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Research article

The Effect of Bicycle Saddle Widths on Saddle Pressure in Female Cyclists

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Abstract

Choosing an unsuitable bicycle saddle increases the saddle pressure and discomfort during cycling. Women contract sports injuries more easily than men during cycling owing to their anatomy. To investigate the effect of saddle widths on the saddle pressure in female cyclists. Ten healthy women with an average age of 20.7 ± 1.3 years, height of 162 ± and 5.9 cm, weight of 56.1 ± 7.5 kg, and a sciatic bone width of 15.5 ± 1.4 cm were recruited for this study. The distributions of saddle pressure for four different saddle widths (i.e., narrow, moderate, wide, and self-chosen) were recorded using a saddle pressure mat. Participants were instructed to pedal steadily with a frequency of 90 RPM and a load of 150 watts. Thirty seconds of riding data was randomly retrieved for analysis. The trials were conducted with a counter-balanced design to minimize random errors. One-way repeated measures ANOVA was used to compare the saddle pressure of different saddle widths, and the significance level was set at α = 0.05. When wide saddles were used, the maximum and average pressure on the right surface of the posterior ischium were lower than those with narrow ($p = 0.001$, $p = 0.012$) and moderate ($p = 0.016$, $p = 0.019$) saddles. The area of pressure on the pubic bone was smaller when using a wide saddle than when using narrow ($p = 0.005$) and moderate ($p = 0.018$) saddles, and the area of pressure on the right posterior sciatic bone was larger under the wide saddle than under the narrow ($p = 0.017$) and moderate ($p = 0.036$) saddles. The average force was greater with the moderate saddle than with the wide ($p = 0.008$) and self-chosen ($p = 0.025$) saddles. Using a saddle with a width that is longer than the width of the cyclist's ischium by 1 cm can effectively improve the distribution of saddle pressure during riding, while providing better comfort.

Key words: Bike fitting, center of pressure, human health.

Introduction

Choosing a suitable bicycle saddle can increase riding comfort and lengthen the cycling time. Previous research has shown that female cyclists have several reproductive health problems (Guess et al., 2011); thus, it is necessary to design bicycle saddles that can help overcome these problems. However, the largest width of a bicycle saddle currently available is 15.5 cm, which is reportedly uncomfortable for a long cycling time and is the main complaint regarding cycling (Chen and Liu, 2014). Cycling can cause pelvic floor pain, perineal numbness, abrasions, urethritis, and other diseases (Guess et al., 2006; 2011; Silbert et al., 1991; Weiss, 1994). Therefore, numerous improvements have been made to the design of bicycle saddles to mainly improve comfort and reduce the incidence of associated diseases. Currently, various saddle designs are available; several adjustments have been made on the incision and sponge filling of the saddle (Lowe et al., 2004). However, most studies have concentrated on improving the material of the bicycle, and few have focused on the influence of the human anatomy when designing a saddle.

At present, bicycle products and accessories have been mainly developed and designed to accommodate the anatomy of male cyclists, and the products are assumed to meet the needs of female cyclists when they are proportionally reduced in size without any further design and development. In addition, sex issues in different sports have recently garnered attention (Bury et al., 2020; Mitani, 2017; Phinyomark et al., 2016). For cycling, sports injuries occur more frequently in women than in men (Briggs and Obermire, 2016; Bury et al., 2020; Priego Quesada et al., 2019). Furthermore, women are twice more likely to develop patellofemoral pain syndrome than men (Boling et al., 2010). Some studies have shown that during exercise, women produce greater hip adduction and pronation and knee joint abduction than men, resulting in differences in lower limb kinetic and kinematic parameters (Ferber et al., 2003), which may be one of the factors causing patellofemoral pain syndrome (Willson et al., 2011). Therefore, adjusting bicycle designs according to the human limb can reduce the incidence of sports injuries (Encarnación-Martínez et al., 2020).

For the examination of riding comfort, a pressure saddle can be used to accurately record and evaluate the pressure distribution of the saddle during cycling (Holliday et al., 2019a) and observe the changes in pressure indexes, which may predict the occurrence of injuries (Vette et al., 2019). Pressure sensors are widely used in gait detection (Booth et al., 2020; Naderi et al., 2020; Yokozuka et al., 2020). Pressure parameters are important reference indexes to help identify and rectify the design of bicycle saddles (Bressel and Cronin, 2005). Previous research has shown that saddles with an incision affect the pelvic inclination angle and comfort of female cyclists (Bressel and Larson, 2003) and reduce the perineal pressure in male cyclists. Furthermore, when changing from holding the upper handles to the lower ones, men have smaller pressure peaks than do women, which may be due to the different distribution of the body mass between men and women, as the center of gravity of women is lower than that of men (Bressel and Cronin, 2005). According to previous studies on bicycle saddles, bicycle saddles should be designed considering the anatomical differences between sexes. When men and women sat in the same position on the same saddle, the

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width of the ischial tuberosity of women was greater than that of men (Chen, 2018). At present, the designs of bicycle saddles are still being improved to accommodate the needs of female cyclists, indicating that most cyclists are not satisfied with their bicycle saddles. Therefore, this study aimed to explore the influence of saddle widths on various pressure parameters in female cyclists. We hypothesized that a wider saddle would reduce the saddle pressure during cycling in women.

Methods

Participants

Ten healthy women were recruited for this study. These participants had an average age of 20.7 ± 1.3 years, height of 162 ± 5.9 cm, weight of 56.1 ± 7.5 kg, and a sciatic bone width of 15.5 ± 1.4 cm. Sample size calculations (G*Power, version 3.1.9.7) revealed that a sample of 10 participants would be sufficient to detect a difference according to the saddle width, with a statistical power of 0.98 and Type I error probability associated with the test of this null hypothesis, 0.05. They had no history of lower limb musculoskeletal injury or injury related to the neurological system during the year prior to the study. The participants provided their informed consent prior to the experiment. The study was approved by the Institutional Review Board and was conducted in accordance with the principles of the World Medical Association Declaration of Helsinki.

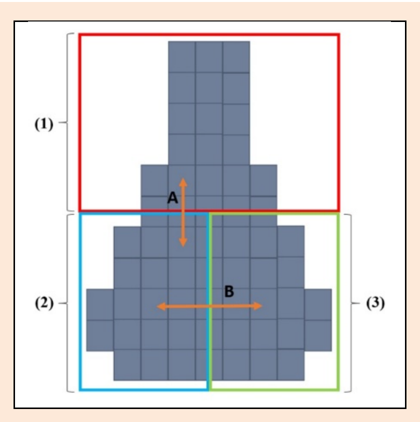

Figure 1. Pressure mat showing the locations of the anterior pubic bone (1), rear left sit bone (2), rear right sit bone (3), longitudinal (A), and transverse (B) movements around the center of pressure. Each square depicts a pressure sensor.

Instrumentation and procedures

Pressure mat (GebioMized, Muenster, Germany)

The saddle pressure mat used in this study has been extensively used by other studies, in which the reliability and validity has been determined (Bressel and Cronin, 2005; Swart and Holliday, 2019). The pressure saddle sensing system was used for all tests at a frequency of 200 Hz. The system consisted of a thin saddle containing 64 square capacitive pressure sensors (7.09 × 7.09 mm) mounted on the saddle, which was calibrated according to the manufacturer's instructions. The GebioMized system recorded the following parameters: maximum pressure, mean pressure, pressure area, pressure front/rear, pressure left/right, maximum force, and mean force (Figure 1).

Saddle widths

Four different saddle widths (i.e., 14 cm, 15 cm, 16 cm, and 17 cm) were tested. Each saddle weighed approximately 600 g (Figure 2) and was made of polylactic acid using a three-dimensional printing machine. The saddle bracket was made of steel. A thick high-density sponge was used to soften the saddle surface to imitate commercially available saddles. Participants whose width of the ischium was 13 cm or 14 cm were excluded from this study.

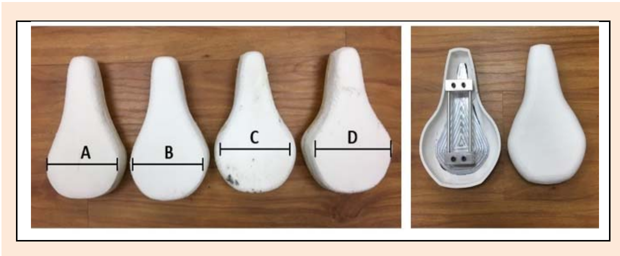

Figure 2. Saddle widths are as follows: 14 cm (A), 15 cm (B), 16 cm (C), and 17 cm (D). The bottom of the saddle is supported by steel brackets to avoid the risk of bracket breakage caused by human weight load during cycling.

Riding posture

For minimal experimental error, the same bike model was ridden by all participants throughout the experiment to exclude the potential influence of different bike frame geometry that might result in changes in riding postures. The saddle height was adjusted until the knee flexion angle reached 30 degrees when the crank was at the 6 o'clock position. Previous research has shown that this posture configuration is beneficial and exerts less stress on the knees, which reduces the incidence of knee and thigh injuries (Swart and Holliday, 2019). Furthermore, the trunk flexion angle remained constant at 45 degrees in this study. Cyclists are recommended to maintain an upright riding posture when riding as it is more comfortable (Priego Quesada et al., 2017). Likewise, participants in this study were instructed to maintain an upright riding posture while holding the upper handles of the bicycle. This riding posture has been previously found to reach a higher ecological validity (Kordi et al., 2019).

Data collection

Upon the arrival of the participants at the laboratory, the experimental procedures were first explained to them. Once an informed consent was obtained, the participants' body and limb segments were measured to determine the suitable saddle. In this study, the saddle with an equivalent length to the participant's ischium width was defined as moderate, while those with a length greater or less by 1 cm were defined as wide and narrow, respectively. The participants also chose a saddle that was considered comfortable for them, and the same researcher installed the pressure saddle on these self-chosen saddles to minimize errors. Before cycling, the participants warmed up for 10 min, and after the installation, saddles with different widths were tested using the counter-balancing method to minimize random errors caused by adaptation or the study design. During the test, the frequency of pedaling and the output voltage were observed using the Giant POWER PRO power meter, and the participants were not informed when data were recorded, to prevent them from changing their pedaling actions. They cycled at 100 watts at 90 rev·min^{-1} and 10 min each time. Stable pedaling for 30 s was recorded, and the participants rested for 5 min between different experimental conditions.

Data processing

The GebioMized system recorded the pressure parameters (Figure 1), and all values are presented as mean ± standard deviation for subsequent statistical analysis.

Statistical analysis

The SPSS software (Version 22.0, IBM Corp., Armonk, NY, USA) was used for statistical analysis. One-way repeated measures ANOVA was used to compare the influence of saddle widths on pressure parameters. According to the square value of net correlation Eta (η2), the effect size was determined. The degree of effect size was defined as follows: 0.01–0.06 = small, 0.06–0.14 = moderate, and > 0.14 = large (Cohen, 1988). When the main effect size was significant, the Bonferroni method was used for post-hoc test comparison. The significance level was set at α = 0.05.

Results

One-way repeated measures ANOVA showed that there were significant differences in the maximum rear left sit bone pressure, maximum rear right sit bone pressure, mean rear right sit bone pressure, pubic pressure area, rear right sit bone pressure area, and mean force when different saddle widths were used. However, the maximum pubic pressure, mean pubic pressure, mean rear left sit bone pressure, rear left sit bone pressure area, longitudinal pressure, transverse pressure, and maximum force did not show any significant differences (Table 1).

Based on the post-hoc comparison, the maximum rear right sit bone pressure on wide saddles was lower than that on narrow (p = 0.001) and moderate (p = 0.016) saddles, and the mean rear right sit bone pressure on wide saddles was lower than that on narrow (p = 0.012) and moderate (p = 0.019) saddles. The pubic pressure area for wide saddles was smaller than that for narrow (p = 0.005) and moderate (p = 0.018) saddles, and the rear right sit bone pressure area for wide saddles was larger than that for narrow (p = 0.017) and moderate (p = 0.036) saddles. The mean force for moderate saddles was greater than that for wide (p = 0.008) and self-chosen (p = 0.025) saddles.

Discussion

This study investigated the saddle pressure of different saddle widths (i.e., narrow, moderate, wide, and self-chosen). Our results showed that changing the saddle width affected the saddle pressure, and the hypothesis of this study was accepted.

In this study, we determined the optimal saddle width for women based on the width of the participants' ischium and found that increasing the bicycle saddle width by 1 cm according to the width of the participants' ischium effectively reduced the maximum and mean pressures of the saddle. This might be due to the dispersion of the maximum and mean pressures by an increase in the pressure area. The results of this study are similar to those reported in previous studies. Different saddle widths provide different pressure distributions, and the results are affected by the pelvic size and area in contact with the saddle (Chen, 2018; Potter et al., 2008). For comfort, the saddle should be widened to provide better support for the ischium (Chen, 2018). However, previous studies did not describe a clear method for choosing a bicycle saddle.

Many cyclists have pointed out that long-term use of regular bicycle saddles causes pubic pain, as they are not designed based on the pelvic anatomy (Keytel and Noakes, 2002). In addition to having differences in the sciatic width, which is measured externally, men and women also differ in terms of internal structures, including the pubic tubercle width, pubic arch angle, and location of the pubic symphysis (Potter et al., 2008). The pubic tubercle is wider in women than in men, and the pubic arch angle in women is greater than 90 degrees while that in men is less than 90 degrees (Chen, 2018). The locations of the pubic symphysis in men and women are 116.5 mm and 134.9 mm (Sauer et al., 2007), respectively, with a difference of 14.0–18.4 mm (Chen and Yang, 2016). However, at present, the saddles for women are wide r than those for men

Table 1. Summary of pressure mat parameters (Mean ± Standard Deviation)

Variables	Location	Narrow	Moderate	Wide	Self-chosen	p-value	Effect size (η2)	Power	Post-hoc test (Bonferroni)
Maximum pressure (mbar)	Pubic bone	503.1±71.9	541.2±116.6	521.6±84.7	512.1±54	.755	.04	.118	NS
	Sit bone (L)	352.2±123.8	393.1±171.6	282.2±100.6	320.2±123.3	.040*	.26	.667	NS
	Sit bone (R)	453.1±106.7	404.7±108.2	300.5±106.4	408.9±103	.001*	.43	.960	a
Mean pressure (mbar)	Pubic bone	184.2±50.6	197.2±62.7	193.1±50.3	191.4±43.4	.591	.06	.167	NS
	Sit bone (L)	81.4±41.6	85.6±59.7	71.8±39.9	72.2±38.2	.678	.05	.140	NS
	Sit bone (R)	123.3±34.1	115.6±32.1	88.3±30.9	120.6±30.2	.009*	.34	.848	b
Pressure area (mm^2)	Pubic bone	5889.9±357.4	6039±357.3	6411±198	6147±404	.000*	.50	.990	c
	Sit bone (L)	3705±1569.1	3410±1755.8	3060±1357.8	2972.5±1152.8	.416	.09	.238	NS
	Sit bone (R)	4186.7±663.9	3852.6±896.7	3277.4±884.8	4077.6±457.9	.003*	.40	.932	d
Max force (N)		268.7±84.5	289.3±90.2	280.2±88.7	265.8±78.1	.283	.12	.315	NS
Mean force (N)		169.7±56.6	176.3±56.8	162.4±53.5	151.7±54.6	.000*	.50	.990	e

* indicates significant differences. a = wide < narrow and moderate, b = wide < narrow and moderate, c = wide > narrow and moderate, d = wide < narrow and moderate, e = moderate > wide and self-chosen. NS, not significant; L, left; R, right.

(i.e., 150 mm vs 130 mm, respectively). Nevertheless, this study found that the average saddle width suitable for women is 160 mm. This width is speculated to improve the saddle pressure during cycling. Incorrect saddle designs do not effectively disperse the weight and reduce the stress, thus increasing the risk of injuries (Andersen and Bovim, 1997; Keytel and Noakes, 2002; Schrader et al., 2002).

This study aimed to explore the saddle pressure of different saddle widths. For reduced experimental errors, only the width of the saddle varied, while other variables remained constant. However, other factors might influence out study results (Bressel et al., 2009). Previous research has indicated that riding comfort and stability vary with time, and that the mean pressure of the saddle increases with an increase in the pedaling load (Holliday et al., 2019a). However, in this study, the experimental time was the same for all participants.

There is bilateral asymmetry when running and riding bicycles, which increases the risk of injury (Carpes et al., 2010). In our study, there were significant differences in the maximum pressure, mean pressure, and pressure area on the rear right sit bone, but there was no difference on the rear left sit bone. Therefore, we speculate that the uneven pressure may be caused by asymmetric pedaling and can increase the incidence of injuries on the rear right sit bone. In addition, our results showed that using a wide saddle could reduce the asymmetric effect of the saddle pressure. Hence, a change in the saddle size might affect the pedaling symmetry (Figure 3).

It is possible to improve performance and reduce sports injuries by adjusting the bicycle posture (Holliday et al., 2019b). Recent research has shown that the same bicycle posture adjustment methods lead to different saddle heights and lower limb joint angles for men and women (Encarnación-Martínez et al., 2020). These differences are due to differences in the pelvic structures between sexes; notably, previous posture adjustment methods have been designed only for men (Silberman et al., 2005). Previous studies on saddle pressure investigated the differences between male and female cyclists (Bressel and Cronin, 2005; Bressel and Larson, 2003; Gordon, 1999) and found that the mean force and maximum pressure of the saddle shift forward for male cyclists and remains more concentrated in the center of the saddle and on both sides of the ischium for female cyclists. Potter et al. also showed that the pressure distribution in women during pedaling is concentrated on both sides of the ischium (Potter et al., 2008). These findings, along with our results, show that men and women experience different degrees of comfort even when the same saddle is used, and that there might be a greater risk of injury when an unsuitable saddle is used. Therefore, it is necessary to adjust the saddle size according to the width of the female cyclist's ischium to accommodate the riding needs of female cyclists.

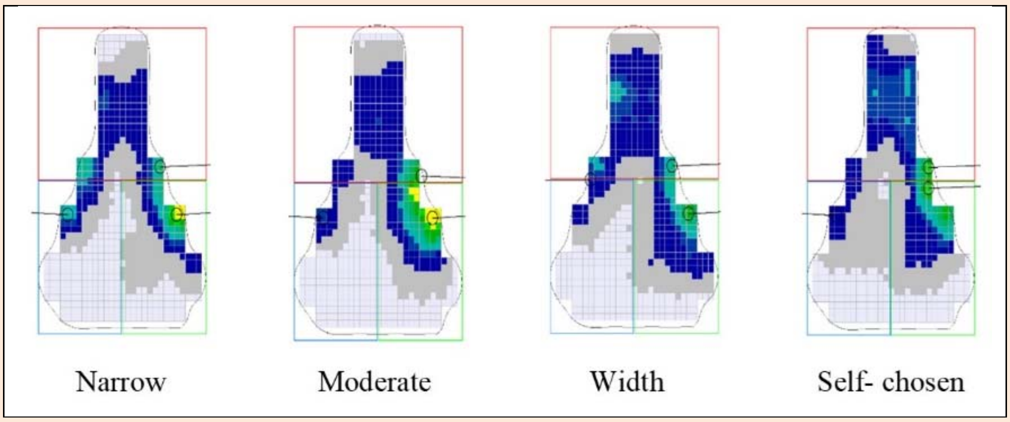

Figure 3. Pressure map of cycling with different saddle widths.

Conclusion

This study found that a saddle 1 cm wider than the cyclists' ischium could improve the pressure distribution of the saddle during riding, thereby providing better comfort. In addition, the pressure is distributed more symmetrically when a wide saddle is used, which may improve the pedaling symmetry.

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References

Andersen, K.V. and Bovim, G. (1997) Impotence and nerve entrapment in long distance amateur cyclists. *Acta Neurologica Scandinavica* **95,** 233-240. https://doi.org/10.1111/j.1600-0404.1997.tb00104.x

Boling, M., Padua, D., Marshall, S., Guskiewicz, K., Pyne, S. and Beutler, A. (2010) Gender differences in the incidence and prevalence of patellofemoral pain syndrome. *Scandinavian Journal of Medicine & Science in Sports* **20,** 725-730. https://doi.org/10.1111/j.1600-0838.2009.00996.x

Booth, B.G., Hoefnagels, E., Huysmans, T., Sijbers, J. and Keijsers, N.L. (2020) PAPPI: Personalized analysis of plantar pressure images using statistical modelling and parametric mapping. *PloS One* **15,** e0229685. https://doi.org/10.1371/journal.pone.0229685

Bressel, E., Bliss, S. and Cronin, J. (2009) A field-based approach for examining bicycle seat design effects on seat pressure and perceived stability. *Applied Ergonomics* **40,** 472-476. https://doi.org/10.1016/j.apergo.2008.10.001

Bressel, E. and Cronin, J. (2005) Bicycle seat interface pressure: reliability, validity, and influence of hand position and workload. *Journal of Biomechanics* **38,** 1325-1331. https://doi.org/10.1016/j.jbiomech.2004.06.006

Bressel, E. and Larson, B.J. (2003) Bicycle seat designs and their effect on pelvic angle, trunk angle, and comfort. *Medicine and Science in Sports and Exercise* **35,** 327-332. https://doi.org/10.1249/01.MSS.0000048830.22964.7c

Briggs, M.S. and Obermire, T. (2016) Clinical Considerations of Bike Fitting for the Triathlete. In: *Endurance Sports Medicine.* Springer. 215-227. https://doi.org/10.1007/978-3-319-32982-6_16

Bury, K., Leavy, J.E., O'Connor, A. and Jancey, J. (2020) Prevalence, prevention and treatment of saddle sores among female competitive cyclists: A scoping review protocol. *Methods and Protocols* **3,** 4. https://doi.org/10.3390/mps3010004

Carpes, F.P., Mota, C.B. and Faria, I.E. (2010) On the Bilateral Asymmetry During Running and Cycling–A Review Considering Leg Preference. *Physical Therapy in Sport* **11,** 136-142. https://doi.org/10.1016/j.ptsp.2010.06.005

Chen, Y.-L. (2018) Predicting external ischial tuberosity width for both sexes to determine their bicycle-seat sizes. *International Journal of Industrial Ergonomics* **64,** 118-121. https://doi.org/10.1016/j.ergon.2018.01.008

Chen, Y.-L. and Liu, Y.-N. (2014) Optimal protruding node length of bicycle seats determined using cycling postures and subjective ratings. *Applied Ergonomics* **45,** 1181-1186. https://doi.org/10.1016/j.apergo.2014.02.006

Chen, Y.-L. and Yang, P.-J. (2016) A preliminary study of the measurement of external ischial tuberosity width and its gender differences. *Journal of Physical Therapy Science* **28,** 820-823. https://doi.org/10.1589/jpts.28.820

Cohen, J. (1988) Statistical power analysis for the behavioral sciences. Lawrence Erlbaum Associates. *Hillsdale, NJ* 20-26.

Encarnación-Martínez, A., Ferrer-Roca, V. and García-López, J. (2020) Influence of Sex on Current Methods of Adjusting Saddle Height in Indoor Cycling. *The Journal of Strength & Conditioning Research*. https://doi.org/10.1519/JSC.0000000000002689

Ferber, R., Davis, I.M. and Williams Iii, D.S. (2003) Gender differences in lower extremity mechanics during running. *Clinical Biomechanics* **18,** 350-357. https://doi.org/10.1016/S0268-0033(03)00025-1

Gordon, C.C. (1999) *Adultdata: The Handbook of Adult Anthropometric and Strength Measurements.* Data for Design Safety by Laura Peebles and Beverley Norris 1998, 404 pages, free to UK addresses UK: Department of Trade and Industry (URN 98/736), SAGE Publications Sage CA: Los Angeles, CA. https://doi.org/10.1177/106480469900700310

Guess, M.K., Connell, K., Schrader, S., Reutman, S., Wang, A., LaCombe, J., Toennis, C., Lowe, B., Melman, A. and Mikhail, M. (2006) WOMEN'S SEXUAL HEALTH: Genital Sensation and Sexual Function in Women Bicyclists and Runners: Are Your Feet Safer than Your Seat? *The Journal of Sexual Medicine* **3,** 1018-1027. https://doi.org/10.1111/j.1743-6109.2006.00317.x

Guess, M.K., Partin, S.N., Schrader, S., Lowe, B., LaCombe, J., Reutman, S., Wang, A., Toennis, C., Melman, A. and Mikhail, M. (2011) Women's Bike Seats: A Pressing Matter for Competitive Female Cyclists. *The Journal of Sexual Medicine* **8,** 3144-3153. https://doi.org/10.1111/j.1743-6109.2011.02437.x

Holliday, W., Fisher, J. and Swart, J. (2019a) The effects of relative cycling intensity on saddle pressure indexes. *Journal of Science and Medicine in Sport* **22,** 1097-1101. https://doi.org/10.1016/j.jsams.2019.05.011

Holliday, W., Theo, R., Fisher, J. and Swart, J. (2019b) Cycling: joint kinematics and muscle activity during differing intensities. *Sports Biomechanics* 1-15. https://doi.org/10.1080/14763141.2019.1640279

Keytel, L. and Noakes, T.D. (2002) Effects of a novel bicycle saddle on symptoms and comfort in cyclists. *South African Medical Journal* **92,** 295-298.

Kordi, M., Fullerton, C., Passfield, L. and Parker Simpson, L. (2019) Influence of upright versus time trial cycling position on determination of critical power and W′ in trained cyclists. *European Journal of Sport Science* **19,** 192-198. https://doi.org/10.1080/17461391.2018.1495768

Lowe, B.D., Schrader, S.M. and Breitenstein, M.J. (2004) Effect of bicycle saddle designs on the pressure to the perineum of the bicyclist. *Medicine and Science in Sports and Exercise* **36,** 1055-1062. https://doi.org/10.1249/01.MSS.0000128248.40501.73

Mitani, Y. (2017) Gender-related differences in lower limb alignment, range of joint motion, and the incidence of sports injuries in Japanese university athletes. *Journal of Physical Therapy Science* **29,** 12-15. https://doi.org/10.1589/jpts.29.12

Naderi, A., Baloochi, R., Rostami, K.D., Fourchet, F. and Degens, H. (2020) Obesity and foot muscle strength are associated with high dynamic plantar pressure during running. *The Foot* 101683. https://doi.org/10.1016/j.foot.2020.101683

Phinyomark, A., Osis, S.T., Hettinga, B.A., Kobsar, D. and Ferber, R. (2016) Gender differences in gait kinematics for patients with knee osteoarthritis. *BMC Musculoskeletal Disorders* **17,** 1-12. https://doi.org/10.1186/s12891-016-1013-z

Potter, J.J., Sauer, J.L., Weisshaar, C.L., Thelen, D.G. and Ploeg, H.-L. (2008) Gender differences in bicycle saddle pressure distribution during seated cycling. *Medicine and Science in Sports and Exercise* **40,** 1126-1134. https://doi.org/10.1249/MSS.0b013e3181666eea

Priego Quesada, J.I., Kerr, Z.Y., Bertucci, W.M. and Carpes, F.P. (2019) The association of bike fitting with injury, comfort, and pain during cycling: An international retrospective survey. *European Journal of Sport Science* **19,** 842-849. https://doi.org/10.1080/17461391.2018.1556738

Priego Quesada, J.I., Pérez-Soriano, P., Lucas-Cuevas, A.G., Salvador Palmer, R. and Cibrián Ortiz de Anda, R.M. (2017) Effect of bike-fit in the perception of comfort, fatigue and pain. *Journal of Sports Sciences* **35,** 1459-1465. https://doi.org/10.1080/02640414.2016.1215496

Sauer, J.L., Potter, J.J., Weisshaar, C.L., Ploeg, H.-L. and Thelen, D.G. (2007) Influence of gender, power, and hand position on pelvic motion during seated cycling. *Medicine and Science in Sports and Exercise* **39,** 2204. https://doi.org/10.1249/mss.0b013e3181568b66

Schrader, S.M., Breitenstein, M.J., Clark, J.C., Lowe, B.D. and Turner, T.W. (2002) Nocturnal penile tumescence and rigidity testing in bicycling patrol officers. *Journal of Andrology* **23,** 927-934.

Silberman, M.R., Webner, D., Collina, S. and Shiple, B.J. (2005) Road bicycle fit. *Clinical Journal of Sport Medicine* **15,** 271-276. https://doi.org/10.1097/01.jsm.0000171255.70156.da

Silbert, P., Dunne, J., Edis, R. and Stewart-Wynne, E. (1991) Bicycling induced pudendal nerve pressure neuropathy. *Clinical and Experimental Neurology* **28,** 191-196.

Swart, J. and Holliday, W. (2019) Cycling Biomechanics Optimization—the (R) Evolution of Bicycle Fitting. *Current Sports Medicine Reports* **18,** 490-496. https://doi.org/10.1249/JSR.0000000000000665

Vette, A.H., Funabashi, M., Lewicke, J., Watkins, B., Prowse, M., Harding, G., Silveira, A., Saraswat, M. and Dulai, S. (2019) Functional, impulse-based quantification of plantar pressure patterns in typical adult gait. *Gait and Posture* **67,** 122-127. https://doi.org/10.1016/j.gaitpost.2018.09.029

Weiss, B.D. (1994) Clinical syndromes associated with bicycle seats. *Clinics in Sports Medicine* **13,** 175-186. https://doi.org/10.1016/S0278-5919(20)30362-8

Willson, J.D., Kernozek, T.W., Arndt, R.L., Reznichek, D.A. and Straker, J.S. (2011) Gluteal muscle activation during running in females with and without patellofemoral pain syndrome. *Clinical Biomechanics* **26,** 735-740. https://doi.org/10.1016/j.clinbiomech.2011.02.012

Yokozuka, M., Okazaki, K., Sakamoto, Y. and Takahashi, K. (2020) Correlation between functional ability, toe flexor strength, and plantar pressure of hallux valgus in young female adults: a cross-sectional study. *Journal of Foot and Ankle Research* **13,** 1-6. https://doi.org/10.1186/s13047-020-00411-1

Key points

- A saddle that is 1 cm wider than the cyclists' ischium width could improve the pressure distribution of the contact area and induce better comfort during cycling.
- Women are anthropometrically different from men; however, the current bike fitting method for women is based on that of men, and a lack of theoretical basis does not support this adjustment for female riders. Therefore, it is necessary to develop a new bike fitting reference based on the anthropometry parameter of women.
- Bike saddle pressure can be viewed as a definite parameter for bike fitting.

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