Correction of scoliosis in adulthood without surgery

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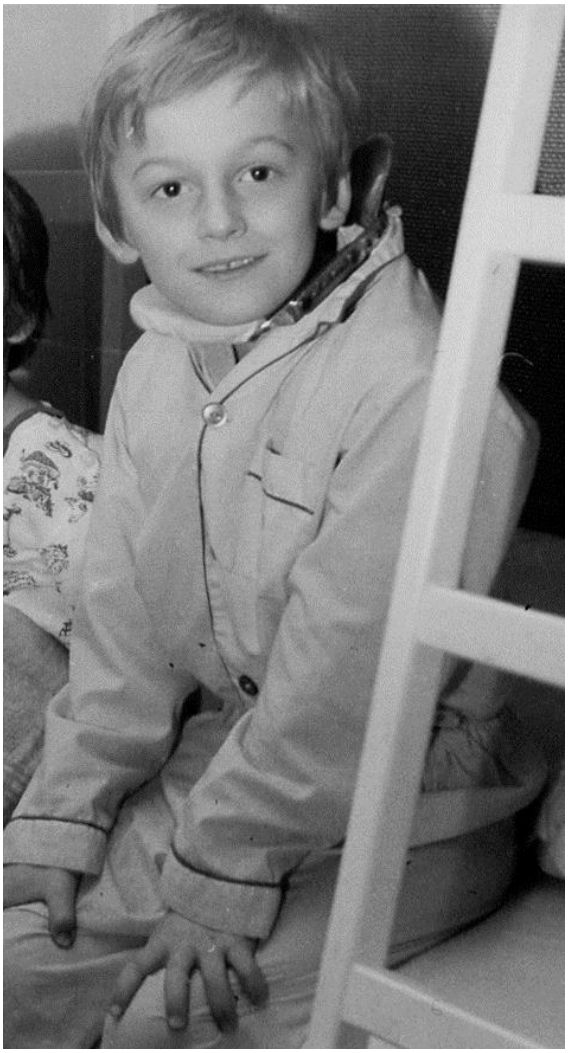
Introduction

The spine is curved in the form of two letters S in a human because of the upright posture, if you look from the side. It is bent back in the thorax and sacrum, forward in the lumbar and neck regions. If you look from behind, the spine is straight when the body is upright. This is true for most healthy people, but asymmetric growth in children can lead to bending of the spine sideways. This state or condition is called scoliosis. The name is of Greek origin, means curvature and was used already by Hippocrates. Galen narrowed its meaning to the sideways curvature. Most often the backbone is curved to the right in the thoracic and to the left in the lumbar part. Vertebrae are also twisted, turned in their axis, causing hump in the back. This happened also to me. Scoliosis was indicated around the seventh or eighth year, the papers were lost long ago. I was sent to the orthopaedic hospital in Valdoltra, where such problems of the youth were cared for then. My body was wrapped with gypsum sheathing which was then cut and taken off. So they got a mold, after which they produced a brace, named after the American city Milwaukee, where it was developed. It was made of leather, hugging the pelvis and loins, while steel brackets, one front and two rear ones, holded a neck ring, which supported the head with a chin pad and a plate at the back of the skull. It was to be worn continuously, day and night. By forcing one's body in the upright position it should at least prevent further false growth. To correct it, it was unlikely as it proved. Some time I stayed



At seven or eight years at home. I wear a Milwaukee brace because of scoliosis, its collar part is only seen. At the age of 11 years I stopped wearing braces because of renal disease and remained without any other treatment of scoliosis as well. Irregular curvature of the spine increased over the years.

in the hospital. I had to get used to wearing a brace, and we also had exercises to strengthen back muscles and swimming in the pool that is good for the back. A primary school was

organized in the hospital and I attended classes there. I remember that it was easy, because we learned things treated in the Ljubljana school earlier. But when nature and society was the subject, I became acquainted with the Primorska, which I liked. As there was no room in the children's section, I was installed with big boys and girls who also made fun with me. I was even prepared to dance. Scoliosis was treated in them with plaster from neck to pelvis, only in the abdomen a cardboard was inserted. When I outgrew the brace, I had to repeat the process. New bodice was a little different. Plastic was already under the chin. In Ljubljana, classmates called me Tortoise because of it.

With children in the school of the Orthopaedic Hospital Valdoltra.

Discontinuation of treatment

When I was eleven years old, I experienced acute renal failure as a result of dehydration, which followed food poisoning. My life was saved in the then young dialysis department of the Medical Centre, where peritoneal dialysis was performed. Renal function was restored, but there was inflammation that couldn't be cured by any antibiotic. Inflammation left lasting effects on the kidneys, and since 1978 when I was 16 years old, I had to go on regular hemodialysis. After the problems with kidneys in 1973, doctors advised against wearing corsets because of pressure on the kidneys. Since then, my scoliosis has developed its own way and never has been considered by the practitioner. A few years I still grew and over the years the back curvature increased. Because of the hump I had to tilt the car seat back more. Since I never had back pains and didn't care for my appearance scoliosis didn't bother me too much. I have reduced lung capacity, however, and was never able to run over longer distances. With a long walk I had no problems, only when walking uphill, I was slower than others.

Therapy restored

From 1992 to April 2005 I was cleaning the blood with peritoneal dialysis in which the internal abdominal membrane is used for the exchange of substances. Several times a day I poured fresh solution into the abdomen through a catheter, and discarded the old one before that. In 2005, that dialysis was no longer viable and I had to go back to hemodialysis, in which blood is cleaned outside the body in an artificial kidney. It was an opportunity to finally do something about my scoliosis. Previously, it was not possible to compress the stomach full of water and the catheter at the waist. I was 43 years old then and the medical profession stands that after growth is completed the correction of scoliosis without surgery is no longer possible. During operation spinal vertebrae are aligned and partly broken, consolidated with metal bars and screws, overlaid with bone tissue harvested from the pelvis, and fused together. The risk of complications in surgery is high and long-term effects are questionable (Weiss & Goodall 2008). Serious operation of kidney transplantation was also projected for me, which I refused until now, but it probably will not be able to avoid when dialysis is no longer possible. So I decided to take action by my own method. The bones do not stop growth in adulthood, after all, they just do not extend any more. Bones are reserves of minerals and proteins in the body and are degraded when organism needs them. Subsequently, they grow again, bone is constantly renewed and transformed. So, my effort can succeed.

I found that my spine is not bent forward in the lumbar part as a normal lordosis, it is only bent sideways. I assumed that the curve sideways will disappear, if I managed to bend the spine forward, as is correct. Perhaps this will also have a beneficial impact on the higher parts of the spine as it will have to establish a new equilibrium. When I still had a catheter, I tucked socks at the back at night under the elastic net that held it in place. When I slept on my back, it was forcing me to arch my back. Then I bought elastic bodice in a shop with medical stuff. I stitched longitudinal metal braces to it, which I twisted in the form of my body. The one that crossed the hump had to be bent almost at right angles to fit it. With this corset I then went to sleep and walks. I also trained the muscles that straightened my body. Three months later, in the spring of 2006, I ordered an underbust corset of

the waist cincher type on the internet. It was actually a band used by ladies to constrict their waists (Axfords C225). It forced me into an upright posture and created lumbar lordosis. I had to take it off before lunch so I could eat but put it on again before sleep. After some time I ordered a longer underbust corset, which grasped the pelvis and ribs better, but since it was not custom made, it did not fit perfectly (Axfords C229). When I received it by post, my mother showed me hers that was very similar, only it was laced by the side, not the rear. She had scoliosis at a young age too and in that time scoliosis was treated with corsets from fabric, like the one I am using now. I walked a lot wearing the corset, also in the mountains. In any case, it is necessary to strengthen the back muscles, so I also practised.

Shorter right leg?

When I looked in the mirror, I found out that my pelvis is leaning to one side. When I raised the heel of my right foot an inch or two, it became horizontal. So I concluded that my right leg is shorter and the cause of my scoliosis. Because of the shorter leg the pelvis leans to one side while walking and spine must find balance of the body in this situation. The balance is established when the spine twists sideways in a S-shaped curve. Doctors never found that and the majority of scoliosis cases are of unknown cause. They are called idiopathic scoliosis.

Leg length discrepancy, as the phenomenon of uneven leg lengths is called, is usually referred only as a cause of nonstructural scoliosis which can be corrected by the use of shoe lift. However, when nonstructural scoliosis is not eliminated in time, it evolves into structural scoliosis, which cannot be corrected by posture improvement (Hawes & O'Brien 2006).

In June 2006 at a lecture. This year, at the age of 43 years, I began to wear a corset of the waist cincher kind which created previously unnoticed lumbar curve (lumbar lordosis). This proper curvature of the lumbar spine is diminished in scoliosis. Photo by N. Elsner.

In order to give the pelvis a horizontal position while walking, I should have the sole of the right shoe two centimeters thicker. So thick heel insoles for shoes are not available, so I made them myself from cork. I inserted them in shoes, but after a long walk the heel became painful and all shoes are not even

suitable for such thick insoles, so I soon gave up. For successful therapy specifically designed shoes should be used, one of them should have a higher heel. But pelvis can be tilted also because of rotation, which is caused by scoliosis. The diagnosis of uneven leg lengths could be wrong.

Finally, progress

After several years of therapy I had the feeling that the back is better, but when I looked in the mirror, the big hump seemed unaltered. Only a proper lumbar curve I managed to develop and because of that the hump was probably slightly reduced. Unfortunately, before the start of therapy, I did not document the initial situation and I had no comparison. Maybe back in the beginning I did not photograph because I did not even believe in success. Therefore, I was happy with the photos from meetings, which were donated to me by friends. On some my back is seen, so I can compare with the current situation.

When I lost hope that I will achieve anything with the corset, I stopped wearing it. After a few days, I was surprised to find that there has been an improvement. Thus it is necessary to interrupt treatment with the corset to allow the spine to find a new balance. The corset prevents that by pressure to the whole body.

I found that I need a corset that would stretch all the way from the armpits to the pelvis, and press the hump in order to reduce. It should be custom made and I found a website where I could order an overbust corset made to my measures in England without too much additional charge (Corsetcurves Venus). I got it after a few days. It fits me much better, just behind the hump it is standing sideways. I wore it since September of 2008.

In August 2009, the hump was still pronounced despite a three-year therapy. Photo by M. Maher.

However, a vein containing arterial blood from the fistula, necessary for the dialysis, clotted in my shoulder. I began to wear the corset only occasionally. Sometimes at night, sometimes during the day or at night and in the forenoon, only a day or two a week. On the trips I went mostly without the corset to strengthen the back muscles while walking. I was afraid that the corset could worsen blood flow by pressure and could promote thrombus formation. When I photographed myself in July 2011 and compared the situation with old photographs, I noticed a significant improvement of my back, anyhow. I noticed the same also by touch and in the mirror. So, the five and a half years of efforts had an effect. Correction of scoliosis in adulthood without surgery is possible.

Overbust corset improves body posture and shapes the chest, but derotation is achieved only after the interruption of corset wear. View from the side, front and rear in July 2011.

From July 2011 until January 2012, I continued to alternate days when I wore the corset, and days when I did not. The corset improved the position of the ribs and arched my back, but it could not decrease vertebral rotation, and therefore did not reduce the hump immediately. But perhaps it softened ligaments, so I can, after I take off the corset, by pressing the hump from behind and with contractions of the back muscles, decrease slightly the hump, moving the vertebrae slightly towards the correct position. Comparison of images taken in July and January documents a substantial improvement. In side view from July, the hump was of a semi-circular shape and connected with the back at right angle. The skin of the chest and abdomen at front was loose, not supported by the ribs. On 10th January the back was evenly narrowing towards the waist. At front, ribs supported skin of the chest and abdomen.

But how to convince someone on my success? Each thinks that it is a hoax. How could I achieve the impossible in such a primitive, Victorian way? But corsets, such as used by me, successfully curved bones through the centuries, only that ladies used them to create narrow waist, a beauty ideal. Initially they were used to treat scoliosis as well, but were then replaced by more modern braces which do not straighten the back by compression, but by supporting and extending it. The bone, however, most effectively transforms under pressure. It is growing stronger in those places that receive maximum stress during movement of the body (Pearson & Lieberman 2004). Good old corset, shaped after the Victorian example, achieves success by putting load on the ribs and vertebrae through them. Since it is made of cloth, it is permeable to the air and moisture, so it can be used even during strenuous walk under the hot sun, which plastic brace does not allow. It is more comfortable as it adapts to the shape of the body. It can be washed by hand, using soap. Spiral steel boning is now used to stiffen it and not whale

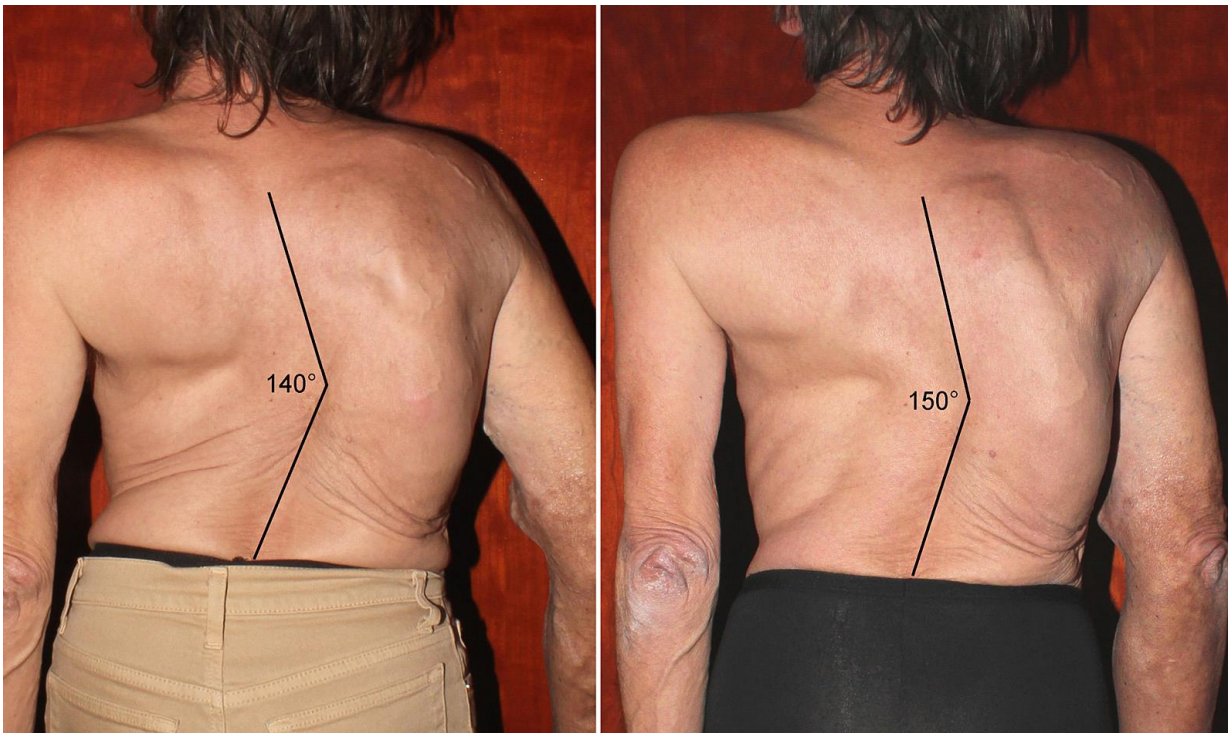
The left image was taken in the first of July 2011. Although I had already reduced the hump, it still looks horrible. It is of a semi-circular shape and connects with the back at right angle. The skin of the chest and abdomen at front is loose, because it is not supported by the ribs.

Right view was created in the 10th January 2012. The difference should be obvious to everyone. From the blade down the back is evenly narrowing towards the waist. At front, ribs support the chest and skin of the abdomen.

bone. The corset is not adjusted to the back deformations, it is symmetric. The body must adapt to it, to straighten.

Monitoring: March 2012

I photographed myself again on the 23rd of March. View from the rear, in comparison with the image taken in January, shows improvement on the left side where we can see previously hidden ribs. If a line is dragged from the extremity of the curve to its upper and lower end, and the angle measured that is formed by these lines, we find that the angle was 140° in January and 150° in March: the apparent curve on the surface is reduced. In an upright spine, this angle would measure 180°. Digital photographs can be taken without limitations as the body is not exposed to radiation like in x-ray imaging. To measure angles the lines from the photos are transferred to a picture of a



Comparison of the back, photographed in January (left) and March 2012 (right). Apparent curve has been reduced and at the left side of the body we see the ribs, which were shifted before.

Comparison views from the July 2011 (left), January (middle) and March 2012 (right). Spatula, which was raised before, descended lower in the right picture.

protractor in the Adobe Photoshop program. The apparent curve on the surface does not correspond with the curvature of the spine, however. It is just a simple indicator used in monitoring of the development and is dependent of several factors.

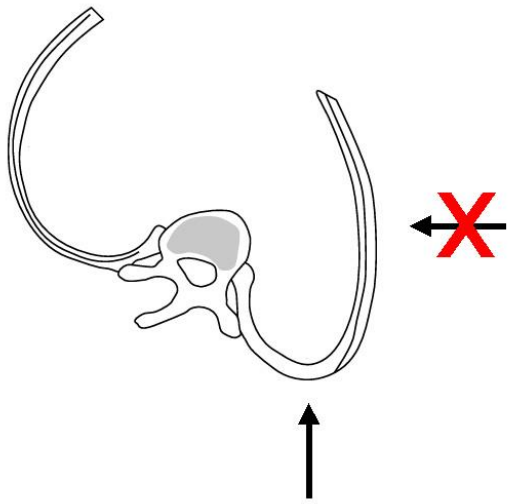
In side view, in comparison with January the hump seems increased again at first sight. But a closer examination reveals that the scapula, which was previously raised by the hump, is lowered. Ribs, which previously raised it, form the curve of the hump. But the chest and abdomen at front are supported well and not loose, as they have been in July 2011.

Why interrupt corset wear

To determine why we need to alternate days when wearing corset and days without it, five days in a row the corset was worn during the day and then the back photographed. In lateral view, the hump was reduced and the scapula lifted. The view from behind showed the curve sideways to measure 144°, thus it was more pronounced than in previous image (151°). The next day, the curve measured 151° again. Corset can thus temporarily worsen the condition of the curve, but this is rapidly corrected when corset wear is interrupted. The chest easily rotates for a certain degree when the corset is tightened too much. Then it derotates again, switching between two stable positions. When this happens often, therapy should be discontinued for a longer time.

After the corset is taken off, derotation forces can be applied to the thorax. Only by them, correction of scoliosis can finally be achieved. We must press the hump from behind, not laterally as this flattens the rib cage. Similar manipulation was performed to correct spinal deformities already by Hippocrates and Galen. While extending the body, they pressed the hump with the leg, whole body or with a plank, attached to the wall for leverage (Vasiliadis et al. 2009). But press against the chair backrest or the hard floor when lying is sufficient.

In the days when corset is not worn the chest can expand and the muscles are more active. Besides, intermittent bouts of loading elicit a greater response in bone forming cells than a single long lasting bout of loading and thus stimulate bone remodeling better. In rats, eight hours of recovery time are required to restore the full responsiveness of cells (Pearson & Lieberman 2004).

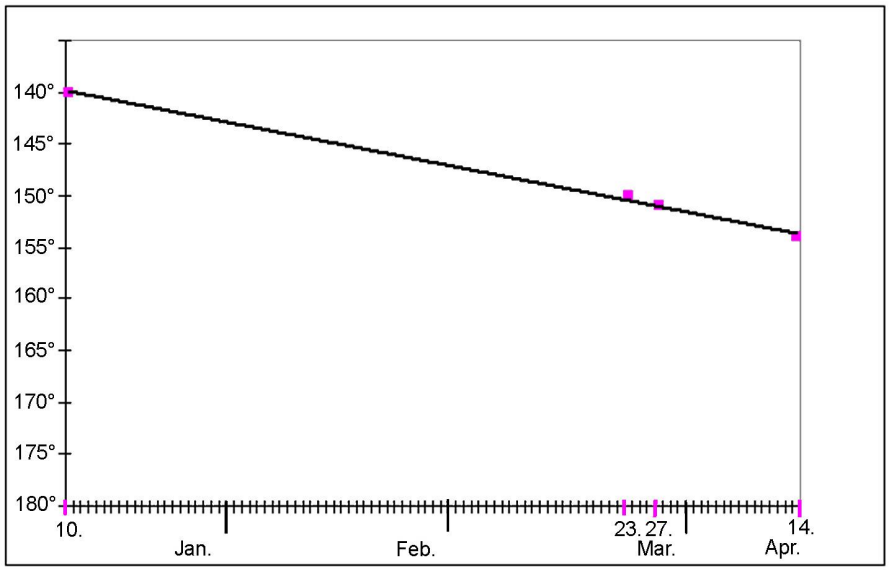


On the hump created by deformed ribs, we have to push from behind. Lateral pressure would flatten the chest even more.

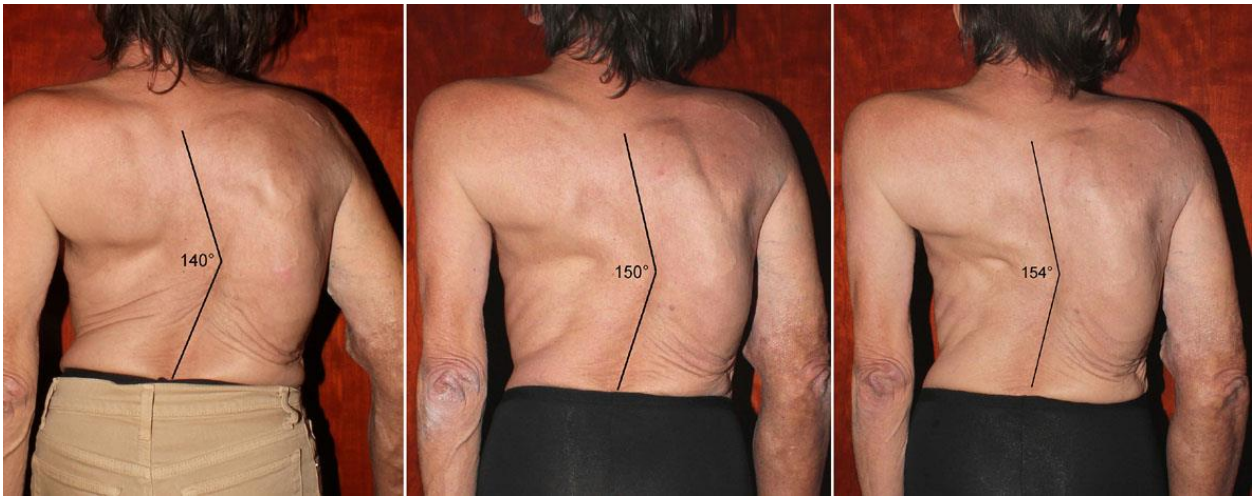
On 27th March 2012 the curve measured 151° (left); after five days wearing corset, the curvature on the 6th April increased to 144° (center); just a day later, the curve measured 151° again (right).

Towards eradication of scoliosis?

Apparent curvature diminished over time. The exceptional case of 6th April cannot be considered because it was not documented in the same conditions. On the 10th January the curve was 140°, 23rd March 150°, 27th March 151° and 14th April 154°. If a graph is drawn of these data points, a straight line can be drawn through. If it is extended into the future, 180°, a completely straight spine, is reached in October. However, in May 4th and 22nd and in June 9th the curve remained the same as in April 14th. Limits of the possible correction of scoliosis could have been reached.



Reduction of the apparent spinal curve from 10th January to 14th April 2012. Through the points we can draw a straight line, so the curve steadily decreased with time.

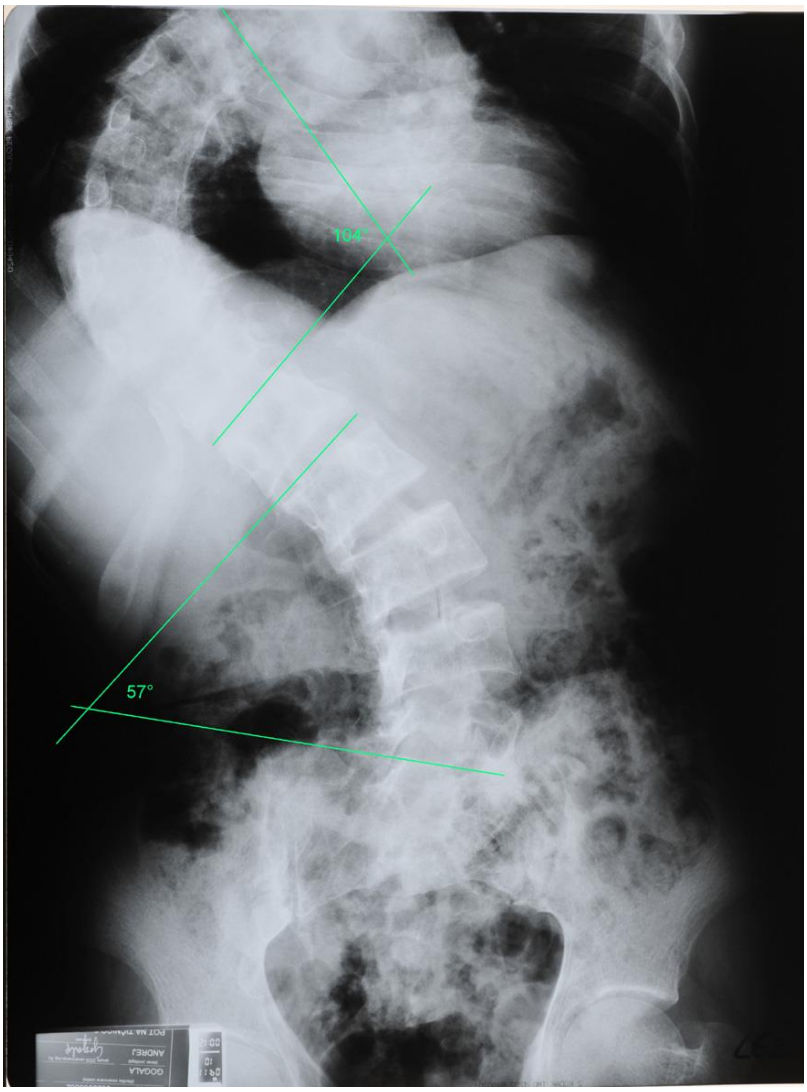


Apparent curvature of the spine on 10th January measured 140° (left), 23rd March 150° (middle) and 14th April 154° (right).

How severe is actually my scoliosis?

From the archives of the Department of Dialysis of the Ljubljana Medical Centre, I got x-ray images showing my spine. Finally I was able to measure Cobb angles, which are used to measure the curvature and to estimate the severity of deformation. In the images from the years 1997 and 2005 only the thoracic curvature is seen which is equal in both images, so it did not deteriorate before the treatment. The image from 2010 shows both curves. Upper thoracic curve is larger and measures 104°, the lower lumbar measures 57°. Curves over 60° are considered a very severe form of scoliosis and in the curves over 80° it comes to lung function impairment. Vital capacity of my lungs measured 1380 ml in 2010, only 40% estimated for my hight.

Early onset scoliosis like mine can cause larger curves than more common adolescent scoliosis because unbalanced growth of the spine lasts longer. Usually the curvature progresses slowly also in adulthood. Linear rate of progression at about one Cobb degree per year had been demonstrated in progressive adult scoliosis (Marty-Poumarat et al. 2007). If untreated, juvenile scoliosis can cause serious cardiopulmonary complications and premature death (Mohar 2012). Untreated late onset scoliosis, for comparison, causes little physical impairment other than back pain and cosmetic concerns (Weinstein et al. 2003).



X-ray image from 2010 with Cobb angles measured. Thoracic curve measured 104°, lower lumbar 57°.

New improvement in June: pelvic obliquity reduced

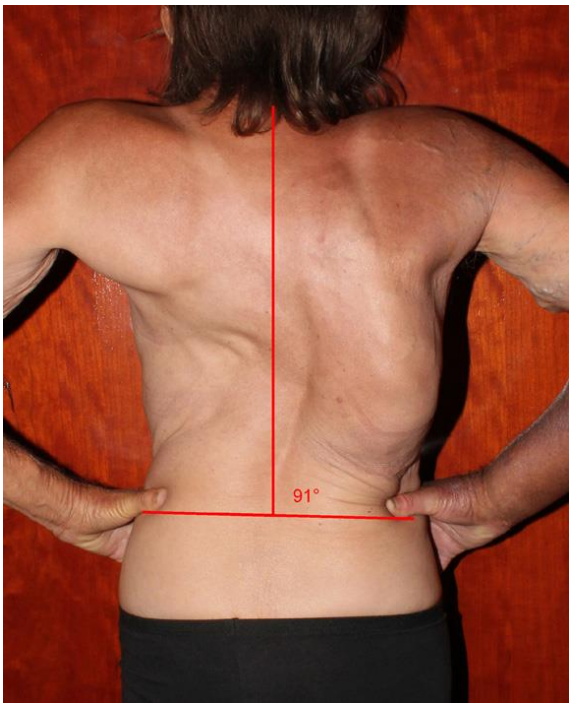
Imaging of June 9th showed unchanged curve of the spine, an important change from the previous state I noticed later. I found that my pelvis is no longer tilted and analysis of the photographs showed a significant difference. Pelvic obliquity can be the consequence of unequal length of legs, but pelvis could also be shifted due to rotation in the lumbar part of the spine present in scoliosis. Scoliosis can develop because of pelvic obliquity, but scoliosis also causes or increases pelvic tilt. It is difficult to determine what occurred first. I linked the iliac crests on the photos with a line and draw a median line of the body. Then I measured the angle between these lines. It would measure 90° if the pelvis was not inclined. In me, the angle at the right side of the body measured 96° in May 4th, but only 92.5° in June 9th. A mistake due to posture is possible, so I waited for the imaging of the June 22nd. The angle was the same, so the pelvic tilt is actually reduced. I measured also a decrease in apparent curvature, first time after April 14th, when it was 154°. This time the angle of the curve measured 156°. Since there was no improvement in May, I increased the time wearing the corset. Again I wore it at night and during the day, several times even during walks, as at the beginning of therapy. New improvement shows that limits of the scoliosis

correction may have not been reached yet, while leveling of the pelvis shows that my legs are not really of unequal lengths or the difference is very small.

When I had to cross a greater distance when walking down, I used to step forward with my right foot, which I could stretch more. I can now step forward with both feet, the difference in muscle and tendon tension is gone. Asymmetry in raising straight legs is typical of scoliosis (van Loon 2012).

The circumference of my chest is much larger now than it was at the beginning of treatment six years ago. Best evidence for that are the underbust corsets I used then. In that time, I tightened them almost to their maximum tightness. Now, I am not able to put them on.

In July 13th the curve measured 158°, a further improvement. But photographs made on July 26th brought disappointment. The curve was 153° again. Two days later I was able to derotate the chest with my hands and back muscles only, what proves that it is



Pelvic tilt measured in August 17th. Thumbs are put to the iliac crests of the pelvis to mark them. The angle at the right side was 91°.

flexible to some extent. In August 17th the thoracic curve measured 156° and pelvic tilt 91°.

Dorsal and lateral views of the state of scoliosis on September 12th 2012.

Is corset harmful now?

From April onwards, there was no real improvement of curvature. A few degrees better and then worse again, the situation remained unchanged on average. I found that the hump increases after wearing corset, several days without it improved the back. I've been watching what happens when I put on the corset. I found that the chest flattens, rotates. This has happened before, but only when I tightened corset too much. Now it happened already at a slight compression. It has become more flexible. I concluded that the therapy with corset is over, I should switch to exercises and other forms of chest derotation, which are more efficient at greater flexibility. Bodice has done its part, in the present state it does more harm than help.

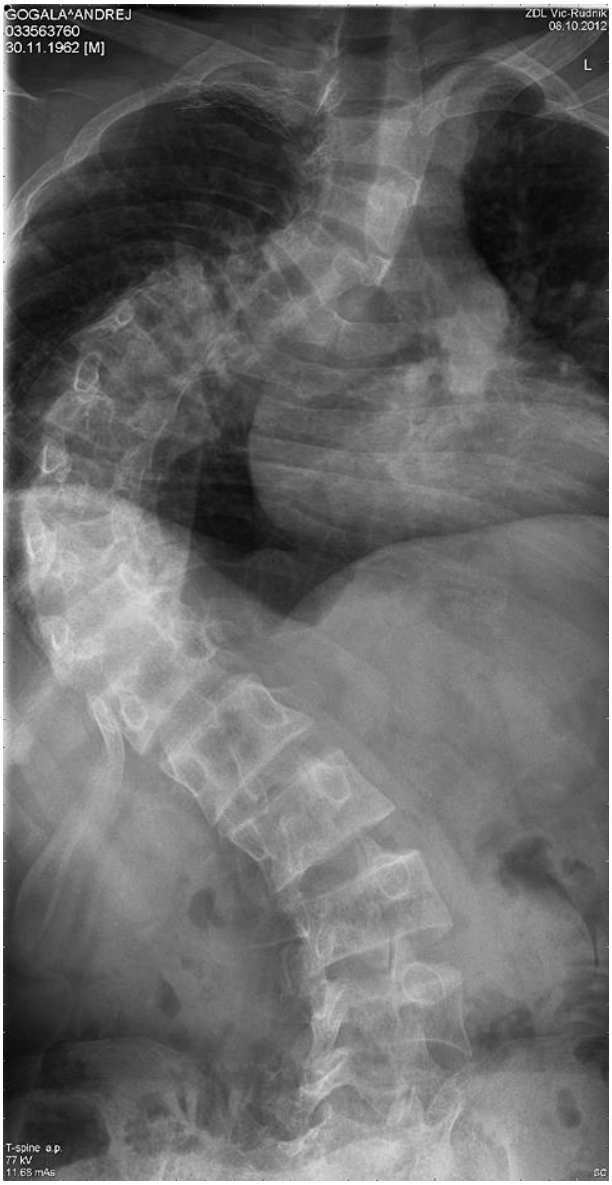
With the end of August 2012 I stopped wearing corset. I straightened my back by frequently correcting posture and by pressing the hump with my hands or the ground. On September 12th thoracic curve measured 157°, less than on September 1st (153°), but equal to the best achievements in the past. Later on, I tried to wear the corset again occasionally and found it can be used again. During longer interruption of wear the chest stabilized in the new, better position.

In a view from the left side made on 1st November 2012 the restored lumbar lordosis is seen well. Smaller picture at right, taken in August 2009, shows a remarkable difference in the hump size and inclination of the back plane. Since lumbar lordosis was missing, the head is shifted forward, and back muscles are strained as a result.

X-ray imaging

According to appearance the scoliosis improved substantially since the beginning of treatment. The hump is markedly reduced, the curvature of the spine seems to be reduced also. But only x-rays can show the true state of the curves, so I was x-rayed on October 8th. Images have shown that in fact there has been almost no change in spinal curvature. All I have achieved is derotation of the chest, improvement of the shape of the ribs and lumbar lordosis. This reduced the hump and led to better rib support of the right side of the chest at front and left side in rear. Changes have a positive effect on breathing and possibly prevent further deterioration of the curves. The curvature didn't improve, however, indicating independence of processes behind bending of the spine and rotation of the chest.

Although the curvature did not reduce, the treatment was successful, as it improved performance and physical appearance. Physical appearance is the most common reason for which patients or their parents choose to have spinal surgery (Hawes 2003, 2006, 2010). In the treatment of scoliosis, attention is focused particularly on the curvatures, but derotation may be more important. Lung volume reduction, which can be life-threatening, is not caused by curvature of the spine, but rotation of the chest which becomes flattened.



X-ray image of the spine, performed on October 8th 2012. If the curvature of more than 100 degrees resulted from uneven bone growth, vertebrae should be wedge-shaped. But no, only intervertebral discs, which are made of cartilage, are transformed. They are stretched like bellows of an accordion.

Discussion

A question remains what is in the successful treatment of scoliosis that distinguishes it from less successful established methods. The most important difference is in constant slight compression of the chest by the corset. I believe it is also important to create lumbar lordosis, thus to correct spinal curvature forwards in the waist. To this end I have slightly adjusted the corset. The lower tip of the front metal busk with staples I bent backwards. Thus I have caused the pelvis to tilt forward and the lumbar lordosis to increase while the pressure to the stomach decreased.

Feeling of a hug given by the bodice is pleasant. Absolutely it should not be tightened too much. If it starts to pinch us, we must release the grip by loosening the lace at the back. This allows us to constantly adapt corset to our body. The body changes with the filling and emptying of the stomach and the degree of hydration.

Corsets of textile embrace the whole body, but the strongest pressure is directed on the most prominent angles of ribs and pushes them inward. Since the bodice acts with the same force on the ribs from the other side also, the ribs are slowly getting more rounded, gaining the proper form. Thus the deformation of the chest is reduced. However, since the corset does not have empty spaces where the chest could expand, treatment with textile corset must be interrupted.

Flat back is often accompanying scoliosis (Negrini et al. 2012). It has the same shortcomings as the flat foot, it does not allow flexibility. The spine should be slightly curved, so the creation of correct lordosis is so important. When the spine is curved in the sagittal plane, curves to the sides could be reduced (van Loon et al. 2008). In people without lordotic curve the head is not positioned above the pelvis, but in front of it. The center of gravity outside the body axis causes overload of back muscles causing pain. Today, it seems incomprehensible that the first Milwaukee braces were designed to reduce lordosis (Fayssoux et al. 2010). TLI (Thoracolumbar Lordotic Intervention) brace, which is symmetric and restores lordosis, is now tested in the Netherlands for the treatment of adolescent scoliosis (van Loon et al. 2012).

A. Negrini et al. (2008) showed it is possible to obtain a significant improvement of scoliosis in adults with exercises. I am convinced that wearing a backpack with camera equipment on my walks in nature was as important for the treatment of scoliosis as wearing the corset, which shapes the chest. Initially, I used them simultaneously, but later alternatingly, what proved to be more effective. Backpack wear leads to strengthening of the muscles that support the spine to stand upright. In addition, straps are forcing my shoulders to be at the same height when wearing a backpack. Backpack with my camera equipment weighs 3.5 kilograms and my weight is 42-43 kg. So pack weighs 8.2% of my weight. When I started going on walks without the corset, a muscle started to ache on the left (concave) side of the back, which was shortened due to scoliosis. But I persisted. If pain was severe, I stopped for a rest and then went on. When the muscle was strengthened the pain no longer occurred. After walking the hump increased temporarily. But the strengthened muscles then straighten the back. We can help by pressing the hump to the chair backrest while sitting or to the ground when lying down.

After the spine bends sideways due to asymmetric posture or other reason, back muscles on the convex side of the curve, which become stretched, cause rotation of the vertebrae and ribs (Brodhurst 1855). The ribs are pulled back to create a hump. This explanation of chest rotation is forgotten now, but several facts speak in its favour. Back muscles are even more tense when we lean forward. The hump becomes larger and is seen even at slight curvatures. Measurement of back tilt when bending forward has long been a test for the presence of scoliosis, called the Adams test. The spinous processes which serve for the attachment of muscles and ligaments are curved to the concave side in rotated vertebrae, a clear sign they have been exposed to a prolonged stress. They are linked together by the muscles, while vertebral bodies deviate easier from the body axis. Derotation and diminished hump can be achieved by the muscles on the concave side, when they are sufficiently robust. This fact is used by the physiotherapists to correct posture in scoliotic patients. On repeated asymmetric loading, however, vertebrae and ribs are transformed, making it difficult or impossible to return to the initial state (Hawes & O'Brien 2006).

The transformation of vertebrae and ribs in the process of bone remodeling is regulated by several hormones. One of them is melatonin, secreted by the pineal gland at night. In chickens and rats with destroyed pineal gland scoliosis developed, but administration of the melatonin prevented that (Acaroglu et al. 2012). It was suggested that lack of melatonin could be the cause of idiopathic scoliosis in humans also. But such a shortage was not detected in scoliotic patients (Brodner et al. 2000). Melatonin receptors can be impaired (Man et al. 2011). Melatonin suppresses bone remodeling by inhibition of bone resorption (Histing et al. 2012). When there is a shortage of melatonin, bone remodeling accelerates. During bad posture, when bones are loaded asymmetrically, scoliosis develops in children with rapid bone remodeling. Melatonin secretion is stopped by light and magnetic fields. To prevent scoliosis, children should sleep long enough in a dark room with electronic devices turned off. Transient melatonin deficiency is associated with curve progression and administration of melatonin before sleep may prevent this (Machida et al. 2009).

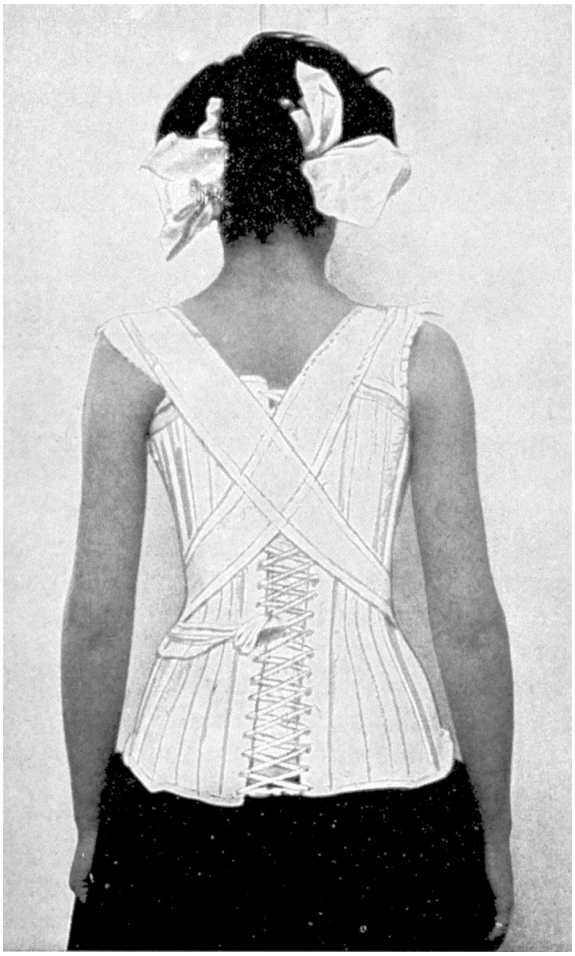
Leptin, secreted by adipose tissue, is also among the hormones suspected to have a role in the development of scoliosis. Girls tend to have higher levels of leptin than boys because they have more fat tissue. Fat deposition is stimulated by the female sex hormone estradiol (Burwell et al. 2009). This could be the reason why adolescent scoliosis is much more common in girls. In mice without front legs, which are forced to walk on two, leptin increased incidence of scoliosis (Wu et al. 2012). In girls with adolescent scoliosis less leptin content was observed in the blood, but increased effect of leptin in the brain. Leptin does not affect the bone directly, but inhibits the production and secretion of the neurotransmitter serotonin in the brain (Yadav et al. 2009). The consequences of reduced secretion of serotonin are appetite loss, reduced self-confidence or a feeling of security and increased activity of the sympathetic nervous system, which releases noradrenalin. This prevents the accumulation of bone mass, namely inhibits the second part of bone remodeling, the formation of new bone tissue, and favours bone resorption. The activity of the sympathetic nervous system produces a lightweight skeleton with long limbs, such as prevalent in girls with adolescent scoliosis.

The level of serotonin in the brain is not only affected by leptin, of course. Uncertainty after diagnosis and the treatment for scoliosis can significantly reduce adolescent self-esteem, increasing the activity of the sympathetic nervous system, which can speed up the curving of the spine. The adolescent needs professional support during treatment (Tavernaro et al. 2012). This gives him a sense of security or, in other words, increases the activity of the serotonergic neurons in the brain which also inhibit the perception of pain.

The disadvantage of plastic braces, used for the treatment of scoliosis and which immobilize thorax, is the atrophy of muscles due to constant support of the brace. Rigid braces reduce the curvature of the spine, but when they are not worn any more, the curve increases again. Weakened muscles cannot keep the backbone in the upright position. A review by Fusco et al. (2011) showed that physical exercises can improve the curvature, strength, mobility and balance of patients with adolescent idiopathic scoliosis.

Children with scoliosis caused by a neurological deficit have weak muscles even without a brace. They are treated in the U.K. by custom designed suits made of Lycra fabric with pre-stressed elastic reinforcement panels which derotate the trunk and guide patient into a proper posture (Matthews & Crawford 2006). Suits are tested also in mild idiopathic scoliosis cases.

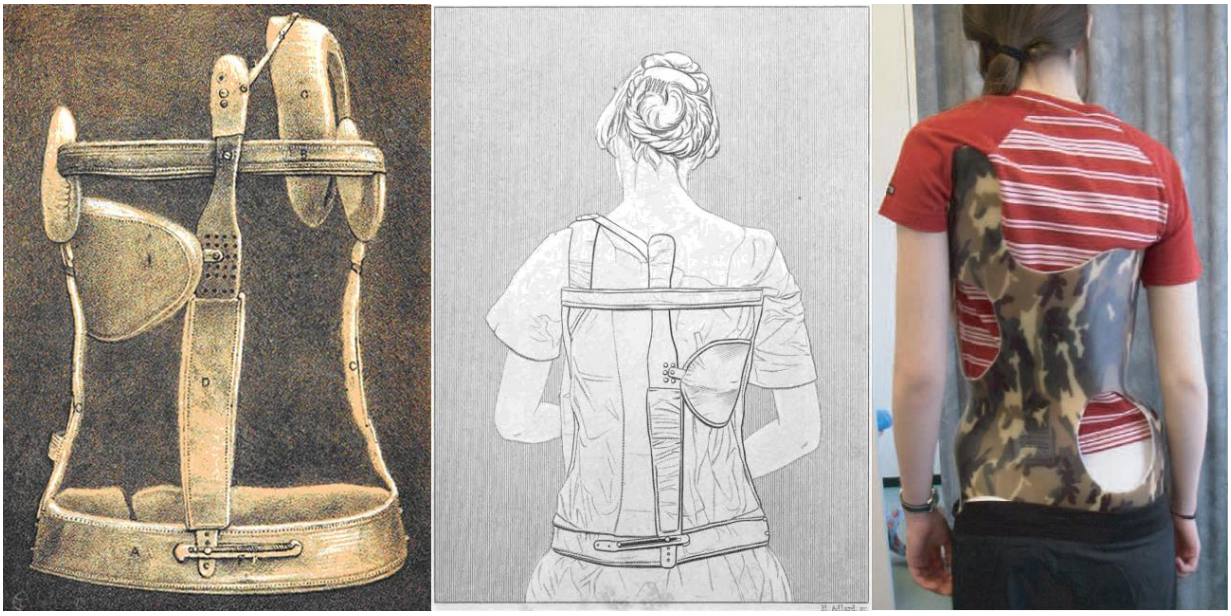
Although corsets from textiles in the 19th and the first half of the 20th century were sometimes used to treat or at least alleviate scoliosis, they did not gain sympathy of the leading physicians of the time. Albee (1919) published a picture of a textile corset for the treatment of scoliosis, but he recommends it only for immobilisation after spine surgery. The doctors cited



The Van Winkle corset-brace for the treatment of thoracolumbar scoliosis. Albee, 1919.

corset wear in young women of higher social classes as one of the main causes of scoliosis, because it causes muscle atrophy. Absurd is that instead of textile corsets they introduced treatment with plaster casts and rigid braces, which weaken muscles just as much, if not more.

Rigid braces for the treatment of scoliosis were used first by Ambroise Paré (1510-1590). They were made of metal. Among other things, he wrote that bracing does not help when the skeleton matures and the growth stops (Fayssoux et al. 2010). This assertion has rarely been contradicted. Brodhurst (1855) describes and figures a fairly successful treatment of an 18-year-old girl with his supporting device, which



Left: Brodhurst's device for the treatment of scoliosis; Middle: the same device in use (Brodhurst 1855); Right: modern Chêneau brace acts by the same principle (Weiss & Weiss 2005).

was the precursor of today's rigid braces and acted the same way. It put pressure on the convex side of the curve and lifted the shoulder in the concave side, just like a modern Chêneau brace made of plastic. Using traction and massage, Brooks, Krupinski & Hawes (2009) were able to improve chest expansion and decrease thoracic curvature in an adult with idiopathic scoliosis. Negrini et al. (2008) hypothesize that improvement of adult scoliosis achieved by their patient is a consequence of recovery from a postural collapse without changes in bone structure.

The treatment of severe scoliosis described here denies the established belief that in adults an improvement cannot be achieved with corsets. Actually, this should hold true also for most adolescents in the time of growth. Guidelines of the SOSORT Society for the treatment of idiopathic scoliosis from 2011 (Negrini et al. 2012) indicate that the goal of treatment with braces is to halt curve progression at puberty (or possibly even reduce it). It is believed that it is impossible to fully eradicate scoliosis with conservative treatment (no surgery). However, by combining the use of textile corsets, manipulation and physiotherapy, chest derotation can be achieved which could prevent further progression of scoliosis. The spine could not bend sideways, if ribs would not withdraw in the process of chest rotation. After derotation, ribs support the spine and prevent further bending, they serve as support beams. So we can possibly avoid operations that may have adverse consequences because of the operation itself or the fusion of the vertebrae.

Successful treatment of a single case does not mean that we can always expect the same result. But even a single successful treatment of an adult provides evidence that the premise about scoliosis as irreversible process is wrong (Hawes 2003, 2006, 2010). If chest deformity can be reduced in a patient with severe scoliosis in adulthood, it is much easier to do that in young patients in the period of rapid growth. Textile corset can improve the shape of the ribs, which cannot be done

by a surgeon at an operation. Lordotic curve of the lumbar spine is also created, if not developed, and with this tension of the back muscles is reduced. This reduces the possibility that muscles turn vertebrae and ribs, to rotate them. Therapy with the corset may not be suitable for people with severely decreased lung function, because corset restricts breathing. But I did not notice this at the beginning of treatment. My chest wall was probably so rigid that wearing corset didn't make any difference. When I tried to walk up a steep mountain path with the corset now, I found it unbearable. Every few steps I had to stop to get breath. I already forgot that such was my usual performance before the improvement of chest volume.

To successfully derotate the chest additional manipulative and physiotherapy is needed. My walks with backpack were not intended to be part of the therapy, but they proved to be just that. Postural corrections at any time during the day are also very important as they eliminate unbalanced loading of the skeleton (Lehnert-Schroth 2007). I added occasional pressure to the hump from behind, recommended also when applying plaster cast as an effective treatment for scoliosis in young children (D'Astous & Sanders 2007). Only derotation of vertebrae and ribs reduces the hump and increases volume of the chest, thus improving lung function. Surgeons only reduce the sideways curvature of the spine in operation, rotation of the chest persists and hump may even increase. To improve appearance, some surgeons excise ribs that form the hump and thus further impede breathing (Weiss & Goodall 2008).

A combination of chest compression by a bending brace together with exercises is used in Brazil to treat scoliosis (Haje et al. 2011). They use plastic braces made after plaster cast moulds. The method is effective in compliant adolescent patients. The effectiveness of a combination of exercises and wearing brace in adult patients with scoliosis was reported by Papadopoulos (2013).

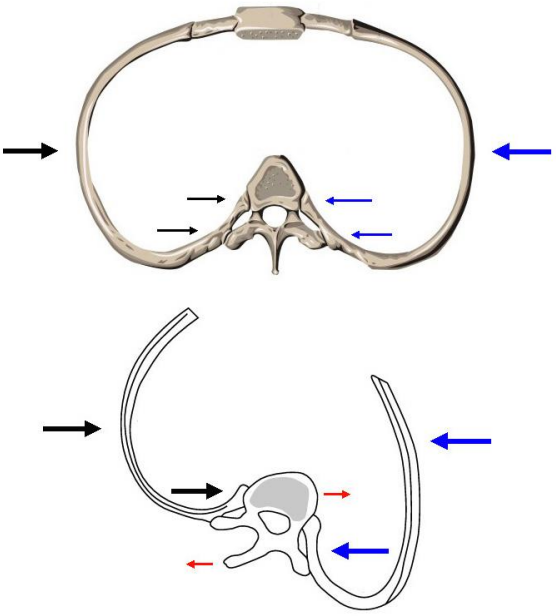
The formation of idiopathic scoliosis is probably not initiated by asymmetrical primary bone growth in the growth plates that exist only in children. Most spinal deformities begin as a nonstructural scoliosis (Hawes & O'Brien 2006). Wedge-shaped vertebrae are not always present, in some cases only cartilaginous intervertebral discs are transformed. Bending of the spine progresses even after fusion of the vertebrae by surgery and may break the metal rods that should keep it straight. All hormones, known to have an impact on the development of scoliosis affect bone remodeling which slows down with adulthood, but never completely ceases. Therefore, scoliosis usually progresses slowly in adulthood. This gives us the opportunity to reverse the process – both in children and adults who have at least some growth hormone secretion.

Aota et al. (2013) found an increased amount of bone resorption marker in the majority of patients with adolescent idiopathic scoliosis, while the bone formation marker was at a normal level. Thus, in them bones degrade faster than regenerate. This decreases the strength of the bone and can lead to osteoporosis, known to cause scoliosis in the elderly.

Heredity certainly influences the development of scoliosis which often occurs in several family members. However, the conclusion that the asymmetric growth is genetically determined is incorrect. The spine must be unevenly loaded first. Mice and rats used in research are forced to walk on two legs to develop scoliosis. If

scoliosis depended on the genetic predisposition only, the amputation of forelegs would not be necessary. The bone remodeling process is regulated by a series of hormones and the functioning of hormones is dependent on their receptors. Genes regulate the production of hormones and the formation of receptors. Because of them the bone remodeling proceeds faster or slower. However, the genes do not determine that the spine bends and how it bends. This depends on the posture, remodeling only allows the bone to adjust to the predominant posture. This is often useful, since the bones are strengthened where they are loaded and thus fractures are prevented, while they become weaker where there is no load. In the case of scoliosis the remodeling is harmful, unfortunately. Vertebrae of curved spine are constantly overloaded on the concave side, but in contrast to intermittent loading, which strengthens bone, static loading does not stimulate bone formation (Klein-Nulend et al. 2012). More attention should be directed to the correct posture of children who are often hunched, or tilt sideways when sitting in school or in front of computers. Scoliotic patients need to learn upright stance, because feelings deceive them to think they are upright when they tilt.

But why most of the thoracic curvatures are directed to the right and lumbar to the left? The spine is functional only with its muscles and their role should be considered. Scoliosis is more common in children who are engaged in certain sports. Modi et al. (2008) found 6 children with thoracic or thoraco-lumbar curve greater than 10° among 116 volleyball players. 5.2% of players with scoliosis is much in comparison with the control group, in which 1% of children had scoliosis. But 20 players (17%) had back tilted more than 5° when leaning forward (Adams test)



Ribs of a symmetric chest stabilize vertebrae and straighten the spine (top). In a rotated chest (above) forces of the ribs turn vertebrae and cannot prevent bending of the spine sideways.

because of rotated ribs and vertebrae. This is due to better-developed back muscles on the side where the hand with which they throw the ball is. Mostly it is the right side, because right-handedness predominates over left-handedness. Among players with scoliosis all right-handed players had thoracic spine curvature directed to the right, the only left-handed player to the left. Imbalanced muscle use may therefore initiate scoliosis by rotation of the ribs and vertebrae. Bending of the thoracic spine to the right in right-handers and to the left in left-handers follows because the spine loses support from the ribs. Spinal curvature triggers the rotation of vertebrae and ribs by the muscles and vice versa. This can lead to a vicious cycle that increases the curvature.

Goldberg & Dowling (1990) found statistically significant correlation between scoliosis configuration and handedness in 254 girls with idiopathic scoliosis. The curve pattern matched

handedness in 82%. Of 228 right-handed children, 197 had a right convex curve pattern; of 26 left-handed children, 12 had a left convex pattern. Thus, asymmetrical use of thoracic muscles initiates scoliosis in a large percentage of cases, but not all.

Vertebral rotation was analyzed in the normal, nonscoliotic thoracic spine of children aged 0 to 16 years by Janssen et al. (2011). They have previously identified a rotational pattern in the normal nonscoliotic adult spine that corresponds to the most common curve types in adolescent idiopathic scoliosis. In infantile idiopathic scoliosis, curves are typically left sided and boys are affected more often than girls, whereas in adolescent idiopathic scoliosis, the thoracic curve is typically right sided and predominantly girls are affected. Analysis of the normal spine showed that the mid and lower thoracic vertebrae were rotated to the left in infants (more pronounced in boys than in girls), were not significantly rotated to either side in juveniles, and were rotated to the right in adolescents. Well-known predominance of right-sided thoracic curves in adolescent idiopathic scoliosis and left-sided curves in infantile idiopathic scoliosis can be explained by the observed patterns of vertebral rotation that preexist at the corresponding age.

We can conclude that rotation of vertebrae usually predates scoliosis formation and determines the direction of the primary curve. A relation between asymmetrical position of the thoracic organs and vertebral rotation in the normal spine has been found by Kouwenhoven et al. (2007). Slightly rotated vertebrae due to internal organ loads can be turned further by the muscles to a degree when a continuous deterioration starts by shear forces of the ribs. If joint ligaments are not firm enough this happens easier. Scoliosis develops in patients with congenital laxity of connective tissue (Bushell et al. 1979) and also in children with idiopathic scoliosis joint hypermobility occurs more frequently than in healthy controls (Czaprowski et al. 2011).

Handedness is a decisive factor of vertebral rotation in older children. Scoliosis without an obvious cause occurs only in humans. The same is true also of handedness: lateralization has not evolved to a similar degree in any other vertebrate. The influence of handedness on the curvature may be mediated through posture. When one sits and writes with his right hand, he often bends to the left. The same happens when we try to reach something high above us with one hand. The spine bends to the opposite side and shoulder on that side is lowered. When the chest is symmetric, the ribs push vertebrae back to the midline and derotate them when we straighten from the bended posture. But when the chest is structurally rotated, they cannot do that entirely. The importance of equal support of the spine through the ribs from both sides had been proved with experiments. Resection of posterior ends of ribs on one side induced progressive scoliosis in young animals. The spine curved to the side where heads and necks of the ribs had been removed (Piggott 1971). Rotation of vertebrae does not eliminate support from the ribs, but ribs on the concave side push only vertebral bodies toward the convex side and ribs on the convex side direct all their force to the vertebral processes. This causes additional turning of the vertebrae and bending of the spine toward the convex side.

Infants and juveniles are not involved in physical activity in which only the dominant hand is used. In them, another factor rotates vertebrae to the left. This

Extending to and hanging with the left hand on barely accessible holds has proven to be the most effective exercise for stretching the spine. If scoliosis is caused by the predominant use of the right hand, it can be cured by frequent use of the left hand in normal work and exercise.

could be the diaphragm, which gives constant left side orientated torsion to the upper lumbar spine (Jansen 1912, summarized in van Loon 2012).

Orthopaedists of today only try to stop progression of scoliosis, but Bernard E. Brodhurst wrote in 1864: "*Spinal curvature is curable; but only when all the circumstances which gave rise to it are taken into consideration*." He already knew how rotation develops and that bone remodeling is behind transformation of the vertebrae. In 1855 he wrote: "*Torsion or rotation of the vertebrae on their axes having commenced, distortion proceeds more rapidly than heretofore...Tension of the muscles on the side of the convexity is at the same time increased. And these acting on the vertebrae, cause them to be twisted,—the spinous processes towards the concavity, and the thickest portion of the bodies of the vertebrae into the convexity of the curve: and, from continued pressure, the bodies of the vertebrae themselves undergo partial absorption, and losing something of their natural form, become wedge-shaped*." He had an answer to the problem: "*...although the treatment required is prolonged, rotation is overcome, when not extreme, in the same ratio as the lateral inclination. This is facilitated by pressure made from behind forwards, on the angles of the ribs*."

Continuation of treatment

In order to stretch the spine and reduce side curvature, I included stretching exercises for the left side of the body into the therapy in 2013. With left hand, I pushed at the hip while standing or at the thigh while sitting and stretched the left side. I lifted the body with my hands holding handles of a chair, and the spine streched due to gravity. With my left

hand, I stretched out to reach holds above the door. The last exercise in particular has proven to be effective, since the hump reduced during the exercise and the spine straightened significantly. This confirms the theory that scoliosis develops due to predominant use of the dominant hand, in my case right. Using the left hand we oppose the forces that caused the curvature. Because I can reach things above me easier, I concluded that the lateral curvatures of the spine are more flexible. Apparent curve on the photographs made in December 2013 measured 161°. But radiographs from 28 October 2014 showed that the curvature didn't improve.

Prognosis for most patients with more than 100 degree curvature of the spine is death in forties or fifties due to respiratory or heart failure, although there are exceptions (Rom & Miller 1978). With my therapy I have tried to show that this fate can be avoided without surgery.

An important difference exists between adult patients with scoliosis and children who are still growing. While vertebrae of an adult change shape only with bone remodeling, in a child they grow in length. Growth takes place with ossification of cartilage in growth plates under the articulating surfaces. In the twisted spine unevenly loaded cartilage is compressed on the concave side and stretched on the convex side. So the bone grows faster on the convex side of the vertebrae which become wedge shaped (Aronsson & Stokes 2011). Effective braces are those that reduce the curvature of the spine and thereby eliminate uneven pressure on the cartilage. A few years ago there were not many studies that proved the effectiveness of braces. The problem was to determine the real duration of brace wear. This problem is now solved with temperature sensors inside the brace, showing how many hours per day the child really wears the brace, as it is effective only on the body. Weinstein et al. (2013) have found that brace prevents progression of adolescent idiopathic scoliosis if it is worn at least 13 hours a day. Results are better when brace is worn over a longer time. 90% of children who wore a brace for at least 13 hours a day, have reached the end of the growth period without the need for surgery. Aulisa et al. (2014) found that brace is very effective also in the treatment of juvenile scoliosis. Curve correction was accomplished in 79% of patients, the curve stabilized in 16%, only in 6% progressed. Lusini et al. (2013) have found that wearing a brace can reduce the curvature even in patients with curve magnitude over 45° Cobb, who had refused surgery.

The state of scoliosis on December 21st 2013.

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