Journal of Science & Cycling
Breakthroughs in Cycling & Triathlon Sciences

OPEN ACCESS

*Abstract*

# Gender related differences in pressure distribution, pelvis movement and subjective perception during cycling

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Received: date; Accepted: date; Published: date

**Abstract:** This research aims to examine and compare the saddle pressure distribution, pelvis movement and subjective feedback regarding perceived saddle pressure and stability of male and female cyclists. For this corresponding data are recorded after three minutes of sporty cycling. The findings Indicate notable differences, which can be attributed to anatomical variations between genders. These results have practical Implications for the design of saddles and seat pads, as they highlight the need for gender-specific considerations In cycling equipment.

**Keywords:** biking; pressure mapping; sex;

## 1. Introduction

While in cycling mainly male cyclists have been studied so far, studies with female cyclists are quickly numbered. Especially when it comes to pressure distribution, there is hardly any data from female cyclists so far. The reintroduction of the "Tour de France Femmes" in 2022 shows an increasing attention on females in cycling. The work by Potter et al. (Potter,Sauer, Weisshaar, Thelen &Ploeg, È, 2008) and Sauer et al. (Sauer, Potter, Weisshaar, Ploeg & Thelen, 2007) suggest that gender differences in anatomy affect pressure distribution on the saddle and seat pad. Knowledge of this can play a major role in the development of saddles and seat pads. In this study, in addition to the pressure distribution, pelvis movement was recorded, and subjective pressure perception was queried to find possible differences between male and female cyclists.

## 2. Materials and Methods

Subjects— A total of fourteen participants took part in this study, consisting of seven females (mean age: 31.5 ± 4.1 years, body weight: 61.7 ± 5.2 kg, height: 167.3 ± 3.2 cm) and seven males (mean age: 41.3 ± 8.9 years, body weight: 80.1 ± 5.0 kg, height: 181.6 ± 4.2 cm) participated in this study. All participants provided informed consent and self-classified themselves as recreationally trained to well trained. Based on their Peak Power Output (PPO), the subjects were classified as trained and well trained following the classification of Decroix et al. and Pauw et al. (Decroix, Pauw, Foster, & Meeusen, 2016; Pauw et al., 2013). No professional cyclists were included in this study.

Methodology— The study utilized a bicycle trainer (Kickr Bike, Wahoo, Atlanta, Georgia) individually adjusted for each participant. The seating position was set according to the guidelines of Burke (Burke, 2003), with the trunk inclination set to 50 °. A

Cube Venec saddle (Cube, Germany) was used, with the size selected based on the seatbone distance. Participants rode at 80 rpm and a power of 70 % of the individual Functional Threshold Power (FTP) value (mean of power: ♀: 136.7 ± 7.3 W, ♂: 194.3 ± 13.5 W). Cycling shorts with a 14 mm thick seat pad with a density of 100 kg/m³ were used, and pressure distribution, pelvis movement, and subjective data were recorded after 3 minutes of cycling. Pressure distribution was measured over a 10-second period using a gebioMized pressure measuring mat (gebioMized, Münster, Germany), with the saddle divided horizontally into three equal parts and the mean pressure calculated by Matlab (The MathWorks, R2022b) for each part and the entire area. Center of Pressure (CoP) was also calculated, along with its horizontal width and vertical length. Pelvis movement was recorded using an inertial measurement unit (IMU, menios GmbH, Ratingen, Germany) placed on the sacrum for 10 seconds, with the absolute pelvic inclination with respect to the vertical axis, range of pelvic angle rotation, obliquity, and tilt, as well as the speed of the sacrum, calculated using the IMU data. Participants were asked to rate the perceived pressure intensity, discomfort caused by pressure, and stability on the saddle-seat pad interface.

Statistical Analysis— The small sample size prompted non-parametric data analysis. The Mann-Whitney-U test was used to examine the independent data, with a significance level of $\alpha$= 0.05.

## 3. Results

### 3.1. Pressure Distribution

Based on the data presented in Figure 1, the mean pressure exerted by males was found to be significantly higher than that exerted by females. Notably, the mean pressure exerted by females was found to be slightly higher in the front zone, although the difference was not statistically significant. Additionally, the males showed higher force and loaded area values on the pressure mat. However, there were no significant differences observed in the CoP parameters.

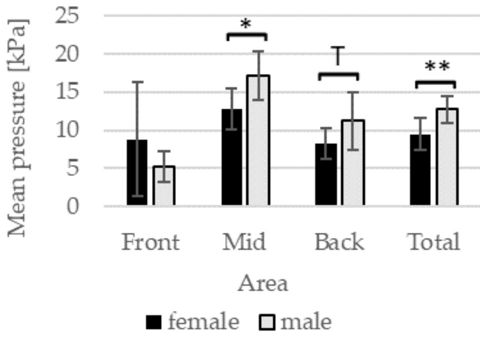


**Figure 1.** Mean pressure distribution of male and female (T: 0,1>p>0,05; *: 0,05>p>0,01; **: 0,01>p>0,001)

### 3.2. Pelvis movement

Significant differences were observed in the total pelvis tilt angle, with females demonstrating a significantly higher angle than males when cycling in a sporty position. Specifically, the mean pelvis inclination in the sagittal plane for males was approximately 23 ° ± 6,7 °, while for females it was about 35 ° ± 7,7 °. However, no other significant differences were found in the IMU-parameters.

### 3.3. Subjective feedback

Females experienced significantly greater discomfort caused by pressure in the anterior region than males did, whereas males experienced more discomfort in the posterior region. Females tended to rate pressure intensity in the anterior region higher than males did. However, no significant differences were observed in the perceived stability of the saddle between males and females.

## 4. Discussion

The observed difference in mean pressure between males and females can be attributed to the difference in weight, with males in this study being approximately 18 kg heavier than females. This finding is consistent with a previous study by Bressel and Cronin (Bressel & Cronin, 2005). Notably, females in the current study showed higher pressure in the front zone, which aligns with both Potter et al. and Bressel and Cronin's findings (Bressel & Cronin, 2005; Potter et al., 2008).

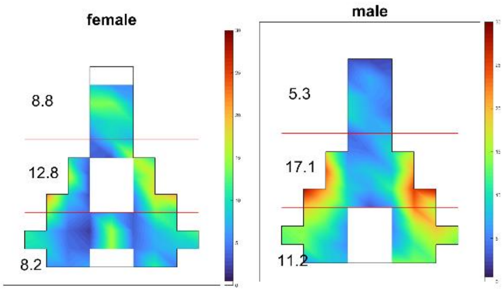


**Figure 2.** Mean pressure distribution of male and female cyclists

Potter et al. explained this phenomenon because of anatomical differences in the pelvis, with females having a greater angle between the pubic arches. This can cause the pubic arches of females to not rest on the saddle, leading to more load on the pubic symphysis or saddle nose, respectively. This explanation is supported by the results of Sauer et al. (Sauer et al., 2007), and the current IMU data confirms a more inclined pelvis in females.

However, it is important to note the high standard deviation of the mean pressure in the front area for females, which may be due to non-professional cyclists requiring some time to settle into the saddle, as suggested by Marcolin et al. (Marcolin, Petrone, Reggiani, Panizzolo, & Paoli, 2015). Therefore, this factor should be considered when interpreting the data.

## 5. Conclusions

This study highlights that gender-specific differences in anatomy have a significant impact on both objective and subjective pressure distribution, in terms of location and magnitude. This knowledge aid in the optimization of saddle and seat pads, regarding padding characteristics and design. As the seatbone distance is already considered in sizing and shaping of saddles and seat pads, this could also be applied to the distance and alignment respectively between the pubic arches. Additionally, the higher mean pressure on the saddle nose for females and generally higher pressure in other areas for males should influence the selection of appropriate saddles and seat pads. These findings should be taken into consideration to improve seating comfort, reduce the risk of injury, and improve the performance of cyclists.

**Funding:** This study was conducted within the framework of the A4SEE project, co-funded by the Erasmus+ Program of the European Union.

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