

ORIGINAL RESEARCH—WOMEN'S SEXUAL HEALTH

The Bar Sinister: Does Handlebar Level Damage the Pelvic Floor in Female Cyclists?

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DOI: 10.1111/j.1743-6109.2012.02680.x

ABSTRACT

Introduction. Cycling is associated with genital neuropathies and erectile dysfunction in males. Women riders also have decreased genital sensation; however, sparse information exists addressing the effects of modifiable risks on neurological injuries in females.

Aim. This study assesses the effects of bicycle setup and cyclists' attributes on GS and saddle pressures among female cyclists.

Methods. Previously, we compared genital sensation in competitive female cyclists (N = 48) to that of female runners (N = 22). The current study is a subanalysis of the 48 cyclists from the original study group. Nonpregnant, premenopausal women who rode at least 10 miles per week, 4 weeks per month were eligible for participation.

Main Outcome Measures. Genital sensation was measured in microns using biosthesiometry measures of vibratory thresholds (VTs). Perineal and total saddle pressures were determined using a specialized pressure map and recorded in kilopascals (kPa).

Results. Handlebars positioned lower than the saddle correlated with increased perineum saddle pressures and decreased anterior vaginal and left labial genital sensation ($P < 0.05$, $P < 0.02$, $P < 0.03$, respectively). Low handlebars were not associated with total saddle pressures or altered genital sensation in other areas. After adjusting for age and saddle type, low handlebars were associated with a 3.47-kPa increase in mean perineum saddle pressures ($P < 0.04$) and a 0.86-micron increase in anterior vagina VT ($P < 0.01$).

Conclusion. Handlebars positioned lower than the saddle were significantly associated with increased perineum saddle pressures and decreased genital sensation in female cyclists. Modifying bicycle setup may help alleviate neuropathies in females. Additional research is warranted to further assess the extent of the associations. **Partin SN, Connell KA, Schrader S, LaCombe J, Lowe B, Sweeney A, Reutman S, Wang A, Toennis C, Melman A, Mikhail M, and Guess MK. The bar sinister: Does handlebar level damage the pelvic floor in female cyclists? J Sex Med 2012;9:1367–1373.**

Key Words. Cyclist's Attributes; Genital Sensation; Handlebars; Seat Pressure; Pelvic Floor and Bicycling

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Introduction

Bicycling is an increasingly popular nonimpact, cardiovascular intense method of exercise transportation and recreation [1,2]. However, it also carries with it the risk of injuries [1–11]. Injuries associated with cycling can be classified into two groups, physical trauma and overuse injuries [1]. The most acute physical traumas result from collisions with motor vehicles and include head, spinal cord, and acute musculoskeletal injuries [1]. Overuse injuries include neck and back pain as well as pain and discomfort in the upper and lower extremities [1]. Numerous saddle-related, overuse injuries have been reported, including chafing, perineal folliculitis, furuncles, and lymphedema [3–5]. Additionally, a recent review of cycling-related issues found that 50–91% of male or female riders or both reported genital numbness [2].

Previous research suggests that saddle design and increased saddle pressures (SPs) are associated with neurovascular compromise and erectile dysfunction in male cyclists [6–11]. Our group identified decreased genital sensation (GS) in women cyclists [12]. Additionally, we showed that cutout saddles place more pressure on the perineum than traditional saddles in female riders, even though saddle design was not associated with alterations in GS [13]. Potter et al. identified significant differences in how the geometry of the bicycle affects SP distributions in males and females using stationary bicycles and standardized positioning [14]. The pressure values for females were significantly greater when the riders' hands were placed in the drops of the handlebars compared to those whose were positioned on the tops of the handlebars [14]. Additionally, Bressel et al. found that the drop position is associated with a more acute trunk angle in both genders, while Sauer et al. found that women in the drop position experience greater pelvic tilt than men [15,16]. We propose that positioning hands in the drops of the handlebars is comparable with positioning the handlebars lower than the seat since both positions can cause the rider to lean forward, decreasing trunk angle and increasing pelvic tilt. These changes in trunk angle and pelvic tilt shift more weight onto the perineum region, instead of the ischial tuberosities (ITs), as would be expected when leaning back in a more upright position [16].

Aims

We hypothesized that as handlebar level decreases relative to the saddle, SP and neurovascular com-

pression increase, resulting in the loss of nerve fibers and decreased GS. The purpose of this study is to evaluate the effects of personalized bicycle setup and cyclists' attributes on SP and GS in female cyclists.

Methods

Selection and Description of Participants

This study uses data collected from our original study, assessing differences in GS and sexual function between female cyclists (N = 48) and runners (N = 22) [12]. The current study is a subanalysis of the 48 cyclists from the original study. Complete details about the recruitment, enrollment, and study design are included in previous publications [12,13]. Briefly, after institutional review board approval was obtained, premenopausal women bicyclists, 18 years or older, were recruited for participation, if they rode consistently, an average of at least 10 miles per week. Eligible women who agreed to participate and provided written informed consent were included [12].

Assessments

Bicycle setup and rider characteristics were assessed by self-report using a bicycling history questionnaire. The questionnaire addressed bicycling practices, previous cycling injuries as well as bicycling-related neurological symptoms or complaints [12]. While not validated, it has been used in other bicycling studies [10,11]. For SP analysis, cyclists brought their personal bicycles and saddles on which they normally rode. The bicycles were mounted on a cycling trainer (Minoura "Mag-Turbo"; Minoura Co., Ltd, Hayward, CA, USA). Saddles were classified as either "traditional" (solid-nosed saddles) or "cutout" (nosed saddles in which the center is removed) [12]. The participants were asked to position their saddles and handlebars in the position they typically used when riding and to pedal at an even cadence. Once they developed a steady cadence, SPs were recorded for 40–60 seconds and measured in kilopascals (kPA), using the Novel Pliance pressure map (Novel Electronics Inc., St. Paul, MN, USA) at a sampling frequency of 20 Hz [12]. Power output as measured by pedaling cadence and resistance was not controlled. SP focused on four areas: mean and peak perineal SP and mean and peak total SP [13]. Custom software written in Labview (National Instruments, Austin, TX, USA) was used to analyze the recorded pressures.

The Medoc Vibratory Sensory Analyzer 3000 (VSA, Advanced Medical Systems, Ramat Yishai, Israel) was used to measure vibratory thresholds (VTs) at eight genital regions innervated by the pudendal nerve: the clitoris, left perineum, right perineum, anterior vagina, posterior vagina, left labia, right labia, and urethra [12]. This evaluation method is a proven, valid, and repeatable measure of sensory nerve function in the genital region [17]. The method of limits, in which the subject is exposed to a stimulus of increasing intensity and asked to indicate the first onset of sensation, was used and results were recorded in microns. Higher VT indicated less sensitivity to the stimulus applied.

Variables

The primary predictor variable was handlebar height as reported by the cyclist and categorized as level with the saddle, lower than the saddle, or higher than the saddle. Few cyclists positioned their handlebars higher than their seat ($n = 5$) and two riders did not answer the question on handlebar positioning. These seven subjects were excluded from the analysis a priori, thus decreasing the sample size from 48 to 41. There were no significantly different attributes between the 41 cyclists and the seven who were excluded (data not shown). Other cycling attributes evaluated were participant's estimates of the percentage of time they spent seated on the saddle, whether or not their bike had shock absorbers and saddle firmness, defined as soft, medium, or hard. A categorical variable called "rough sit" was created, also. "Yes" replies were assigned to women who reported staying on the saddle while riding on rough terrain, pot holes, or curbs, and "no" replies were given to women who reported being unseated under such conditions.

Statistical Analysis

Demographic data, SP, and VT were compared between women who rode with their handlebars level with their saddle and lower than their saddle. Means and standard deviations were calculated, and bivariate significant differences were assessed using Student's *t*-test, chi-squared test, or Fisher's exact test. Multivariable regression was conducted with handlebar level as the primary predictor variable and adjustments made for age and saddle type since these variables have been shown to be significantly associated with our outcome variables [12,13]. Saddle type was classified as traditional (nosed saddle) or cutout (a nosed saddle with a central part cut out). Statistical analyses were con-

ducted using Stata 11 (StataCorp, College Station, TX, USA). All tests were two-sided with a significance level set at <0.05 .

Main Outcome Measures

Our primary outcome, GS, was determined by biothesiometry. The secondary outcome measures, perineal and total SP, were measured by using a specially designed pressure map. All outcome measures were compared between cyclists who rode with their handlebars level with their saddle and those who rode with their saddles lower than their handlebars. The effect of age, a continuous predictor, and saddle type, either traditional or cutout, were evaluated for an effect on the main outcomes.

Results

Table 1 reports the baseline characteristics of the study participants dichotomized according to handlebar positioning. There were no significant differences between the two groups. Sixty-two percent of the cyclists in our study reported a history of genital numbness, tingling, or pain in the last month. On bivariate analysis, significant increases were noted in both mean and peak perineal SP for women who rode with their handlebars lower than the seat (Figure 1). Handlebars lower than the saddle were also significantly associated with increased VT (decreased GS) in the anterior vagina and left labia (Table 2).

After adjustments for age and saddle type, the women who rode with handlebars positioned lower than the seat had a 3.47 kPA increase in mean perineum SP compared with the women riding with their handlebars level with the saddle (Table 3). Additionally, anterior vaginal sensation was significantly decreased in the women whose handlebars were positioned below the saddle (Table 4). Left labial GS, was also nonsignificantly decreased ($P = 0.07$). Age was no longer associated with SP or GS when handlebar level was in the model.

Further age stratification into 10-year intervals was done to better clarify the relationship between age and SP and GS. Eighty percent of the women in the youngest age group rode with their handlebars lower than the saddle, while the majority of the women in the oldest age stratum (80%) positioned their handlebars level with the saddle.

Discussion

To the investigators' knowledge, this is the first study to identify a correlation between bicycle

Table 1 Cyclists' demographics, bicycle details, and cycling characteristics

	Handlebar level		Handlebar lower		P < 0.05
	n	Mean (SD) or %	n	Mean (SD) or %	
Cyclists demographics					
Age	22	37.8 (6.4)	19	34.5 (6.5)	0.12
20–29	1	4.6	5	26.3	
30–39	12	54.6	11	57.9	
40–49	8	36.4	2	10.5	
50≥	1	4.6	1	5.3	
Body Mass Index	22	22.1 (2.4)	19	23.0 (4.1)	0.39
Underweight	2	9.1	1	5.3	
Normal	18	81.8	15	79.0	
Overweight	2	9.1	2	10.5	
Obese	0	0	1	5.3	
Miles rode/week	22	95.0 (87.1)	19	115.0 (64.9)	0.42
Hours rode/week	22	7.8 (6.1)	19	8.4 (4.4)	0.74
Bicycle setup					
Saddle type	21		18		0.46
Traditional	13	61.9	9	50.0	
Partial Cutout	8	38.1	9	50.0	
Saddle width (inches)	21	5.8 (0.5)	18	5.8 (0.6)	0.72
Shock absorbers	22		19		0.49
Yes	2	9.1	0	0	
No	20	90.9	19	100.0	
Seat firmness	21		19		0.79
Soft	3	14.3	1	5.3	
Medium	13	61.9	13	68.4	
Hard	5	23.8	5	26.3	
Cyclists details					
Percent of time in saddle	22	91.6 (8.8)	19	93.1 (6.3)	0.56
Riding rough terrain	22		19		0.52
Seated	5	22.7	6	31.6	
Unseated	17	77.3	13	68.4	
Numbness in last month	22		19		0.98
Yes	14	63.6	12	63.2	
No	8	36.4	7	36.8	

setup and neurological compromise in women cyclists. Our findings that handlebars positioned lower than the saddle results in increased perineal SP and decreased GS are consistent with our hypothesis. Low handlebars may cause riders to lean forward, thereby shifting more weight to the

perineal region instead of leaning back on their ITs, as would be expected in a more upright position.

Potter et al. examined SP in experienced male and female cyclists (N=22) riding with their hands on the tops vs. the drops of the handlebars [14]. Compared to men, women had a greater change in maximum anterior pressure when switching from the tops to the drops. This is similar to riding with handlebars level to the saddle and lower than the saddle and supports the concept that higher pressures are placed on the genital structures when the hands are positioned below the saddle. While Potter et al. used only traditional saddles, we included both traditional and cutout saddles. This suggests that low handlebars compromise neurological function for women riding nosed saddles. In evaluating male cyclists, Schrader et al. noted significant improvements in GS after reducing perineal SP using noseless saddles [11]. Further studies are warranted to determine if noseless saddles provide a similar protective effect to the female pelvic floor.

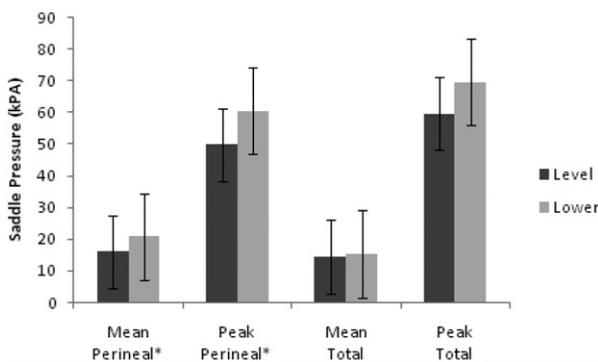


Figure 1 Average perineum and total saddle pressures by handlebar position compared with the saddle. *Statistically significant at 0.05 level.

Table 2 Bivariate comparison of vibratory thresholds (VT) in female cyclists who ride with their handlebars level or lower than the saddle

	Handlebar level		Handlebar lower		<i>P</i> < 0.05
	n	Mean (SD)	n	Mean (SD)	
Vaginal anterior	19	2.0 (0.86)	19	2.8 (1.15)	0.02*
Vaginal posterior	22	3.2 (5.2)	19	2.5 (1.7)	0.58
Urethra	22	3.6 (4.2)	19	2.8 (1.8)	0.43
Clitoris	21	1.5 (0.8)	18	1.2 (0.2)	0.13
Left labia	20	2.0 (0.9)	19	3.0 (1.8)	0.03*
Right labia	22	3.9 (5.6)	19	3.8 (3.9)	0.94
Right perineum	19	2.9 (3.2)	19	3.3 (2.8)	0.74
Left perineum	22	4.1 (5.2)	18	3.1 (2.4)	0.50

*Statistically significant

Carpes et al. measured SP in an upright and forward position while participants (N = 22) were seated on traditional and cutout saddles [18]. The authors did not find any statistically significant associations between trunk position and total SP in female riders. Similarly, handlebar level, which affects trunk position, was not significantly associated with total SP in our study. However, we also evaluated pressures in the perineal region and found that low handlebars were significantly associated with increased perineal SP. Based on our findings and those of Potter et al., one would anticipate that a bicycle setup, saddle design, or a cyclist's position that increases the forward angle of the pelvis could result in similar increases in perineal pressure and decreased neurological function.

Table 3 Multivariable regression model of mean perineum saddle pressure in female cycling study ($F_{[3,34]} = 6.05$, adjusted $R^2 = 0.2905$, N = 38)

Predictor variable	Coefficient (95% confidence interval)	<i>P</i> < 0.05
Handlebar level		
Lower than seat	3.47 (0.24, 6.70)	0.036*
Age	-0.24 (-0.47, <0.00)	0.051
Saddle type		
Traditional	-3.17 (-6.31, -0.04)	0.048*

*Statistically significant

Table 4 Multivariable regression model of anterior vagina vibratory threshold in female cycling study ($F_{[2,35]} = 3.58$, adjusted $R^2 = 0.1224$, N = 38)

Predictor variable	Coefficient (95% confidence interval)	<i>P</i> < 0.05
Handlebar level		
Lower than seat	0.86 (0.18, 1.53)	0.014*
Age	0.03 (-0.03, 0.09)	0.287

*Statistically significant

Bressel et al. assessed the influence of saddle design on pelvic angle and trunk angle in female cyclists (N = 20) [15]. They found that partial cutout saddles increase anterior pelvic tilt regardless of the hand position on the tops or the drops of the handlebars. Thus, it is not surprising that riding on cutout saddles was independently associated with higher perineal SP in our study. Interestingly, after adjusting for saddle type, mean perineal SP remained significantly higher for women who rode with their handlebars positioned lower than the saddle compared with those who rode with their handlebars level with the saddle. These findings suggest that handlebar height and saddle type may have a cumulative effect on perineal SP and pelvic floor trauma. Further research with larger studies is needed to fully elucidate these relationships.

It is compelling that regions in the mid-perineum were most affected by the handlebar level. We posit that the right and left perineum sites and posterior vagina may be less affected due to their more posterior positioning near the ITs and that the clitoris and urethra may be too cephalad to receive an impact. Similarly, we cannot explain why GS deficits were one-sided in the labia. One can hypothesize that riders have a dominant side to which they exert more pressure. This theory is supported by previous studies that have identified unilateral vulvar hypertrophy and lymphedema in competitive cyclists [4,5]. Since decreases in left labial sensation was only significant on bivariate analysis, larger, dynamic studies are needed to identify spatial relationships of increased pressure points and compromised blood flow or altered neurotransmission to these areas during riding.

Interestingly, we previously showed that SP are not significantly associated with GS [13]. It is possible that the handlebar position exerts an effect on GS through methods other than compression or

that our method for recording pressure lacks sensitivity to detect the influence of pressure on neurological function. The small sample size may have precluded our ability to effectively evaluate these relationships. Still, it is important to note that simple changes to bicycle setup may provide beneficial effects to pelvic floor integrity.

It was surprising to note that in the multivariable models, the strong positive associations between age and SP and age and VT diminished when handlebar positioning was included in the models. One can speculate that as women age, they modify their riding styles to reduce untoward symptoms, given the disparity in handlebar positioning between younger and older women in our riders. Larger, longitudinal studies are warranted to determine the validity of this conjecture.

Overall, our results suggest that handlebars positioned below the saddle yield detrimental effects to the female pelvic floor. However, this conclusion contrasts the recommendations by Thompson et al., who reported that correct bike fit for the handlebars should be 1 to 2 inches lower than the saddle [19]. While the authors did not state whether the recommended bicycle fit was geared toward the more serious cyclists or to recreational cyclists, a lower handlebar position enhances the aerodynamic posture of the rider. This exemplifies the ongoing struggle between selecting a more aerodynamic bicycle position for control and speed or a more ergonomic position to reduce neurovascular compromise [14]. Our participants used their own bicycles that were setup to their preferences and specifications. We believe that these conditions were more likely to yield results that are closer to real-world relationships between cyclists' configurations and bicycle geometry. Additional research is needed to establish the best risk/benefit profile for women riders in order to allow women to decide at what cost they will ride.

Our study, as well as several of the studies described earlier, may be limited by a selection bias as noted in the original study [12]. Specifically, study participants who were uncomfortable with their body and women who do not suffer from neurological symptoms may not have been motivated to participate. In addition, most of the women were normal weight, more experienced cyclists. Therefore, our findings may not be generalizable to the less experienced, recreational, overweight, or underweight cyclists. In addition, our sample size was small. While a power analysis was conducted for our original study, an additional power analysis was not performed for this secondary analysis [12]. A larger

sampling would allow us to assess whether the paucity of differences were due to a lack of power or a lack of association. Still, ours is the largest, published study addressing this very important women's health issue and presents further evidence that female riders are susceptible to detrimental consequences to the pelvic floor. Our findings also emphasize the fact that enhanced knowledge about female-specific bike fit is necessary. While all of the women in our study had normal sexual function, our group and others have identified an association between female sexual dysfunction and altered GS [12,20,21]. In addition, genital sensory stimulation has been shown to play a critical role in sexual arousal and the erectile response in men [22]. Longitudinal studies with larger, more diverse groups of women cyclists are needed to further discern the role that different components of bicycle fit and accoutrements have on adverse cycling outcomes as well as to determine the long-term effects of increased SP and decreased GS on sexual function in women.

Conclusion

Low positioning of handlebars relative to the saddle is associated with increased perineal SP and decreased sensation in critical pelvic floor structures. Correcting modifiable risks factors for pelvic floor damage may serve as the most important next step in enhancing riding safety in women cyclists.

Acknowledgments

We are grateful to Dr. J.C. Huber who provided assistance in the data analysis. Also, we would like to thank Dr. D. Gorman for his review of the earlier versions of this article. This work was supported in part by National Institute of Health (NIH) grants UL1 RR024139 from the National Center for Research Resources (NCRR), #5K12HD047018 and The Robert Wood Johnson Foundation (RWJF) Harold Amos Faculty Development Program. The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the NIH, National Institute for Occupational Safety (NIOSH) or the RWJF. Mention of company or product names does not constitute endorsement by the NIH, NIOSH, or RWJF.

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Conflicts of Interest: None.

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