



Samgönguvika 16. til 22. september 2007

Bike Ergonomics for All People Reykjavik 18.09.07

by
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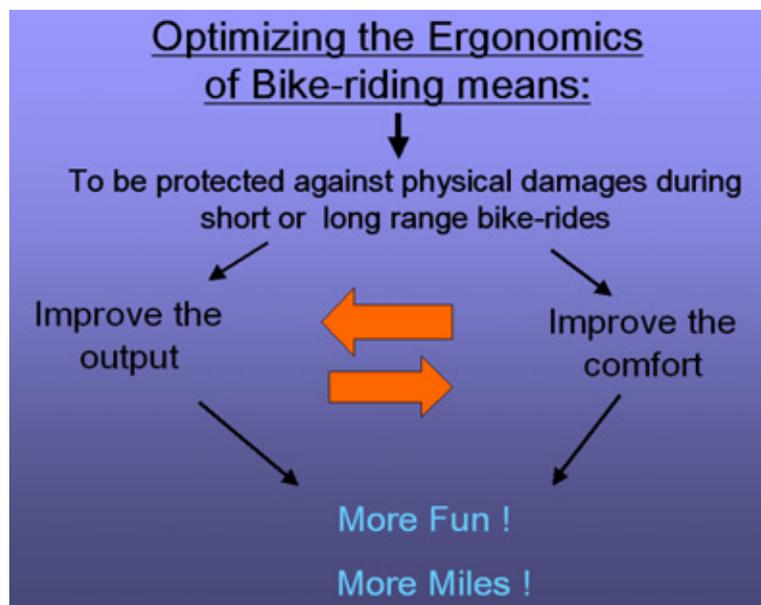
The Author: Juliane Neuss is working by herself with ergonomics since more than 20 years. She developed a growing up children´s bike in 1994 and was a bike-dealer from 1996 until 2002. She founded a bike company in 1998 beside her regular job and developed a foldable recumbent and a scooter for sitting and running, like the old Running-machine from Mr. Drais (1817). She has a lot of experience with long range bike rides, like “Trondheim-Oslo” and was a triathlete as well for several years, but she loves ice-speed-skating more than every other sport.

Juliane is a member of the German Bicycle Association (ADFC Allgemeiner Deutscher Fahrradclub) and is working with the technical committee of the club to solve customer problems. She is also writing a frequent column for the ADFC periodical .

In 2006 Juliane started working for the “Gebiomized Company”, which customizes saddles. Together with some other bike companies she has been trying to get a research-project about ergonomics by the “Nationaler Radverkehrsplan” , which is supported by the German Government.

Juliane got in touch with Magnus Bergssons and the ÍFHK 12 years ago, when she was in Iceland for the fifth or sixth time. This year Juliane spent the whole summer in Iceland again to work on a farm, but she also tried to use the free time to start writing her book about bike ergonomics.

Ergonomics is the investigation about humans and work. Especially when optimizing the physical contact between humans and engine.



Ergonomics helps to improve the output and the comfort of bike riding. When improving the comfort, you can use your power more for bike riding and not for struggling against pain. When you improve your output you get more comfort, because your muscles become stronger and you don't sit on the bike like a sack of potatoes.

This lecture will be arranged in three parts:

- Part 1: Ergonomics when sitting on the bike
- Part 2: Ergonomics, when riding a bike
- Part 3: Interesting things about saddles

Part 1

When I was working in the bike shop I always found that 80 to 90 % of the serious bikers are suffering from pain in the neck, in the back, in the shoulders, in their wrists (hands) and in their bottom!!

The good news is, that the other 10 to 20 % don't have these problems, so they already found a solution. You only need to watch and ask them. I watched and ask bike riders, mostly myself, since more than 20 years, because I don't have these problems either.



Bike Ergonomics doesn't mean choosing a bike only by the frame-size of the saddle-tube and an all purpose handlebar.

That is only very easy for the bike dealer!

More important is the length of the frame, but today that length is only determined by the amount of frames fitting in a 20 feet container. (that's no joke!!)

The three important areas to look at in bike ergonomics

The strain on arms and shoulders

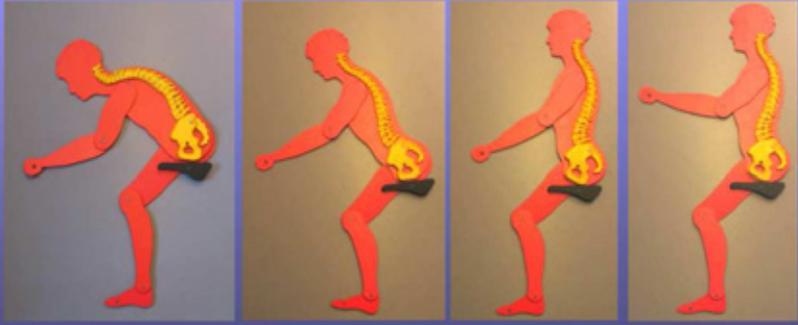


The muscle support and position of the lower back

The work of proper pedalling

The work of the shoulders is also the work of the upper body, up to the end of the breast-spine. The lower back is working with the pelvis and helps to stabilize your body. Proper pedalling is not only the work of the legs, but of the whole body. For our special investigation however, we have to look especially on the legs.

Standard-Sitting-Positions



Racing or sportive bike

All purpose travelling bikes

Old-Dutch-Position

„Modern Comfort Thinking“
(City-Bike)

It is necessary to have a definition for sitting-positions. There are only a few, when we look to the shape and the inclination of the back. The racing bike allows the rounded back. There is usually no problem with the curved back of the racing bike rider, because of the good trained muscles. He is flying over the bike with less contact with seat and handlebar.

The all purpose travelling bike is only defined by the inclination of the back, but it is not necessary to have a special bike for this position. Every good bike, and even a folding bike, could give you this position, if its really fits. You might find it funny, that I make a difference between the Old-Dutch Position and the City-Bike! This difference however, is much bigger than you would think, and with it the problems you could get. To understand bike ergonomics we have to have a look at the origin of bike riding.

When the bike was developed in the 19th century (between 1817 and 1890) men thought of horseback-riding as an origin of bike riding.

On a horse you are sitting straight and the hands are deep and near your body.

There are two important aspects to this sitting-position:

The spine keeps in its usual double-S-shape.

The whole back has the task of holding the upper body vertical, only with the help of the muscles



Fig. 294. Dame in guter Haltung auf dem Fahrrad.

Old-Dutch bikes fits everybody, like a horse. You are never worried about the length of a horse, you like to ride. You only have to think about the length of your leg.

How the double-S-Shape of your spine protects and works for your body

- the muscles are perfectly built to work with the double-S-Shape. They are supporting the spine when you keep the S-shape.
- ten times more elasticity than when the 32 bones of the spine are only a „tower“
- It keeps you movable and you can turn your body 180° (when the pelvis is fixed)
- It helps to fix the pelvis, so the legs have a stable point to start their work.

-This Protection only works, when your muscles are doing their work!

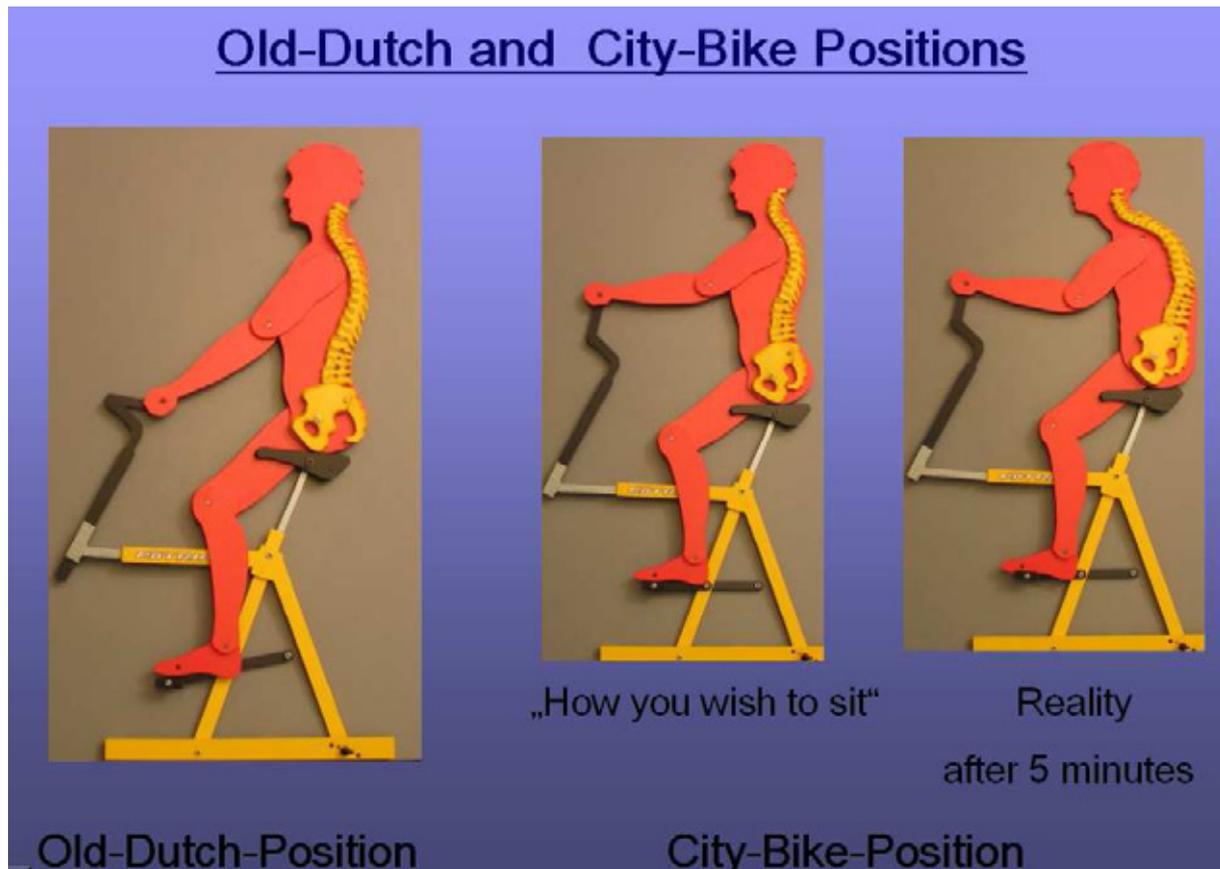


If you lose the double-S-shape, some muscles will be partly overstretched and can't work properly. They begin to hurt. Other muscles become unnaturally short, and they could stay so, if you are in the wrong position very often or during a long time. Every curve could make the elasticity of your spine twice as big as when there is no curve. The elasticity is necessary to protect your back against damages of bumps and it is a natural suspension for your body.

The S-shape allows you to turn your upper body 180° when the pelvis is fixed. You can try it easily by yourself. If you have your back in a bad curve, you can only move your neck.

For bike riding, your legs need the pelvis fixed on the saddle. The muscles of your back help you to keep the pelvis still. Only when the pelvis is fixed can the legs work perfectly, because they need a stable point to start the movement. If this point is moving as well, you will lose the power in the movement.

All this only works, when your muscles are working. If your sitting position allows your muscles to relax unnaturally you will lose this protection.



The problem of the modern thinking City-Bike position is the problem of too much relaxing of the muscles. With the Old-Dutch-position the muscles have to work like when you are on a horse. For this the hands are deep and near your body.

The City-Bike was developed in the last 15 years when the doctors said „You have a back problem. You have to sit straight and vertical on your bike“. So they started thinking about a higher handlebar, because the simple thinking of the man's mind is combining the hands up position with straight and vertical sitting.



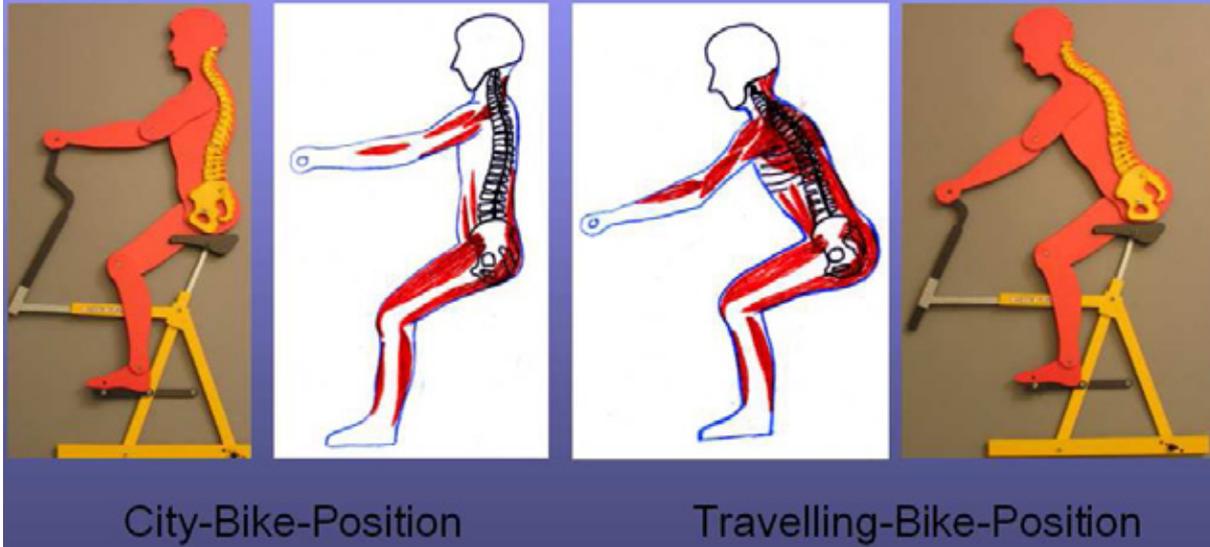
But, this is a mistake!

If the level of the handlebar is more than approximately 10 cm over the level of the saddle, the muscles of your back stop working, because there is no work anymore. Your arms are fixing the body too much. After a few minutes your back make a very relaxed and bad curve and you get all the problems we know, such as the pain in the neck and the back.

The best relaxed position is when the handlebar is on the same level as your saddle. Also, when you have to push your bike, this is best position.

Sometimes I see middle-aged women who push their city-bike, full of shopping bags on the handlebar, and the handlebar is as high as their shoulders!!! That already hurts my neck and shoulders, only by seeing it!!!!

How to use the muscles in different Positions



If you want to stand comfortably through long range bike riding, you have to take care that you use as much of your muscles as you can!!! A good ergonomic position is „strenuously comfortable“. If there are a lot of muscles working, like in the travelling-bike position, every muscle have to work very little, so you can stay in this position a longer time.

The key and the advantage of the Travelling-Bike-Position



Double-S-Shape
of the spine



(by I.A.Kapandji)
Straightening of
the upper body
by using the
„key-curve“ of the
S-Shape

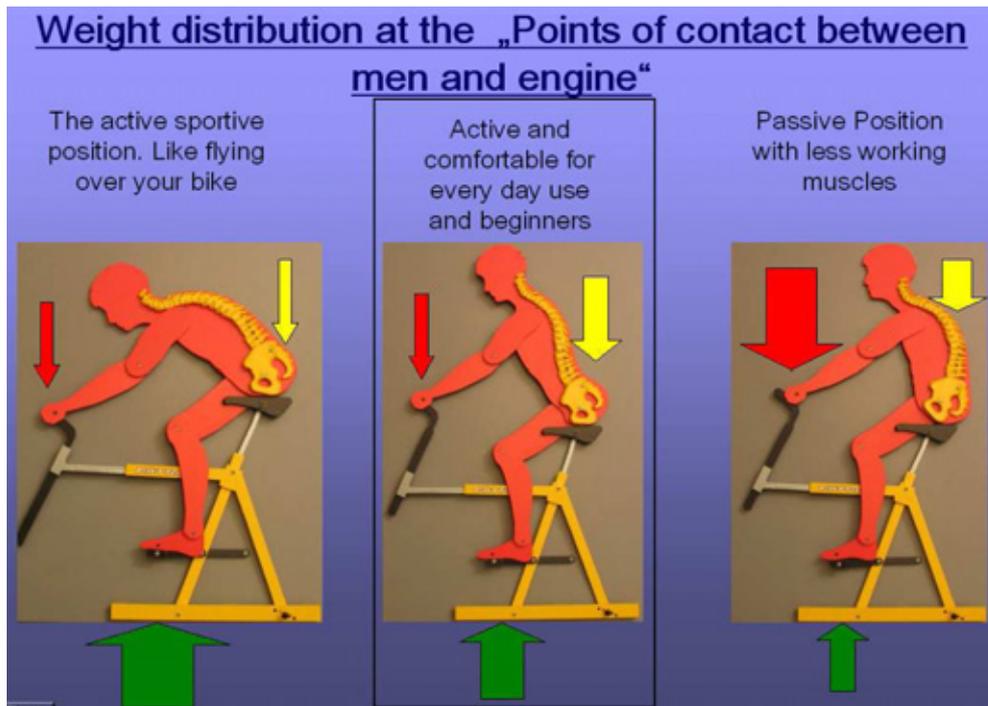


Reducing the strain
on your wrists!!

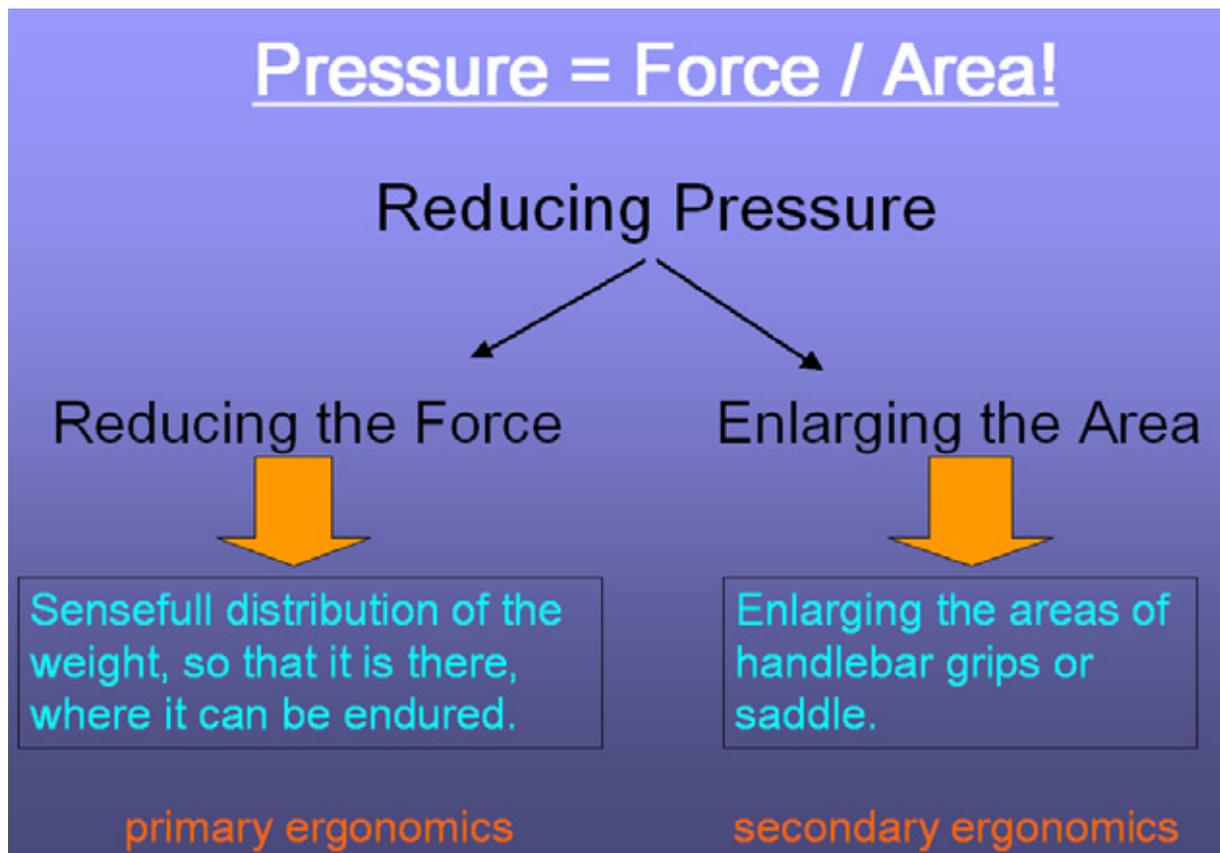
Wristproblems during biking have their origin in
back-problems!!!

To hold the S-Shape of the spine, the curve in the lower back is the key!! If you lose this concave curve (the lordosis or hollow-back) you can not find the s-shape: Your upper body bends more towards the ground and then you have to bend your head backwards. The muscles in the lordosis-curve need to be in a good shape to hold your body straight. Most people do not use these muscles. They sit in their office-chairs like in a TV-armchair, so the muscles start to become weak. Bike-riding in the correct position is the best way to strengthen these muscles. A good test: Try to sit on your bike in the position the bike is giving you and then try to take the weight away from your arms and hands. If you can hold this position some minutes, it is ok for you. If not, you need a more upright position (higher handlebar, but do not reduce the distance between handlebar and saddle!) and more practice for your lower back.

In former times, like in the sixties or seventies, we (especially girls) were educated by our parents to not have a hollow back!! It was not proper to show the curve of the behind!! The result was an unnaturally flat back, flat bottom and back problems, like the slipping disc also called lumbago. More than half of the cases of slipping discs have their origin in an unnaturally flat back and non practiced muscles.



There are differences in the weight distribution, when you are sitting in different ways. The minimum strain is in the racing position, the only position which allows a convex curve in the lower back, because the whole body is working, like flying over the bike. The power goes in a circle from the handlebar to the feet and back. The travelling bike position, where a good distribution of the weight is possible, is when you can stretch your back and you have the 90° angle between your arms and your body. When we tried this position with a suspension seat-post, we could see that the suspension works more when we sit properly (the seat-post sank deeper because of the weight) and works less, when we are sitting on a short bike with the bad curve in the back. The weight load "jumps" from the saddle to the wrists!! (the suspension seat-post coming up more).



There are two ways to reduce the pressure. Reducing the force could be reducing your weight, but it needs time (heavy people have a lot of problems with the hands, because they have a lot of weight to hold with the muscles, or to have on the wrists!!!) If you are going bike riding with a rucksack on your back, you also have this load together with your body on your wrists. It is better to have bags on a rack.

Reducing the force by primary ergonomics means bringing the weight load to a point, where it can be endured, like the pedals or the saddle. This is only possible with the right ergonomic geometry of the bike.

Enlarging the area could be the second step to get more comfort. Ergonomic handlebar-grips are not the solution, if you have not taken the first step to find the right geometry for your sitting position.

The meaning of the 90° angle to the upper body



90° angle for optimizing the power between arm and shoulder

stretched back



The too small distance between saddle and handlebar is responsible for the too small angle



Compensation for the origin 90° angle to reduce the strain on the arms and shoulders.

flexed back

Your body needs the 90° angle between the arms and the upper body to work properly. If you try to support your body with the arms, you always use this angle automatically. If you have ever tried to do push-ups, you know that it is impossible to do this with the arms behind the shoulders (less than 90° angle).

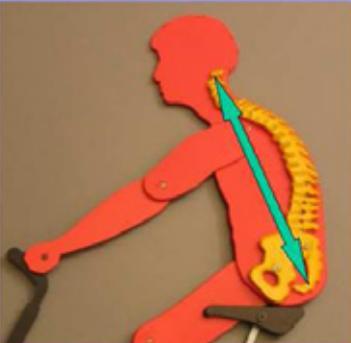
With a small distance between saddle and handlebar you are in the situation that you can not work properly, but your body finds the solution by itself and opens the angle up to 90°. To open this angle, however, destroys the S-shape of your spine and you get the classical problems.

„My bike is too long!“

The flexed back could be more than 15 cm shorter than the stretched one, so the bike seems to be too long.



stretching the back

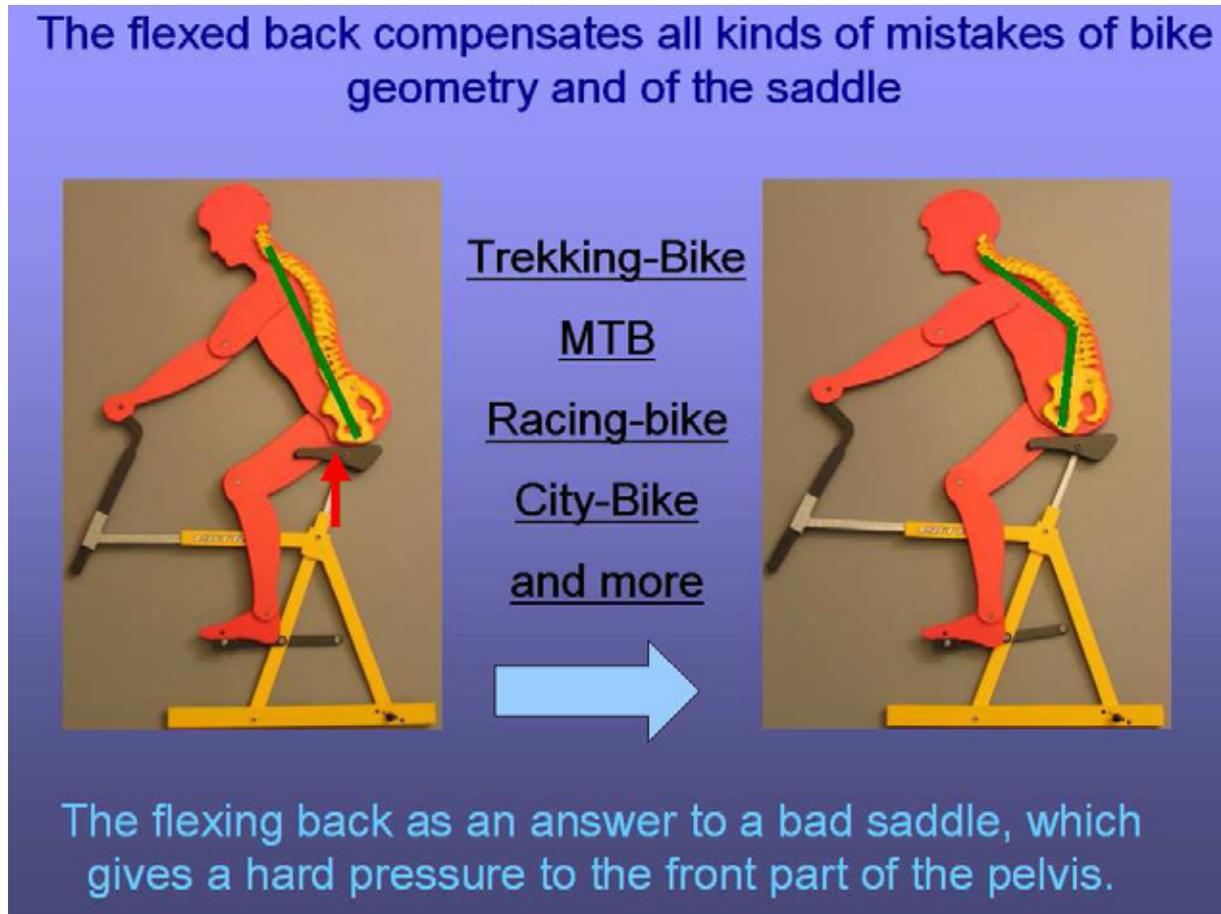


Flexing the back

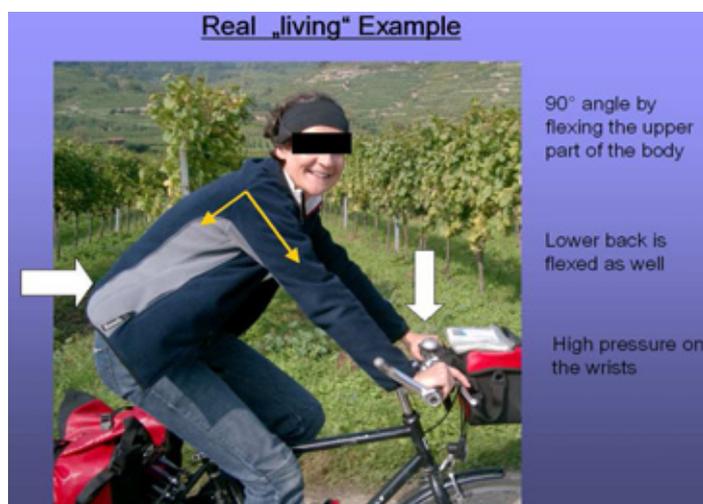
- The head is bent in the neck
- The shoulders come down
- The back is unnaturally flexed
- The missing s-shape puts more weight on the wrists
- The arms are really stretched

If you are in this sitting position, with the bad curve in your lower back, with the head bent in the neck and with stretched arms, you usually think that your bike must be too long. In fact it is too short!

Your back could become more than 15 cm shorter when you have the convex curve in your lower back and then the bike seems to be too long.



You can get the same result with a bad saddle. When your saddle hurts you in the front part of the pelvis, you try to avoid it. The pelvis will be moved backwards, and you have the same problems as when sitting on a too short bike. There will be the convex curve in your lower body, the head is bent in the neck and the arms are stretched.



This bike is more than 20 cm too short. This young lady tried a lot of funny things to solve her problems, like turning the bar ends in the opposite direction, or pushing the saddle very far back.

There are only two kinds of correct sitting positions!!

**All other positions cause a flexed back and
back problems**



Only the height of the handlebar is responsible for the sitting-position, but the length has to be the same



The Old-Dutch Position needs only half the length

Because the 90° angle is imperative you could think of a triangle in your upper body. This triangle can be rotated, so your back is more or less inclined. Because your body defines this triangle you are not allowed to shorten the length between saddle and handlebar. To get a more upright position for your back, you only have to rise the handlebar. Not more than 10 cm over the level of the seat though, because then you are in the City-Bike Position with the problems of non working muscles. For the Old-Dutch Position you don't have to think about the distance between handlebar and saddle. It has to be around half the length of that on a trekking bike, but it doesn't matter if there are 5 cm more or less. The handlebar has to be deep and near your body.

Part 2 Bike-Riding

Improve riding by:

- + the height of the seat
- + the horizontal position of the saddle in comparison to the bottom bracket
- + the crank-length
- + the optimizing of the movement



Most people sit too low on their bikes. They often think that they have to reach the ground with their feet. Mostly however, it is impossible to combine this postulation with the correct height of the saddle, because the bottom bracket needs a certain space over the ground. Standing with the bike is not the most important thing, when you like to go bike riding.

The correct height of your saddle prevents knee-pain and gives you maximum pedalling-power.

Saddleheight during riding!!



In the deepest position the leg is almost stretched.

The heel is always lifted a little bit, so the achilles` tendon can` t be overstretched.

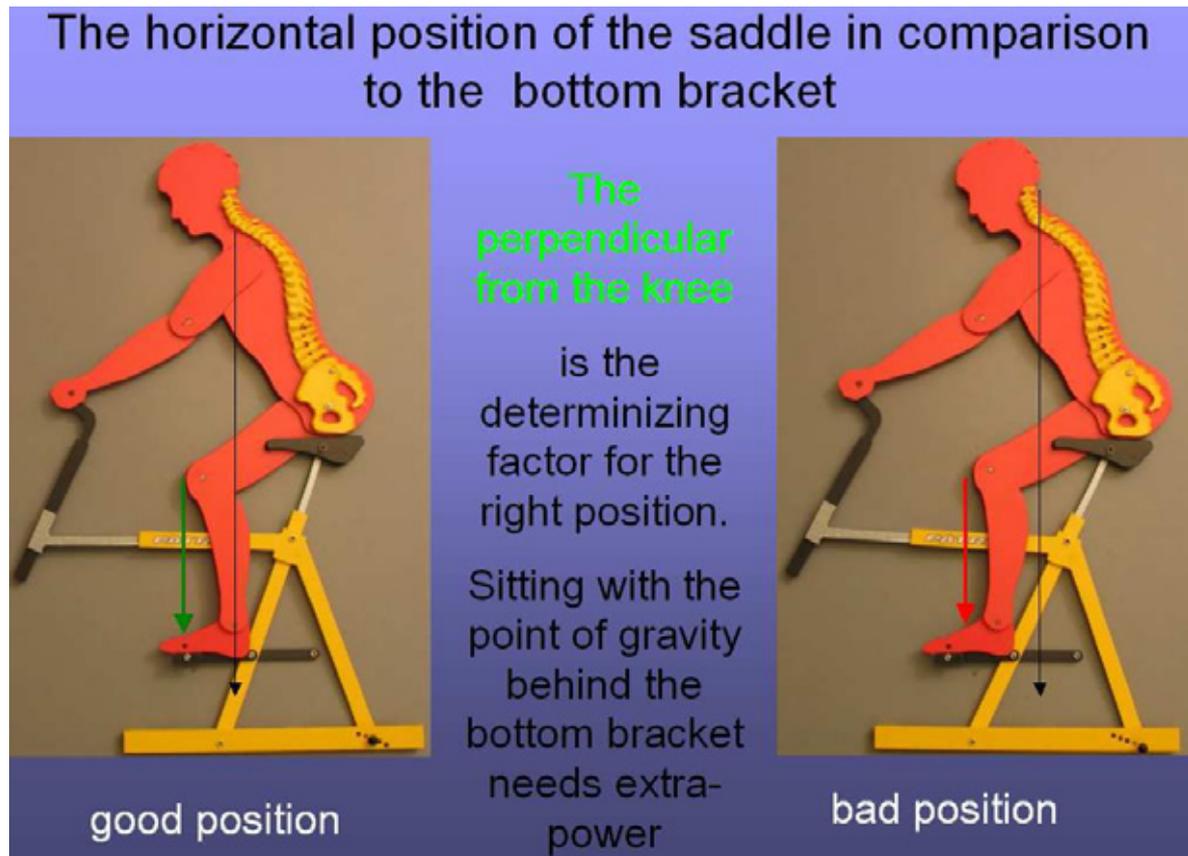
Watch the movement of the pelvis. Only when moving sideways the seat is too high.

Try it! Never feel fixed by the recommendation of your bike-dealer!!!

You can not test the saddle-height on a standing bike, because the position of your feet are different during riding. Usually you lift your heels much more when pedalling and for this you need a higher seat-position.

Don` t just trust your bike dealer with fixing the saddle-position for you. Normally he can` t know it. Try to raise the saddle by yourself, little by little, as long as you feel comfortable. Only when your pelvis and your hips begin to move sideways, have you reached the limit.

It is worse to sit too low, because you don` t really notice it. It could damage your knees and you need a lot of extra power for pedalling. Sitting too high is not dangerous, because you feel it after some minutes. Dare yourself to try it!!



The perpendicular from the knee has to be pointed at the middle of the pedal, when the pedal-crank is in its horizontal position in the front. With it, the point of gravity of your body is in front of the bottom bracket and the power works on the front pedal. Moving the seat backwards, or having the seatpost-tube in a too flat angle puts your body's point of gravity behind the bottom bracket and you are hindering yourself by having the power on the back pedal. You need extra power to move your bike.

In a very sportive position the perpendicular from the knee is allowed to be more to the front, up to 3 cm. The reason is the lower upper body in the sportive position. With sitting so the angle between your legs and your body opens for better breathing and blood-circulation to the legs.

It is not a mistake to sit more to the front, it is worse to sit too far back. Never move the saddle far back only to get more space between the saddle and the handlebar. The position of the seat is only determined by the geometry of your legs, not by your arm-length.

Determination of the crank-length



Children and grownups shorter than 170 cm usually need shorter cranks. (about 135 or 150 mm)

In the highest position of the pedal, the angle of the knee mustn't be smaller than 90°

It is only recently that bike-factories has started thinking about crank-length. None of the bike-part factories have shorter cranks in their program, beside the usual dimensions, like 165, 170 or 175 mm. Only very small and expensive companies are offering special sizes. The usual crank sizes of 170 or 175 mm fit to people taller than 170 cm up to approximately 190 cm. Taller people could have longer cranks, but it is not really necessary. Short cranks never hurt!!!

There is more of a problem for shorter people. If they use normal cranks their legs will be angled at more than 90° in the upper position of the pedal. That could hurt or damage their knees.

However, these people mostly find the solution on their own. They start sitting with a very high saddle, so the knee is not hardly angled in the upper position. They are then tiptoe pedalling more than usual in the lowest position, but this doesn't matter. The power is more in the upper position.

The optimizing of movement

Tiptoe pedalling gives freedom to the knees. The knee is not a simple joint. It moves in different directions, when it is opened or closed. For this you need another joint working against the knee. Only the ankle could do this. If the ankle is fixed, the knee will be forced in a wrong direction and start hurting. It is important not to use the heel or the whole foot for pedalling. People who do this, are usually sitting too low on the bike. Using the heel then shortens the effective length of the leg, so you have a little bit more power. But it is better to sit high enough.

The recommendation for pedalling frequency cadence is mostly between 80 and 100 rounds per minute. Serious and long range bikers like to use more than 95 rounds per minute, because it is easier for the knees and this gentle movement is also nice to your technical equipment.

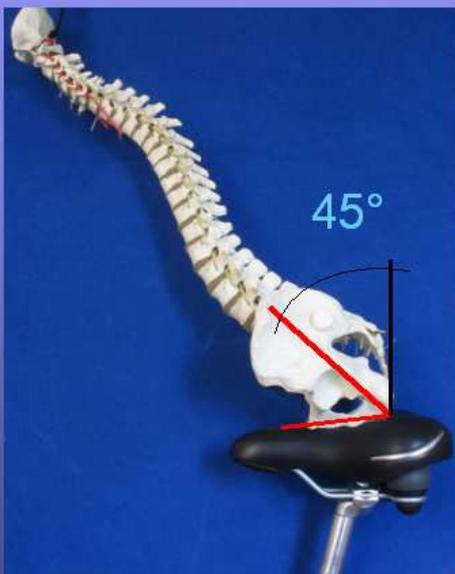
If you see that you like to choose higher gears, and pedal slow and hard, it could be that the saddle is uncomfortable to you and you try avoid pain by using the higher gears.

Part 3

Interesting things about saddles

Maximum inclination of the body when sitting on a bike with a stretched spine

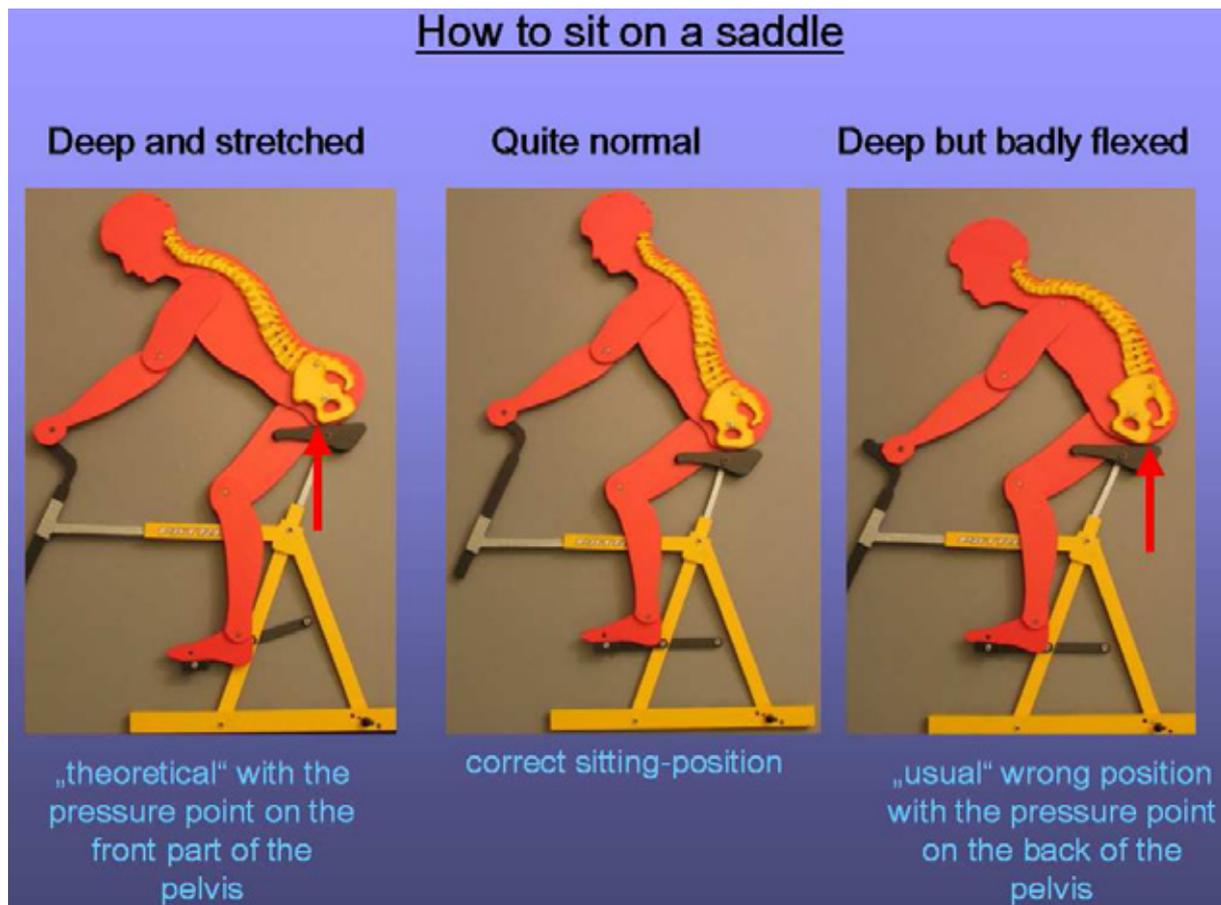
Man



Woman



When considering ergonomics, we like to know, how the pelvis fits to the saddle during more or less inclination of the upper body. There is a difference to the pelvis bones between man and woman. The pelvis of a man has a smaller angle, so he can sit deeper in the sportive position than a woman. When the bottom of the pelvis has full contact with the saddle, a man is able to sit with a 45° angle but the woman has her limit at 35°. It is important to know this, because behind this angle the body starts to bend the spine and also lose the S-shape.



There are three different ways to sit on the saddle. One is with the pressure point on the front part of the pelvis, but this is only theoretical, because nobody would stand it. This area is very sensitive and everybody would avoid such a sitting-position and find another one. Sometimes you can see that the saddle is lowered at the front because of a deep racing position. Only men can do this, because they don't roll on the saddle as women do. Usually the deep racing position goes together with the convex curve in the lower back, which allows the pelvis to have the full contact with the saddle.

In the everyday, not very deep sitting-position, the bottom of the pelvis has full contact with the saddle and the inclination of the back is within its natural limit.

The usual wrong position, often recommended by saddle companies like "SQLab", is to sit with the pressure point on the back part of the pelvis. For this position you could use almost any saddle, but only for a short time. The two tips of the bones in the far end of the pelvis are very small and so is the pressure-area. After a short time it will start to hurt.

This position will be also used, when the back is badly curved.

Sometimes I say: If you don't have a saddle-problem, you must have a back-problem.

The principle construction of saddles



Most producers use the distance between the bones in the back of the pelvis to determine the size of a saddle.

These bones are only used during the upper sitting-position like the Old-Dutch,

or when the spine is badly flexed (wrong sitting-position)!!

The distance between the bones in the back of the pelvis is only important to know when you are sitting in the Old-Dutch Position, very straight. In all other inclinations of your back, these bones have no contact to the saddle and are of no interest for the shape of the saddle.

How the bottom of the pelvis is shaped

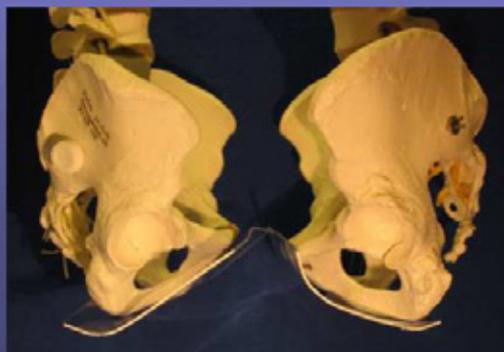


Man



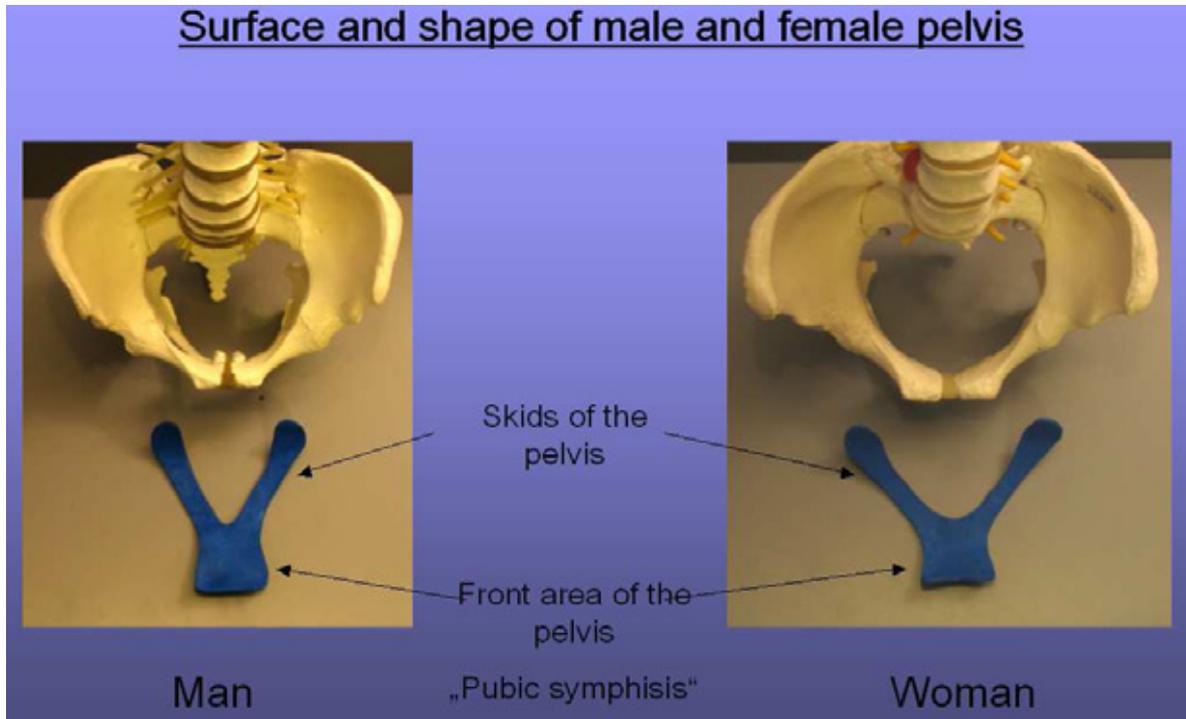
Woman

Flat shaped

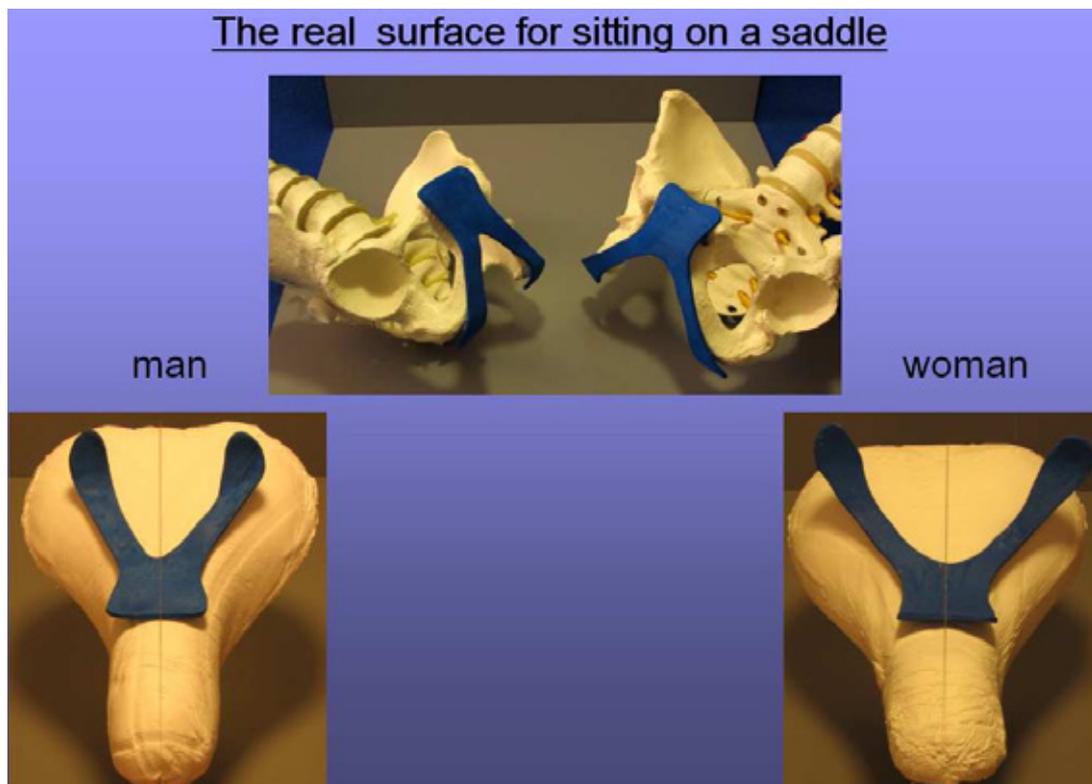


Concave shaped
(like the skids of a sledge)

The difference between a male and a female pelvis is not only the width but also the shape of the bottom of the pelvis. On a man this is very flat and on a woman it is concave shaped like the skids of a sledge. As a result of this fact, the saddle for a man could be with a flat surface, but not for a woman. She would roll back and forth on such a saddle .



The width of the pelvis as a typical difference between man and woman.



(The white "saddles" are plaster casts made with someone sitting on a saddle)

How men and women are sitting



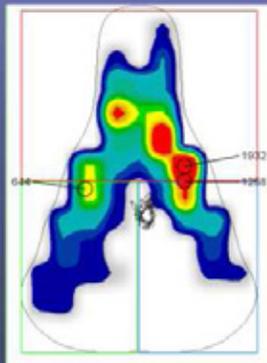
Men (flat)



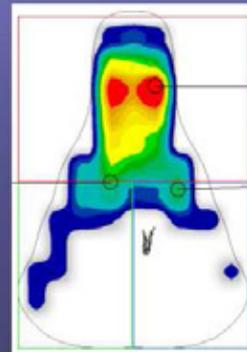
Women (curved)



whole
area is
used

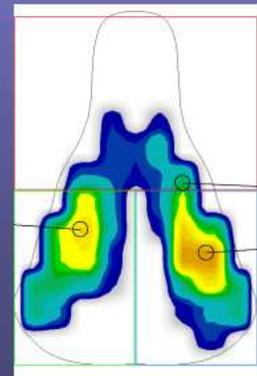
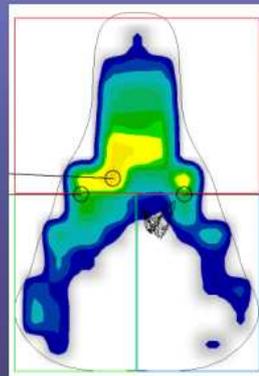
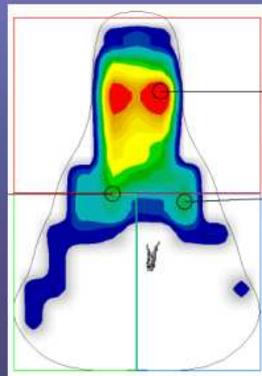
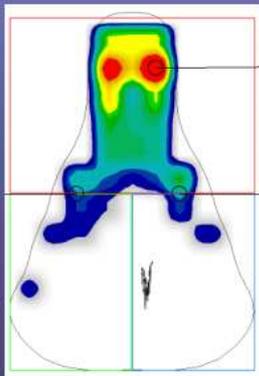


Partly and
pointedly
used



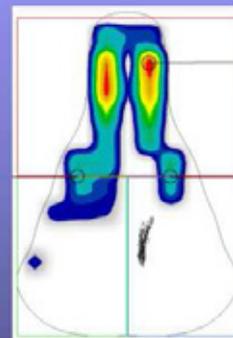
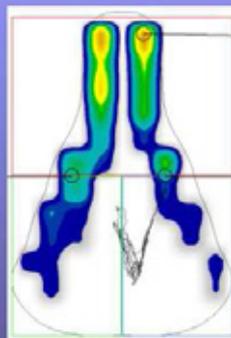
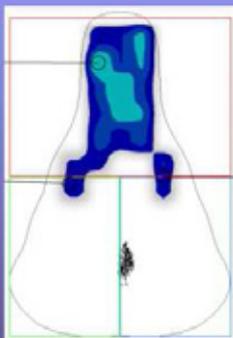
When we measured the saddle surface electronically with special thin layers at the “Gebiomized company” we could see that a man can use the whole surface of a saddle but a woman can’t. The two pelvises on the top of the page show that the “acetabulum”, where the joint of the leg is positioned, points in different directions. This is the result of the difference in width. It shows, however, that the saddle for a woman has to be smaller in the front, because the legs are closer to the saddle. (T-shaped)

How women try to change the pressure points by
changing sitting-positions....
without succes !



When women try to find a painless position, the pressure point wanders, but there is no comfortable solution because of the curve of the pelvis.

Present solutions for men and women.....
without succes!!



Air-Seat
(like a bike
tire, but
bigger)

„gender neutral“
(with two
different levels)

Saddle with a hole in
the front area
(Losing more than one
third of the surface)

The present solutions for men and women are all different, mostly funny and without success.

The Air seat is like a bike tire, filled with air, but it is so soft that the pelvis moves too much and the legs can't work and you need a lot of extra power for pedalling.

The "SQLab" company presents saddles with two levels. You sit with the back part of the pelvis in the wrong position on the upper level, and the front part should then be free, but it doesn't work, neither for men nor for women. However, the company recommends it as a "gender neutral type"

Saddles with a hole in the front are very common, but they never solve problems. The area for sitting is much smaller because of the hole, and the pressure much higher. Even if the pressure is not on the main-nerves and the main-artery, it could damage the skin and other structures.

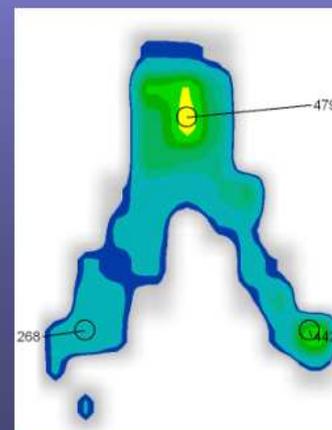
First test with an old „Brooks“ (2003)



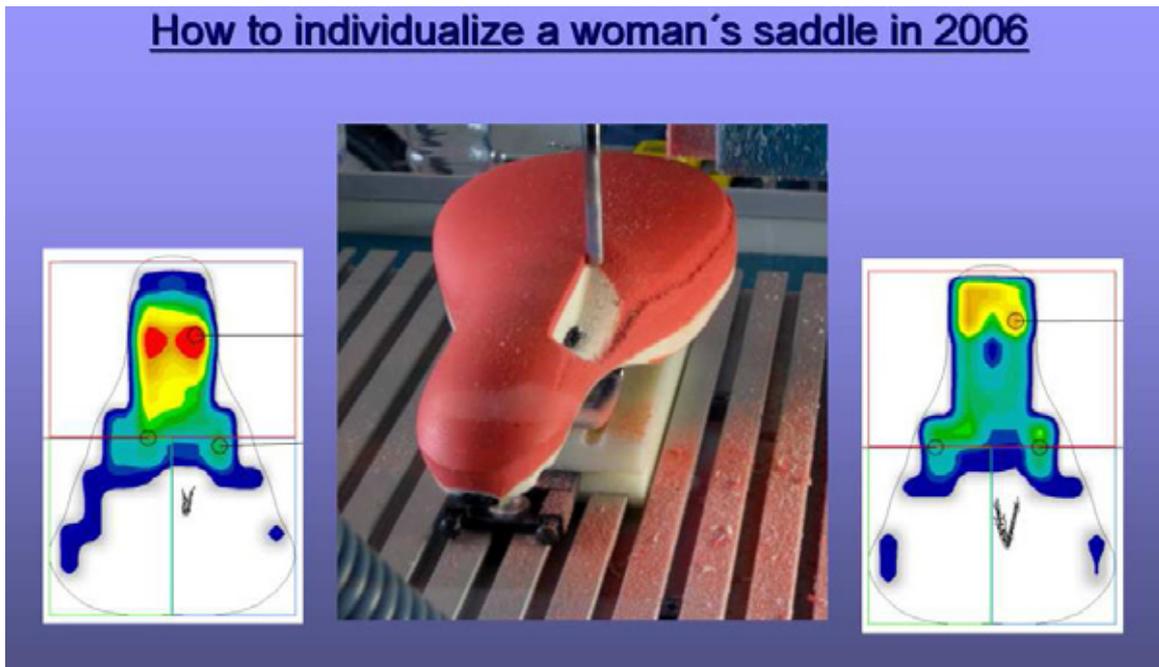
Concave



and T-shaped!! (triangle shaped)

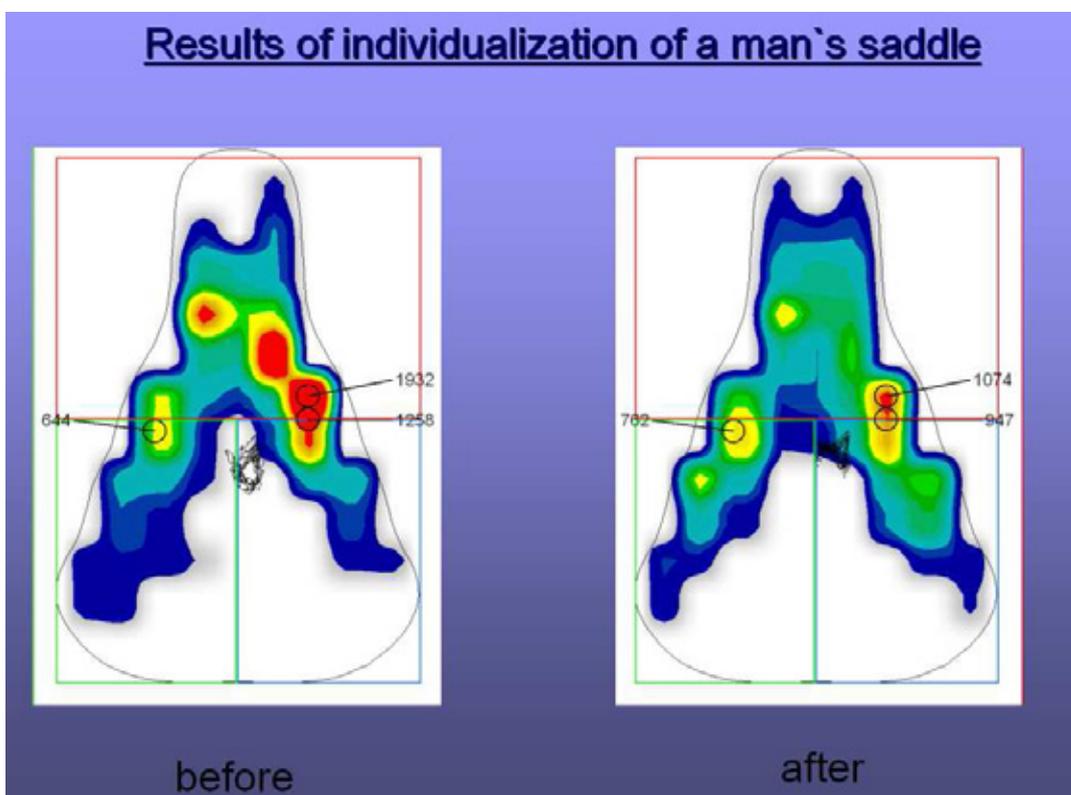


With an old "Brooks" I figured out the shape of a special saddle for women. The frame of the saddle was bent and I cut the leather to form the deep curve. After this I had to fix the leather, so it couldn't spread sideways. The result was a deep concave and t-shaped saddle, which fits. (The white lines shows the usual triangle form of most saddles for women.



The point with the highest pressure is gone. There is still some in the front, where it is necessary to stop the pelvis from rolling, but now the pressure is in an area that is less sensitive.

(The back part of the saddle wasn't high enough with foam, so we still partly missing the contact).



Individualization of a saddle for men has had a good result as well. The area became more equal and the pressure was reduced by half.



**Thank you very much
for your attention!**

I thank the members of the Icelandic Cyclists` Federation for their invitation, so that I had the possibility of giving this lecture.

It is my present wish to help all people get a well fitting bike and have much more fun bike-riding, so they keep their cars standing!

I thank Jannica Hovenäs from Skálholt for her time and help with the translation during several nights!!!!