunkt nicht weiter nach unten. Das Becken beginnt auf der anderen Seite nach unten zu kippen (gelbe Pfeile in Abb. 6). Bei der maximalen Beckenkippung werden Beckenwinkel und Winkel der Lendenwirbelsäule erhoben, bzw. die Bilder der maximalen Kippung beim Schritt rechts und Schritt links einander gegenüber gestellt.

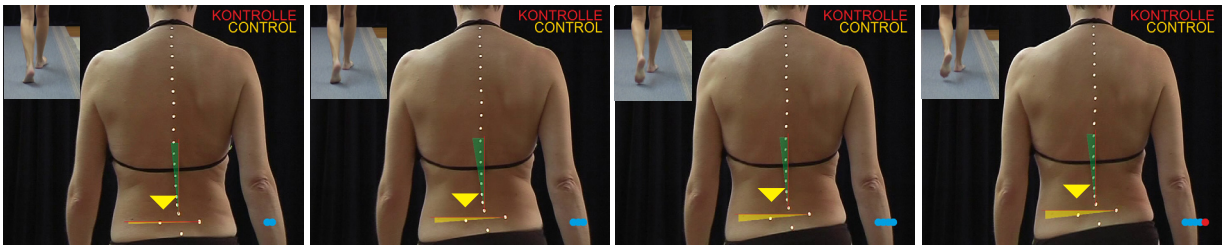

Abb. 6: 2. Bild nach dem Aufsetzen, 3. Bild nach dem Aufsetzen, 4.Bild nach dem Aufsetzen, Referenzzeitpunkt.

In der Bildreihe und im Video wird das Aufsetzen des Fußes rechts im Bild auf der rechten Seite mit einem blauen Punkt markiert. Die nächsten Bilder haben 2 bis 4 Punkte und der Referenzzeitpunkt ist mit einem zusätzlichen roten Punkt markiert. Im Video - wie auch in der Bildserie Abb. 5 und 6, sind die Beckenwinkel und die Winkel für die Lendenwirbelsäule eingezeichnet.

Video vor und nach der Gangschulung

Das Video vor der Therapie zeigt den markierten Rücken. Die Winkel für Becken und Lendenwirbelsäule werden nur zum Referenzzeitpunkt eingeblendet und zwar nur beim ersten Schritt rechts und beim Schritt links. Beim letzten Aufsetzen rechts werden keine Winkel eingeblendet, da sie für den Rechts-links-Vergleich nicht herangezogen werden.

Auch im Video nach der Therapie werden nur die Winkel der beiden ersten Referenzzeitpunkte angezeigt. Im Video ist die Seitansicht der Fußbewegung eingeblendet. Damit können der Zeitpunkt des Fußaufsetzens und der Referenzzeitpunkt (= beide Knie auf selber Höhe) genau bestimmt werden.

Die Videos zeigen, wie im Beitrag ausgeführt, dass vor der Therapie zwischen dem Schritt rechts und dem Schritt links eine deutliche Differenz der Beckenwinkel und der Winkel der Lendenwirbelsäule zur Vertikalen besteht. Der Seitenvergleich bringt also eine deutliche Asymmetrie zum Ausdruck. Nach der Therapie ist die Symmetrie verbessert. Damit ist neben der Schmerzfreiheit und dem subjektiven Eindruck der verbesserten Körpersymmetrie auch eine Harmonisierung des Gangmusters erreicht worden.

In den drei Videosequenzen sind die Einzelbilder jeweils 10mal eingeblendet. Dies entspricht einer Bildfrequenz von ca 250 B/sec.