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Ergonomics of 2 Bicycle Saddles

Pressure at the Pudendal Area in Women of a Normal Saddle with Gel and of a Saddle with a Hole

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Introduction

The aim of the study is to evaluate the ergonomics of bicycle saddles designed for women and to evaluate the differences between a flat surface saddle with gel (Royalgel) and a saddle with a hole (control). Both types of saddle in fact are becoming more and more popular. Both saddle types claim to have a better comfort than an ordinary saddle without gel or without hole. The objective of the research is to identify which of the 2 saddles performs best in terms of pressure distribution and in relieving pressure from delicate parts of the outer genitals of women.

Analysing how different saddle constructions perform in terms of distribution of pressure in the outer genital area of women is a new field of study where no research has been done before. Measuring the amount of pressure on the genital area is as important as evaluating where this pressure is located, and how this can effect the different anatomical structures, so the study should give some indications on how to prevent or reduce the risk of health problems in women's genitals.

Research has been done in the field of bicycle problems related to the saddle, but most of it so far has been done on men.

> Sommer, F. et al (2001) describes in his studies the changes in penile blood flow during cycling. The results showed that cycling in a seated position decreased the penile blood supply significantly.
> Rodano, R. et al (2002) drew "a comparison between normal "flat" saddles and saddles with a "hole" in the perineal area". "Five cyclists underwent a number of cycling sessions. In each session, a saddle from the sample was selected at random…". The study showed an increase in pressure around the edges of the saddles with a hole. It has to be known that the pudendal nerve and artery run most likely around this area and pointed out that saddles with a hole are likely to increase pressure on these delicate parts of the body.
> Lücker, B. (2000) ran a survey of overload symptoms of mountain bike riders. The most common symptoms were in almost 50% of the cases located in the seating area said the study by Lücker.

As said, all the above-mentioned studies focussed on men. Since women have a different anatomy, the problems women cyclists have are different.

Even though extensive statistics on the health problems occurring to women cyclists are not available, a study undertaken by the Brugmann University Hospital amongst more than 60 Belgian competitive female cyclists suggested a prevalence of the lymphatic swelling (Bicyclist's Vulva, Fig.12) in about 1 competitive cyclist in 6. About 70% also suffered from some other type of seat problems.

Fig.12 Bicyclist's Vulva (Baeyens et al **(2002)**)

In the observational study named "Bicyclist's vulva", Baeyens, L. et al (2002) reported on a unilateral permanent swelling of labium major due to a compression of the groin area and also due to repetitive perineal skin infections and resulting finally in a lymphatic damage. Other risks of health problems in the genital area for women are chafing, folliculitis, nodules and also temporary insensitivity of the clitoris, and other problems due to the compression of the groin.

In this study different tests should quantify the comfort of the saddles. The first part is to evaluate the surface pressure at the pudendal area in women. The criteria for comfort are:

a) low mean pressure Px (in g/cm²)
b) a big pressure area (in cm²)
c) low/ less pressure peaks Pmax (in g/cm²)

In addition to the pressure measurement a personal judgement completes the evaluation of comfort.

Finally it will be observed where the highest levels of pressure are located in order to comment if these pressures interact with more or less delicate parts of the outer genitals.

Method

The measurement of the comfort of two types of bicycle saddles was quantified with two main tests:

a) objective measurement with physical parameters;
b) subjective measurement with individual rating of comfort.

Realisation

To evaluate the pressure differences of different saddles twelve subjects (n=12) rode each one of the two saddles (Selle Royalgel and Selle Italia Ldy Trans Am = control) for 30 minutes on an ergometer (Focus Raven on RBM Avantronic). The two saddles had similar dimensions, but different construction solutions. The outline of the saddles were very similar. The main differences between both saddles was the cushion and a hole in the middle of the control saddle. The Royalgel had a special gel cushion to distribute the users weight. The long period of measuring was chosen in case of occurring pressure differences, which might happen after the gel adapts due to temperature change. To get a better comparison every saddle was ridden for 30 minutes. The pedal cadence was 75 rpm, which is about average for bicycle riding. The pedal force was adjusted differently for every single subject to 1.5 N/kg/body weight which is close to reality on flat terrain and still easy to maintain for a longer period of time.

The position on the bike was 40 degrees from horizontal with the back (fig. 1), which is similar to the position on a racing bike. The position was controlled with a goniometer. As a more moderate position the subjects added 1 minute after each 60 minutes with a 60 degrees angle (fig.2). The entire time the subjects were in a seated position with their hands on the top bar (fig.1).

Fig. 1 – athletic position - 40°	Fig.2 – moderate position – 60°
	

a) Objective Measurement

To measure the pressure we used an F-Scan (Tekscan®) measure system, which measures 60 pictures/sec. with 4 pressure sensors/cm² (fig. 3, 4). The sensors identify the weight on the whole saddle surface. For the single sensor this value is described as pressure. Other relevant parameters are the mean pressure over the whole contact area, the maximum pressure peak, the size of the contact area and the weight loading on the saddle.
The F-Scan system has high resolution, so real pressure forces can be measured and presented. A filtering of error points (very low and high values) is necessary. The filter deletes all values under 50 g/cm² and over 1000 g/cm². With the scanning of the saddle outline and the converting into a matrix the values becomes much truer.

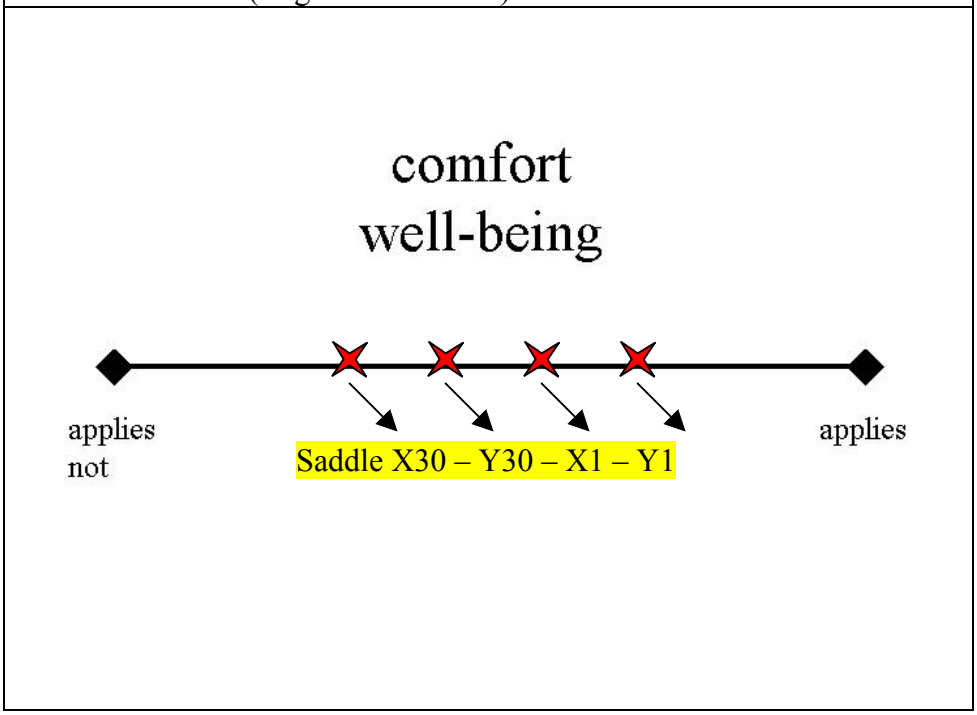
Fig. 3: sensor	Fig. 4: complete installation of the testing construction
	

b) Subjective measurement

To evaluate the personal feeling of comfort of each subject we asked the women to give a judgement of every saddle in both positions. To perform this we developed a special tool. The

subjects should sign a cross on a line with two ending points for their subjective feeling on comfort and well being. On the left side is no comfort and on the right side big comfort. The judgement was directly performed after the ride. After all rides we transformed the line in numerical values.

Fig. 5: Scale for subjective rating of comfort and well-being, example of translated version (orig. in attachment)



Results

The results are divided in two parts. In the first part the data from the objective and subjective measurement are described quantitative. In the second part the F-Scan pictures are described qualitative.

Quantitative results

a) Objective measurement with F-Scan

Statistics

The statistics were made with the software Easystat 3.4©. The data were checked with a multiple analysis of variance for repeated measures. The level of significance is fixed on $p<0,05$.

For the mean pressure (Px) over the saddle surface the parameter position has a p-value of 0,001. This is significant. The mean value for the 60 degree position is 281 g/cm² and for the 40 degree position 235 g/cm². The standard deviation for the 60 degree position is 48 g/cm² and for the 40 degree position 28 g/cm². So the mean pressure over the whole surface is higher in the more upright position (60 degrees). The p-value for the saddle is with 0,078 not significant, but near to the level of significance. The differences between the saddles are

small. The mean value for the Royalgel amounts to 248 g/cm² and so it is a little bit smaller than the control saddle with a mean pressure of 267 g/cm².

An analysis of the parameter contact area on the saddle surface (A) shows high significances for both parameters, position (p-value = 0,000) and saddle (p-value = 0,009). The mean value for the area is for the 40 degree position 86 cm² (sd = 15 cm²) and for the 60 degree position 97 cm² (sd = 16 cm²). With the Royalgel saddle the area is with 97 cm² bigger than the area on the control saddle with 86 cm² (mean for both positions). In the more bent position the values are smaller but the relationship between both saddles is the same (Royalgel 91 cm², control 81 cm²).

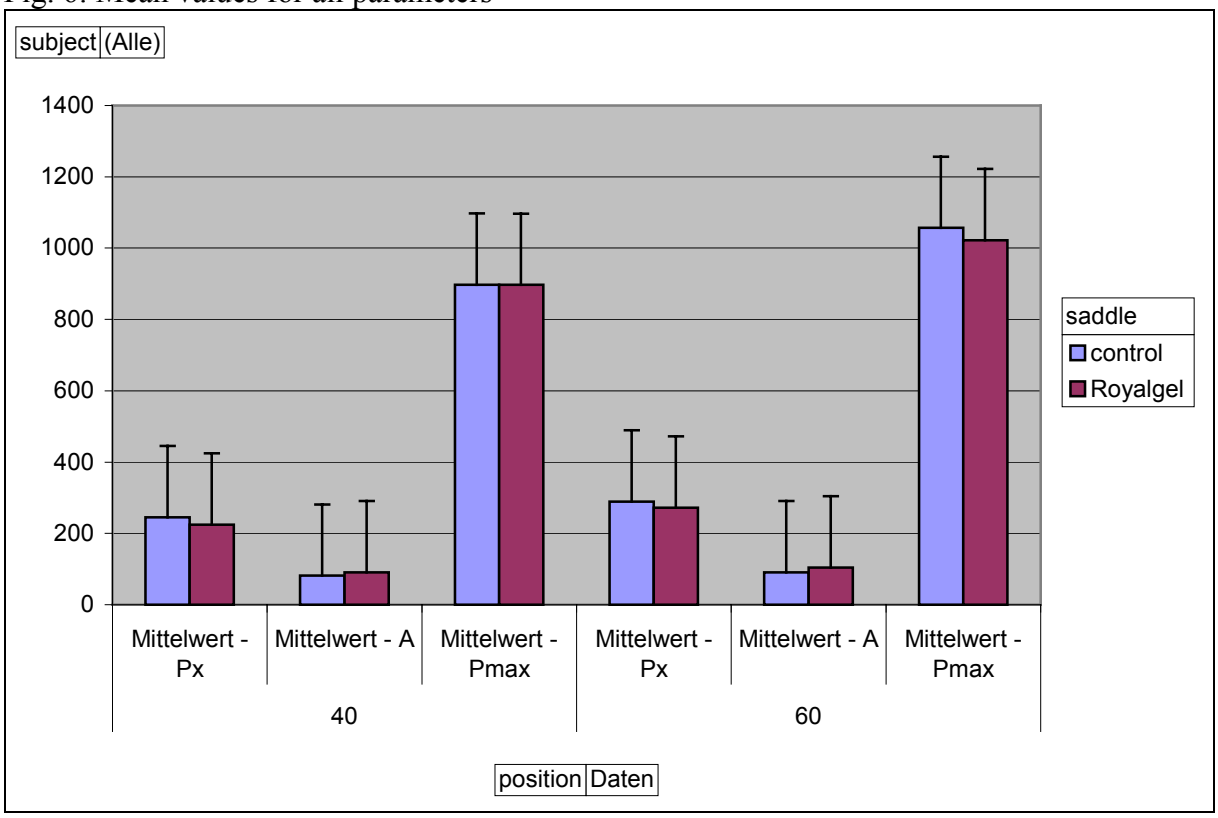
The values for the maximum pressure on the contact area (Pmax) differs very much. The mean value for all tests amounts to 968 g/cm² but the standard deviation is high with a value of 289 g/cm². The p-values show that there is no significance between the Pmax and the parameters saddle or position (tab. Pmax). Anyway high pressure points give no information about the location of these pressures. So it is necessary to analyse visually.

The last parameter to control the position of the subjects is the weight (w). Similar to the area the value is higher for the more upright position (40 degrees 20 kg, 60 degrees 27 kg). The difference is with a p-value of 0,000 high significant. The differences between the saddles are not statistically significant (p = 0,48). The values in the 40 degree position amounts both 20 kg (with sd40 = 4,4 kg; sd60 = 5,3 kg).

Tab. 1: Mean values for all parameters

subject	(All)			
		saddle		
position	Daten	control	Royalgel	Gesamtergebnis
40	Mittelwert - Px	245	225	235
	Mittelwert - A	81	91	86
	Mittelwert - Pmax	897	897	897
	Mittelwert - w	20	20	20
60	Mittelwert - Px	289	272	281
	Mittelwert - A	91	104	97
	Mittelwert - Pmax	1057	1022	1039
	Mittelwert - w	27	28	27
Gesamt: Mittelwert - Px		267	248	258
Gesamt: Mittelwert - A		86	97	92
Gesamt: Mittelwert - Pmax		977	959	968
Gesamt: Mittelwert - w		23	24	24

Fig. 6: Mean values for all parameters

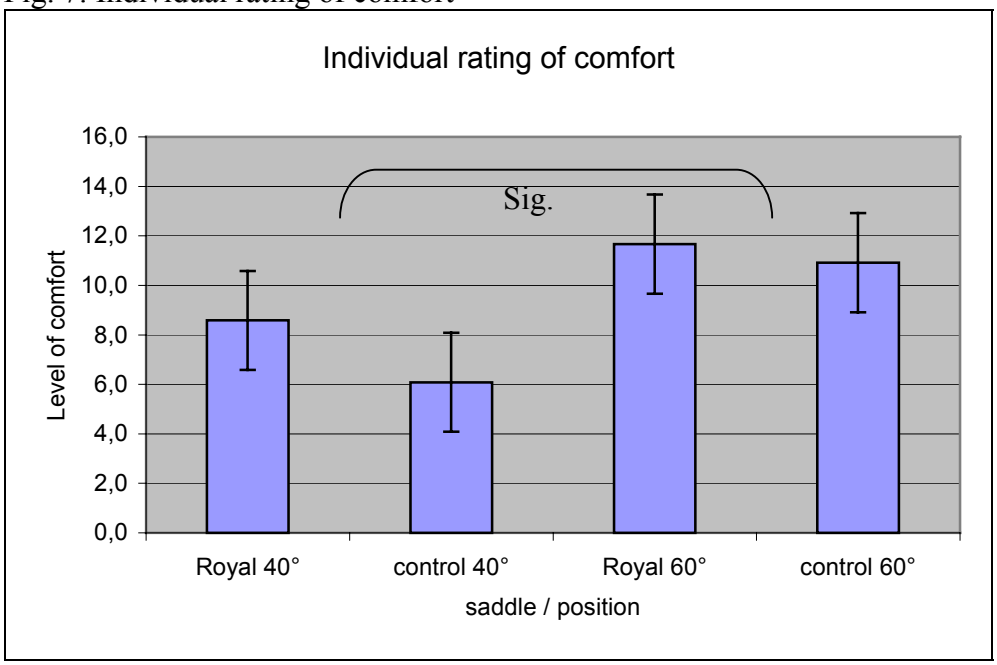


Legend
Pos = position (40 and 60 degrees from horizontal)
Px = mean pressure (in g/cm²)
A = contact area (in cm²)
Pmax = maximum pressure (in g/cm²)
Mittelwert = mean value

b) Subjective measurement with personal rating of comfort

The results for the individual and subjective perception of comfort show that there are differences between the saddles and the position. The differences between the saddles are not significant. But most subjects felt more comfortable with the Royalgel (9 preferred the Royalgel and 3 the control in the racing pos.). The p-value with 0,001 for the position is significant. However the values for the comfort varies between 0 (= no comfort) to 18 (max. comfort). The mean value in the 40 degree position amounts to 8,6 for the Royalgel to 6,1 for the control saddle. A statistic test of only this difference showed no significance, too. The mean values for the position 60 degree are much higher and so the subjects felt more comfortable with 11,7 for the Royalgel and 10,9 for the control saddle.

Fig. 7: Individual rating of comfort



Tab. 2: All values of individual rating of comfort

subject	Royal 40°	control 40°	Royal 60°	control 60°		
TH	0	6	2	13		
SA	8	4	15	10		
BT	6	7	4	9		
IG	12	3	16	18		
MK	15	10	14	12		
LM	11	5	12	6		
CM	6	10	14	11		
JK	14	4	16	7		
CS	13	6	14	8		
KW	6	4	16	13		
BB	4	2	7	8		
NK	8	12	10	16		
Sum	103	73	140	131	**112**	**Sum ges**
x	8,6	6,1	11,7	10,9	**9,3**	**x ges**
sd	4,3	3,0	4,7	3,5	**3,9**	**sd ges**

Analysis of the pressure in the mid part of the saddle

The main difference between the saddles is the hole in the mid part. So a special analysis of only this area should show differences more clear. To restrict the mid zone, the front and the back part was cut. The area of the mid zone was defined in the front with the end of the hole and in the back with the beginning of the incline of the outline. In the following analysis the main attention is on the racing position (40 degrees) because in this position more pressure is measured in the mid zone of the saddle, where delicate tissues get in touch with the saddle.
The weight on the mid zone is the same for both saddles (12 kg), therefore the hole of control saddle does not lower the total amount of pressures in this area. Moreover the mean pressure over the mid zone is lower with the Royalgel with 253 g/cm² to 271 g/cm² with the control,

even though this difference is not statistically significant. The area is significantly bigger with the Royalgel (49 cm² to 42 cm²=control), because –of course- the hole of the control saddle takes sitting surface away. The Pmax is nearly the same, but the Royalgel has a slightly lower value (895 g/cm²) than the control saddle (914 g/cm²).

Tab. 3: Values of the mid zone analysis at 40 degrees position

subject	(Alle)			
		saddle		
position	Daten	control	Royalgel	Gesamtergebnis
40	Mittelwert - Px	271	253	262
	Mittelwert - A	42	49	45
	Mittelwert - Pmax	914	895	904
	Mittelwert - w	12	12	12

Fig. 8: Mean pressure and maximum pressure of the mid zone at 40 degrees position

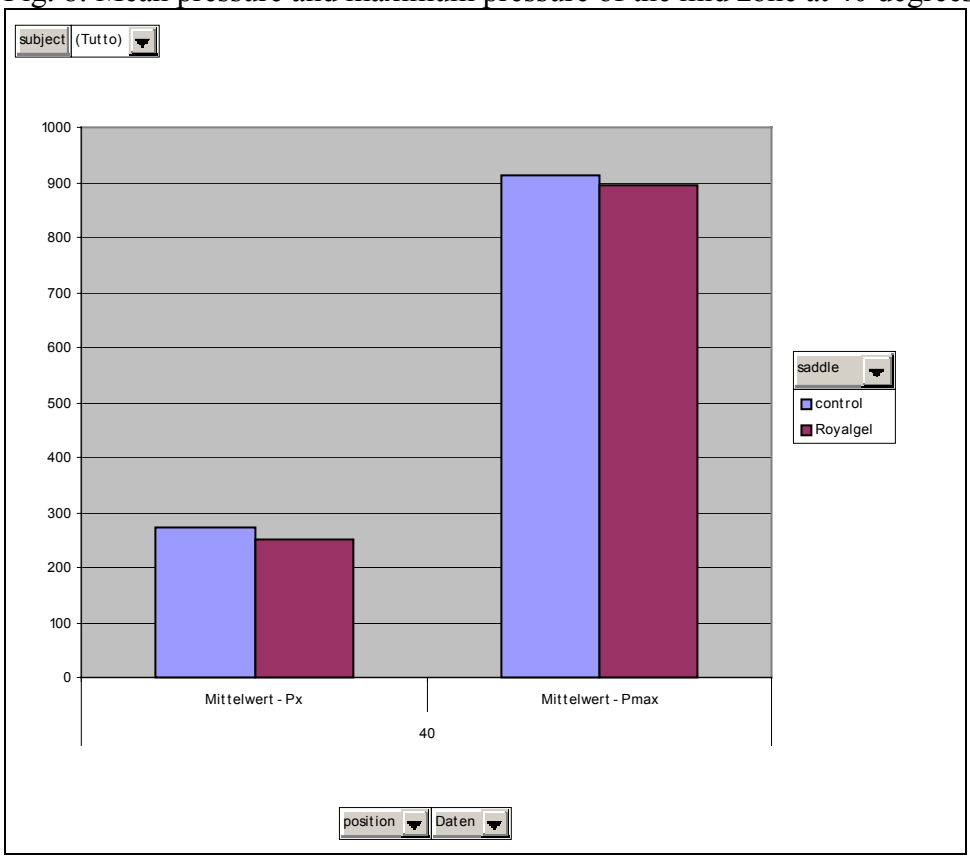
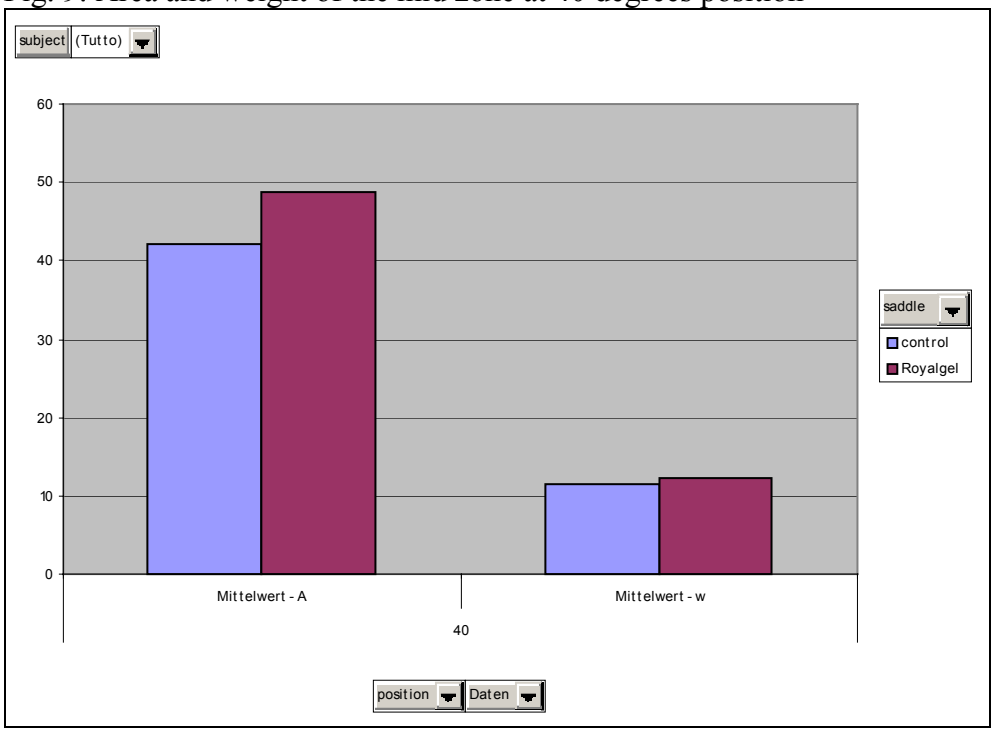


Fig. 9: Area and weight of the mid zone at 40 degrees position



Legend
Pos = position (40 and 60 degrees from horizontal)
Px = mean pressure (in g/cm²)
A = contact area (in cm²)
Pmax = maximum pressure (in g/cm²)
Mittelwert = mean value

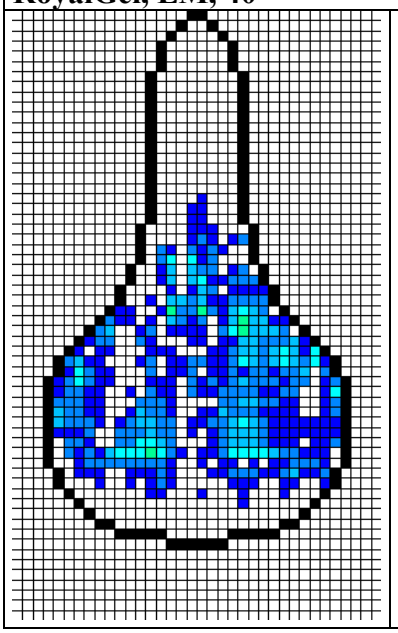
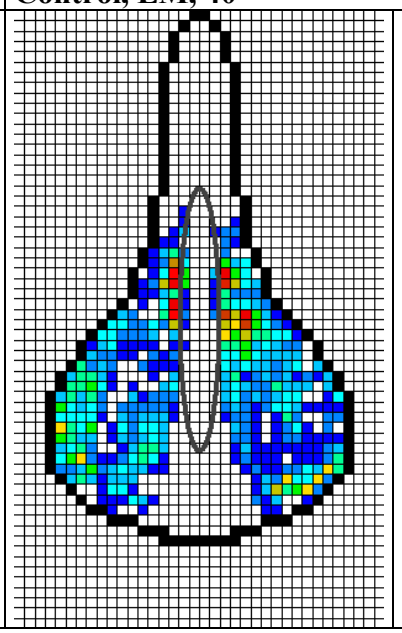
Qualitative Results

The quantitative results showed that there is negligible difference between the 2 saddles in terms of reducing the total pressure in the front part of the saddle. Therefore qualitative analysis will seek to show where pressure peaks for both saddles are localized, since the different geometry of the construction leads to a different positioning of the maximum pressures, both for the 40 and 60 degrees sitting positions.

1) Pressure distribution on position 40 degrees

Fig 10 shows the individual measurements on the same subject for both saddles. The pressure distribution with the Royalgel is evenly spread. The control saddle with the hole has no pressure in the hole but higher pressure areas at the edges of the hole.

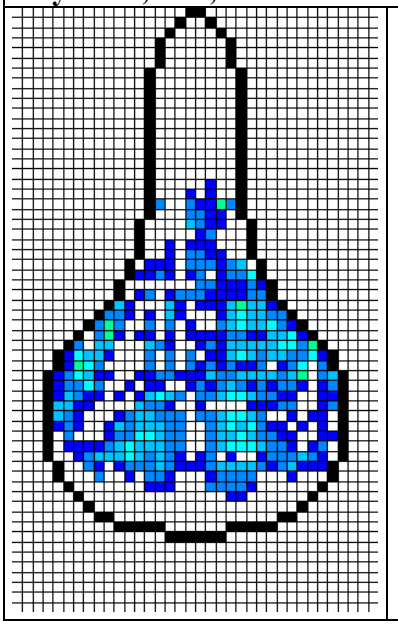
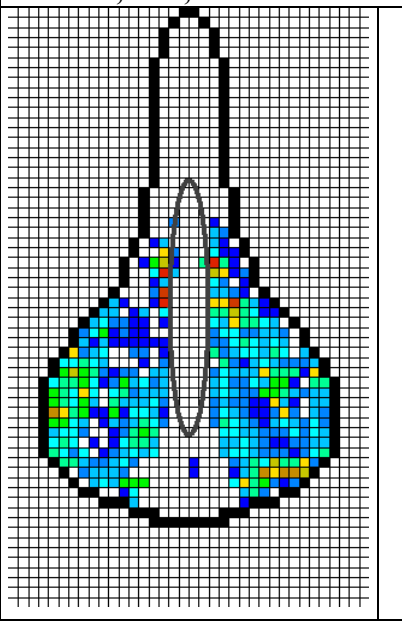
Fig. 10: racing Position (40 degrees)

RoyalGel, LM, 40°	Control, LM, 40°
	

2) Pressure distribution on position 60 degrees

Similar to the 40 degrees position the pressure distribution with the Royalgel is evenly spread, too. Many times subjects sit more in the back part of the saddle if they sit more in an upright position. For the control saddle it can be shown that the pressure at the edges of the hole causes higher pressure peaks.

Fig. 11: moderate Position (60 degrees)

RoyalGel, LM, 60°	Control, LM, 60°
	

Conclusion

Measuring the amount of pressure on the genital area is as important as evaluating where this pressure is located, and how this can effect the different anatomical structures. Fig.13 and Fig.14 show the position of the outer women genitals (Labia Majora) on the 2 saddles.

The **quantitative results** show that for both saddles in both positions high pressures are measured in the central part of the saddle. The most significant outcome of the study was the difference in pressure values between the two saddles in relation to sitting positions. Whilst the two saddles performed fairly evenly in the quantitative analysis, showing a negligible difference in reducing total pressure at the front part of the saddle (except the contact area, where the gel filled saddle performed better), most values for the sitting positions are significant. Whilst the mean pressure is higher in the more upright position (60 degrees), because more weight is on the saddle, the women themselves found this position significantly more comfortable. The reason for this is that in the more bent position (40 degrees) more sensitive areas were stressed. Moving to a more upright position (60 degrees), pressure goes more on the back of the saddle and the delicate genital area is relieved. Therefore the women perceived the more bent position as more uncomfortable and the more upright as more comfortable.

In the racing position, 9 out of 12 women preferred the Royalgel saddle. One reason for this could be that the edges of the hole cause more discomfort as the hole is in the middle of the saddle, and the scan pictures show higher pressure at this part of the saddle with the hole (Fig.14).

The **qualitative analysis** of where the high pressures are located, was necessary in order to give some indications on how to reduce the risks of health problems.

A first conclusion could be led by the comparison of the pressure distribution maps of each saddle in the two different sitting positions (Fig.10 and Fig.11). It can be noticed that in the more upright position, high pressures tend to move for both saddles in the back, where the ischia are located, relieving pressure from the labia majora. Shifting position to a more upright posture, therefore, could help preventing health problems due to the compression of the outer genitals.

The choice of a saddle becomes more critical when riding on a bent forward position (as in a racing position), because more pressure goes on the genital area. Looking at the position of the high pressures on the 2 different saddles, it can be noticed that

- the flat saddle with gel (Royalgel) distributes pressure over a bigger surface (with higher pressure eventually at the centre of the saddle);
- the saddle with a hole (control) distributes pressure over a smaller surface, with high pressure at the sides of the hole.

Therefore not only did the saddle with a hole not change the amount of pressure on the central part of the saddle, it centralised it in an area, which can potentially cut blood and lymphatic supply to a woman's outer genitalia. On the control saddle (Fig. 14) high pressures can occur on the sides of the hole, therefore compressing parts of the Labia Majora (shown in red). In the central part of saddle, the Labia Majora gets caught in the middle of the hole. Compression over a limited portion at the centre of each Labium could damage the skin and the lymphatic system, compress the nerves or cut blood supply to the rest of the Labium falling in the middle of the hole. This does not happen on the flat saddle with gel (Fig.13).

Fig.13 Saddle with gel and women's genitals

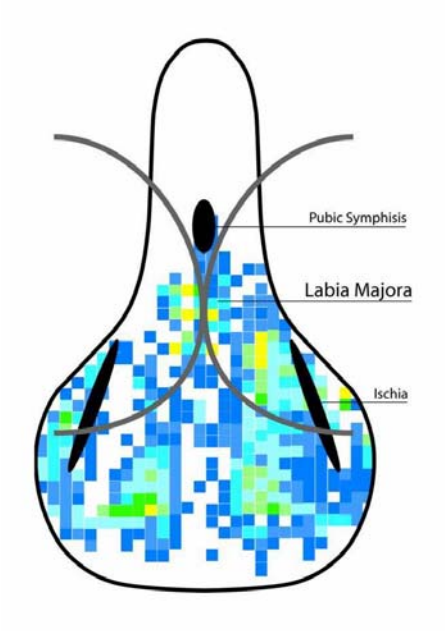
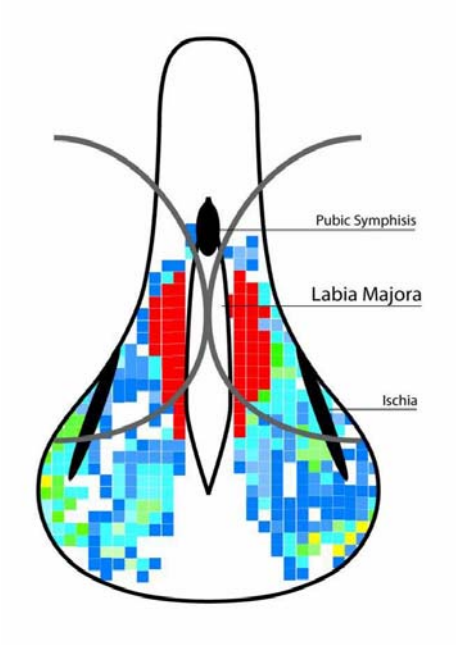


Fig.14 Saddle with hole and women's genitals (critical area shown in red)



To conclude, it must also be said that health problems are less likely to occur to recreational cyclists, because they normally ride for a shorter time and in a more upright position, possibly relieving pressure from the genital area, as indicated by the tests. It' worth saying that besides positioning the saddle correctly on the bicycle, as well as using a good padded saddle (ex. with gel), to reduce the risks of the health problems it is important to use good padded cyclist shorts and to maintain a correct perineal hygiene.

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