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Conference Abstract

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Influence of Seating Posture and Gender on Pelvic Movement and Saddle Pressure during Cycling

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Abstract

The aim of the present study was to compare female and male cyclists riding in an inclined and an upright seating posture based on saddle pressure distribution and pelvic movement. The results show differences between females and males as well as between the two seating postures. In general, females show less mean saddle pressure and less pelvic movement in the frontal plane. However, females reveal a higher anterior forward pelvic tilt which contributes to higher mean pressure around the anterior saddle region. The results of the study confirm the importance of selecting the appropriate saddle and seat pad respectively depending on gender and cycling specific activities to improve seating comfort and to reduce the risk of injury.

Keywords

cycling; seating posture; pressure distribution; IMU; pelvic movement; saddle

1 Introduction

Cycling has been the most popular sport in Germany for several years now. According to the sports satellite account, 41 % of the German population are active cyclists (BMWi, 2021). Looking at the type of bicycle used, only 10 % of cyclists ride a road bike (Jurczok et al., 2023). Most cyclists use conventional bicycles (45 %), mountain bikes (31 %) and/or trekking bikes (22 %) (Jurczok et al., 2023). Contrary, most of cycling research referring to biomechanics and ergonomics of road cycling. Moreover, suggested bike fitting interventions are mostly related to road bikes. Indeed, seat problems such as saddle soreness, chafing, numbness or seating comfort in general affect all cyclists.

The aim of the present study is to investigate and to compare female and male cyclists riding on a stationary bike in an inclined (e.g., road bike) and an upright (e.g.

trekking bike) seating posture. The focus of the research is related to pressure distribution on the saddle and pelvis movement to derive knowledge to optimize saddles and seat pads for cycling activities with a more upright seating posture such as bicycle touring using a trekking bike.

2 Material and Methods

2.1 Participants

Nine female (age: 31.1 ± 4.3 years, height: 167.7 ± 5.2 cm, weight: 63.0 ± 3.8 kg) and ten male (age: 42.1 ± 9.1 years, height: 180.9 ± 3.0 cm, weight: 80.8 ± 5.3 kg) cyclists participated in the study. Based on their absolute and relative Peak Power Output (PPO), the participants were classified as recreationally/regularly trained (PL2) following the classification of Decroix et al. (2026) and De Pauw et al. (2013).

2.2 Methodology

For the inclined seating posture, the trunk inclination was set to 50° and for the upright seating posture to 70°. Within the “inclined” cycling condition all subjects rode a cadence at 90 rpm and a power of 70 % (♀: 122.3 ± 13.5 W; ♂:169.4 ± 20.6 W) of the individual Functional Threshold Power (FTP) value. The “upright” condition was realized at 70 rpm and a power of 45 % (♀: 78.7±8.7 W; ♂:108.9±13.3 W) of the individual FTP value.

During the upright condition a saddle (Cube Sequence, Pending System GmbH & Co. KG, Waldershof, Germany) and a cycling short (T-Pad, 15 mm thickness; 100 kg m^{-3} density, VAUDE Sport GmbH & Co. KG, Obereisenbach, Germany) for trekking bikes/activities were used. For the inclined trunk condition a road bike saddle (Cube Venec, Pending System GmbH & Co. KG, Waldershof, Germany) and a cycling short designed for gravel cycling/MTB (X-Pad, 15 mm thickness; sandwich construction: 110 kgm-3 / elastic TPU layer / 110 kg m^{-3} density, VAUDE Sport GmbH & Co. KG, Obereisenbach, Germany) was used. With exception of the standardized trunk inclinations each participant was individually adjusted on a stationary bike (Kickr Bike, Wahoo, Atlanta, USA) according to the bike fit guidelines recommended by Burke (Burke, 2003).

Pressure distribution between saddle and buttocks was measured over a 10-second period using a gebioMized pressure measuring mat (SnM gebioMized GmbH, Münster, Germany). The saddle mat was divided horizontally into three equal parts, and the mean pressure was calculated for each part and the entire area. In addition, the location of the center of pressure (CoP) and its trajectory were analyzed.

Pelvic movement was simultaneously recorded again for 10 seconds using an inertial measurement unit (Wave Track, menios GmbH, Ratingen, Germany) placed on the sacrum. Based on the IMU data absolute pelvic tilt referring to the sagittal plane as well as the range of motion (RoM) of pelvic angle rotation, obliquity and tilt were calculated and analyzed.

2.3 Statistical Analysis

Data preparation and evaluation was done in MATLAB® (R2021a, The MathWorks Inc., Natick, United States). Statistical differences between the two seating positions were carried out using repeated measures ANOVA and Bonferroni-corrected post-hoc tests. For gender comparison the independent - samples t test was applied (IBM SPSS Statistics Version 29, IBM Corporation, Armonk, NY). The significance level was set at α= 0.05.

3 Results

3.1 Comparison of Seating Posture

Cycling in the upright seating posture exhibit a significant lower pelvic movement in the frontal plane (rocking) in both females and males (Table 1 & 2). As expected, the pelvis is significantly more upright aligned in the upright seating posture (Table 1 & 2).

Table 1. Females (n=9): Pelvic Motion (RoM) and absolute pelvis tilt during inclined versus upright seating posture.

Pelvic motion [°]	Inclined	α	Upright
RoM - Obliquity (frontal plane)	6.8 ± 1.9	**	3.7 ± 1.0
RoM - Rotation (transverse plane)	4.2 ± 1.4		5.4 ± 2.8
RoM – Tilt (sagittal plane)	2.6 ± 0.7		3.4 ± 1.1
Absolute pelvic tilt (sagittal plane)	63.0 ± 6.4	**	74.9 ± 7.2

Table 2. Males (n=10): Pelvic Motion (RoM) and absolute pelvis tilt during inclined versus upright seating posture

Pelvic motion [°]	Inclined	α	Upright
RoM - Obliquity (frontal plane)	8.9 ± 1.9	**	6.3 ± 2.0
RoM - Rotation (transverse plane)	4.5 ± 1.5		5.3 ± 1.3
RoM – Tilt (sagittal plane)	3.6 ± 1.1	*	2.3 ± 0.9
Absolute pelvic tilt (sagittal plane)	75.5 ± 6.4	*	84.6 ± 7.4

The mean saddle pressure is significant lower only in females during cycling in the upright seating posture compared to the inclined condition (Figure 1). In this context the contact area between saddle and buttocks is significant greater in females during upright cycling. There are no significant differences for males comparing the two seating postures regarding seat pressure parameters. However, statistically not significant but biomechanically relevant, cycling in the inclined seating position leads to a higher mean pressure in the anterior saddle region in males and especially in females. This goes hand in hand with an anterior shift of the CoP while riding in the inclined seating posture (Figure 1). Nonetheless, no significant differences in any of the center of pressure parameters (e.g. CoP-trajectory/elongation in medio-lateral and anterior-posterior direction, CoP-position) were observed between riding in the inclined versus upright seating posture.

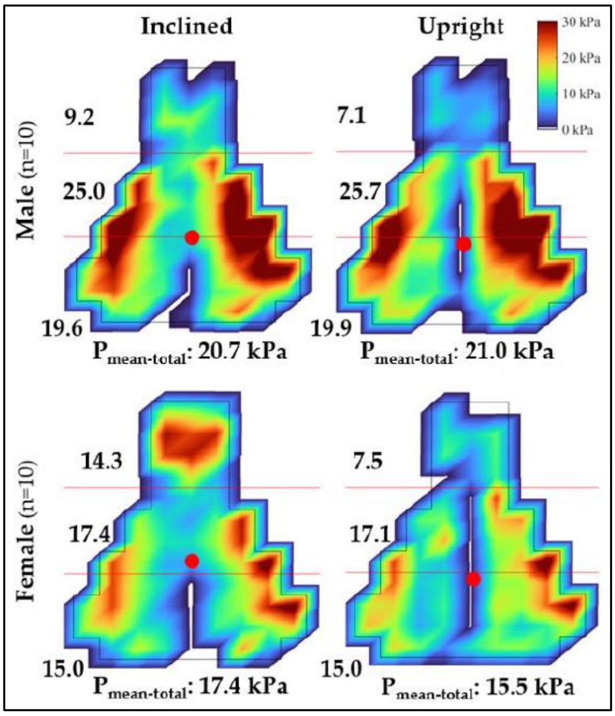

Figure 1. Mean pressure distribution of male and female cyclists during cycling in an inclined (left) and upright (right) seating posture for each saddle region and entire saddle region ($p_{mean-total}$); red dots indicate CoP, red horizontal lines subdivide anterior, center and posterior saddle region.

3.2 Gender Dimorphism

Female cyclists show significant less pelvic movement in the frontal plane regarding both upright and sportive seating position (Table 1 & 2). Furthermore, the female pelvis displays a significant higher forward tilt (sagittal plane) in both seating postures.

The mean total saddle pressure and the mean pressure within the center zone as well as the force are significant lower for females compared to males (Figure 1). This is valid for both seating postures. Moreover, the pressure distribution patterns display a higher mean pressure in the anterior region of the saddle for females especially in the inclined seating position. However, due to the high variability in the data this finding is not statistically significant (Figure 1).

4 Discussion

4.1 Comparison of Seating Posture

Richter (2022) and Freunek et al (2023) conducted similar studies with the same research goal as the present one. However, they used a wider and more cushy saddle for the upright cycling condition. The inclined seating posture was done with the same trunk inclination (50°). However, cycling in the upright seating posture was performed with 80° trunk inclination. Like in the present study the mean saddle pressure was significant lower only in females during cycling in the upright seating posture compared to the inclined condition. The male participants in the two studies mentioned above also showed a lower average saddle pressure in the upright seating posture, but without a significant difference. Consequently, the results of the present and the previous studies (Richter, 2022, Freunek et al., 2023) suggest, that the whole saddle-seat pad-unit (wider and more upholstered saddle/softer seat pad) during the upright seating condition can "compensate" the higher load on the saddle due to the more upright trunk position. However, it cannot be ruled out that the lower wattage and the lower cadence during cycling in the upright condition contribute to this "compensation effect".

Also, Richter (2022) could recognize a significant lower anterior pelvic tilt and lower pelvic movement in the frontal plane (rocking) for females and males during cycling in the upright condition.

4.2 Gender Dimorphism

The difference in mean pressure between the female and the male subject group can be mainly attributed to the difference in body weight (ca. 18 kg lower for females). This finding goes hand in hand with previous studies (Bressel & Cronin, 2005, Freunek et al., 2022, Richter et al., 2023).

Also the higher pressure in the anterior saddle region in females are consistent with other studies (Potter et al., 2008, Richter et al., 2023). Potter et al. (2008) attributes this different pressure pattern to the gender-specific pelvic anatomy. The female pelvis displays a greater angle (pubic arch) between the pubic rami. In addition, the pubic symphysis in females is lower located compared to males. This can lead to the pubic rami not resting completely on the saddle and hence, causing more load on the pubic symphysis or anterior saddle region, respectively.

This explanatory approach is supported by the IMU data of the present study as well as the results from Sauer et al. (2007) and Richter et al. (2023). These findings reveal a significant anterior forward tilt of the pelvic in females compared to males.

5 Practical Applications & Conclusions

This study highlights the importance of gender specific differences for both seating postures – the inclined and the upright position. Due to differences in gender specific body weight, difference of the "effective mass" acting on the saddle and the different exercise loads during cycling in the inclined versus upright trunk position, the stiffness characteristics of padding material as well as the design of the entire seating system (saddle and seat pad) should be considered. For females – especially riding in the inclined seating position – the design (geometry, contour and padding characteristics) of the anterior saddle (and seat pad) region seems to be very important towards enhanced comfort and injury prevention. The forward and downward motion of the hip joints during downstroke causes pelvic movement and hence shear loading along the perineal region. Therefore, increased emphasis should be paid on designing the saddle contour regarding the center region (transition zone) to support the ischiopubic rami while not excessively stressing the tissues in the perineum and pubic arch.

In general, the results of the study confirm the importance of selecting the appropriate saddle and seat pad respectively depending on gender and cycling specific activities to improve seating comfort, reduce the risk of injury, and possibly enhance performance during cycling.

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Conflicts of Interest: The authors declare no conflict of interest.

References

Bressel, E., & Cronin, J. (2005). Bicycle seat interface pressure: Reliability, validity, and influence of hand position and workload. *Journal of biomechanics, 38*(6), 1325–1331.

BMWi-Bundesministerium für Wirtschaft und Energie. (2021). Sportwirtschaft: Fakten & Zahlen. Retrieved from https://www.bisp.de/SharedDocs/Kurzmeldungen/DE/Nachrichten/2021/SSKSportwirtschaft2021.html

Burke, E. (2003). High-tech cycling: Human Kinetics.

Decroix, L., De Pauw, K. de, Foster, C., & Meeusen, R. (2016). Guidelines to classify female subject groups in sport-science research. *International Journal of Sports Physiology and Performance, 11*(2), 204–213.

Freunek, J., Litzenberger, S., & Michel, F. I. (2022). Saddle-pressure distribution and perceived comfort during inclined and upright cycling. In d: Krumm, S. Schwanitz & S. Odenwald (Eds.), *spinfortec 2022* (pp. 73-76). Chemnitz: Chemnitz University of Technology.

Jurczok, F., Gensheimer, T., & Specht, F. (2023). *Fahrrad-Monitor 2023*. Retrieved from https://bmdv.bund.de/SharedDocs/DE/Artikel/StV/Radverkehr/fahrradmonitor.html

De Pauw, K. de, Roelands, B., Cheung, S. S., Geus, B. de, Rietjens, G., & Meeusen, R. (2013). Guidelines to classify subject groups in sport-science research. *International Journal of Sports Physiology and Performance, 8*(2), 111–122.

Potter, J. J., Sauer, J. L., Weisshaar, C. L., Thelen, D. G., & Ploeg, H.-L. (2008). Gender differences in bicycle saddle pressure distribution during seated cycling. *Medicine & Science in Sports & Exercise, 40*(6), 1126–1134.

Richter, S. (2022). *Entwicklung einer Untersuchungsmethodik zur Evaluierung des mechanischen Sitzkomforts von gepolsterten Radhosen* [Development of a test methodology for evaluating the mechanical comfort of padded cycling shorts]. (Unpublished master thesis, Chemnitz University of Technology).

Richter, S., Schwanitz, S., & Michel, F. I. (2023). Gender related differences in pressure distribution, pelvis movement and subjective perception during cycling. *Journal of Science and Cycling, 12*(2), 6-8.

Sauer, J. L., Potter, J. J., Weisshaar, C. L., Ploeg, H., & Thelen, D. G. (2007). Influence of gender, power, and hand position on pelvic motion during seated cycling. *Medicine & Science in Sports & Exercise, 39*(12), 22004-2011.