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Perineal tissue deformation under bicycle saddle pressure

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1. Introduction

For ecological, economical and public health reasons, sustainable urban mobility such as bicycle commuting has increased in French cities, especially since the Covid-19 pandemic. Nevertheless, despite the advantages, some people are refractory to using bicycle because of the pain from the saddle.

Indeed, due to the time spent on saddle, bicycle commuters, sport cyclists (leisure or competition) or professionals (such as delivery cyclist) may suffer from more serious troubles than discomfort. These troubles can be numbness of the perineal region, apparition of nodules, irritations, erectile troubles, loss of sensibility, oedema, etc (Van der Walt et al. 2014).

Up to now, most of the studies working on bicycle saddle discomfort have focused on the interface pressure between the saddle and the soft tissues of the perineum (Guess et al. 2011). However, even if it shows disparity of the pressure distribution among cyclists, the measure of pressure is not enough to predict discomfort because it does not give information on soft tissue stress.

In order to access to more information, some authors measured the blood flow through the perineum while sitting on a saddle (Piazza et al. 2020). But this measure is not directly linked to discomfort, nor most of the troubles. Another idea from Bressel et al. (2007) was to use MRI in order to directly observe the perineal tissue deformation. Because it was in a conventional MRI, the participants had to be lying on their back. For applying saddle pressure, a device was developed where the participant was harnessed to pull up the saddle toward the perineum. But the position of the participants was far from their position on a bicycle. Consequently, the soft tissue deformation observed in this study may not be relevant due to unrealistic loading conditions.

In this study, we used an open MRI to reproduce upright cycling postures during the image acquisition to measure deformation in different soft tissues of the perineum from image segmentation.

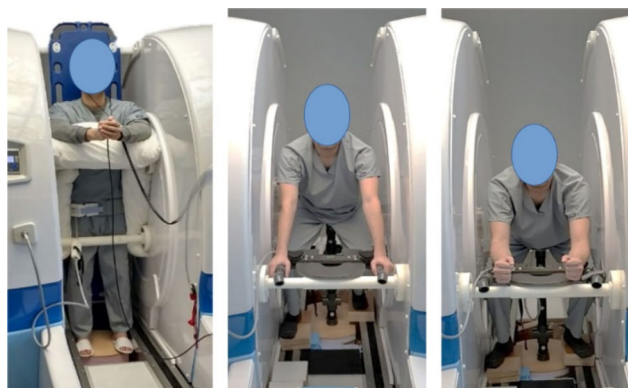


Figure 1. Set up in the open MRI. Left: reference position; middle: top position; right: drop position.

2. Methods

2.1. Experimental setup

An upright MRI scanner (Paramed[®] 0.5 Tesla, Figure 1), from the European Scanning Centered in Manchester, United Kingdom, was used.

A plastic mockup, composed of a 3D printed saddle, handlebars and supports, was built in order to fit in the MRI which requires non-metallic material to avoid ferrous metal and interferences.

Three male participants, aged 28, 35 and 31 years old, were asked to hold three postures (Figure 1):

- the ‘reference’ posture, where the participants stood up on their feet, in order to get anatomical images of the unloaded perineum’s participants;
- the ‘top’ posture, where the participants were seated on the saddle, holding the handlebar such as their back is approximately at 45°, corresponding to a cruising posture;
- the ‘drop’ posture where the participants were seated on the saddle, with their forearm on the arm rests, so their back was approximately at 25°, corresponding to a racing posture.

The resolution of the scans was set to 2 mm slice thickness, and 1 mm slice gap. For this resolution, the field of view was adjusted to be 300 × 300 × 300 mm in sagittal, coronal and transversal planes respectively. Each scan took approximately 8 min. In order to help participants not to move during the acquisitions to avoid blurry scans, two stabilizers allowed the participants to lean their upper body for stability.

The protocol was approved by the ethical committee of Université Gustave Eiffel (formerly the French

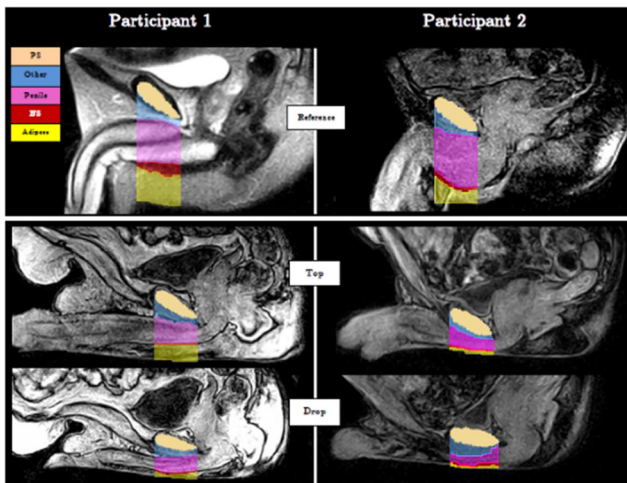


Figure 2. Segmentations in the ROI in the medial sagittal view in the reference, top and drop posture. The four tissue categories are highlighted as well as the pubic symphysis (PS) in peach.

Institute of Science and Technology for Transport, Development and Networks – IFSTTAR).

2.2. Data processing and analysis

The acquired MR images were segmented and processed in 3D slicer. It was desired to compare levels of tissue deformations below the anterior face of the pubis, from the reference to the top and drop postures. This anatomical location was of particular interest, as the peak deformation due to saddle induced forces are observed in this region according to (Bressel et al. 2007). Hence, for each participant, a region of interest (ROI) was subsequently defined as the tissues below the pubis symphysis (perpendicular to the saddle) in between the bilateral pubic tubercle (Figure 2).

The visible tissues identified in the ROI were divided into four categories: adipose tissue (fat and skin), the bulbospongiosus muscle (BS), penile tissues (PT) (comprised of corpus spongiosum and corpus cavernosum), and other (i.e. suspensory ligament of the penile body, etc.). These tissues were then separately segmented within the ROI for all participants' posture scans, and their individual segment volumes were extracted. These volumes were then used for determining the individual and total percentage tissue deformations.

3. Results and discussion

The MRI images of the three postures are shown in Figure 2 where the four tissue categories from the ROI are highlighted. The maximum compression of

Table 1. Percentage of the tissue compression in the ROI for the top and drop postures compared to the reference state.

Tissues	Other	Penile	BS	Adipose
	Participant 1			
Top	26%	32%	80%	45%
Drop	28%	49%	77%	80%
	Participant 2			
Top	12%	69%	70%	83%
Drop	29%	73%	62%	81%
	Participant 3			
Top	12%	71%	31%	55%
Drop	18%	72%	45%	76%

the tissues in the whole ROI occurs in the drop posture. For the participant 1, this value is approximately 50%, however for the second and third participants it is more than 70%. The BS muscle is the most compressed tissue in the ROI in both postures for participants 1 and 2. This is the case for the adipose tissue in the participants 3's ROI.

Table 1 shows tissue compression based on volume in the ROI in top and drop postures compared to the reference posture: $1 - V/V_{ref}$. It seems that the penile and the adipose tissues are the most compressed.

It appears clearly that there are disparities in between participants in anatomy as well as in tissue compression (Figure 2 and Table 1). Because the number of participants in this study is small, it is not possible to conclude on the possible cause of discomfort and health trouble due to bicycle saddle. Further work needs to be performed with more participants.

4. Conclusions

Results show a difference between the anatomies and percentage tissue compositions across the participants. Surely these differences have major influence on the manner with which the respective tissues deform in the perineal region, and hence affect the neurovascular vessels they enveloped within them.

With regards to the effect of cycling posture on tissue deformations, the results indicate that the maximum tissue-bundle deformation occurs during the drop posture across all the participants.

In conclusion, pelvic and perineal anatomical structures should be taken account during saddle conception and should be added to the parameters that need to be assessed before choosing a saddle.

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