ORIGINAL RESEARCH—WOMEN'S SEXUAL HEALTH

Genital Sensation and Sexual Function in Women Bicyclists and Runners: Are Your Feet Safer than Your Seat?

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ABSTRACT

Introduction. Bicycling is associated with neurological impairment and impotence in men. Similar deficits have not been confirmed in women.

Aim. To evaluate the effects of bicycling on genital sensation and sexual function in women.

Methods. Healthy, premenopausal, competitive women bicyclists and runners (controls) were compared.

Main Outcome Measures. (1) Genital vibratory thresholds (VTs) were determined using the Medoc Vibratory Sensation Analyzer 3000. (2) Sexual function and sexually related distress were assessed by the Dennerstein Personal Experience Questionnaire (SPEQ) and the Female Sexual Distress Scale (FSDS).

Results. Forty-eight bicyclists and 22 controls were enrolled. The median age was 33 years. The bicyclists were older, had higher body mass indices (BMIs), were more diverse in their sexual orientation, and were more likely to have a current partner. Bicyclists rode an average of 28.3 ± 19.7 miles/day (range 4–100), 3.8 ± 1.5 days/week, for an average of 2.1 ± 1.8 hours/ride. The mean number of years riding was 7.9 ± 7.1 years (range 0.5–30). Controls ran an average of 4.65 ± 2.1 miles/day (range 1.5–8) and 5.0 ± 1.2 days/week. On bivariate analysis, bicyclists had significantly higher VTs than runners, indicating worse neurological function at all sites ($P < 0.05$). Multivariate analysis found significant correlations between higher VTs and bicycling at the left and right perineum, posterior vagina, left and right labia. Increasing VTs at the clitoris, anterior vagina, and urethra were associated with age. In bicyclists, there were no correlations between VTs and miles biked per week, duration of riding, or BMI. Composite SPEQ scores indicated normal sexual function in all sexually active subjects. Neither group suffered from sexually related distress.

Conclusion. There is an association between bicycling and decreased genital sensation in competitive women bicyclists. Negative effects on sexual function and quality of life were not apparent in our young, healthy premenopausal cohort. **Guess MK, Connell K, Schrader S, Reutman S, Wang A, LaCombe J, Toennis C, Lowe B, Melman A, and Mikhail MK. Genital sensation and sexual function in women bicyclists and runners: Are your feet safer than your seat? J Sex Med 2006;3:1018–1027.**

Key Words. Sexual Function; Quantitative Sensory Testing; Pudendal Nerve

Introduction

Estimates from surveys conducted by the United States Department of Transportation in 2002 suggest that approximately 13 million American women bicycle regularly [1]. Whereas the benefits of this sport are many, bicycle riding has also been associated with several detrimental consequences. In both men and women riders, the most serious injuries and fatalities are usually the result of motor vehicle collisions, which account for more than 250,000 emergency room visits annually [2]. Neck and back pain also have been reported in up to 66% [1,3,4] of all riders, and a number of saddle-related problems, including chafing, perineal folliculitis, furuncles, and lymphedema, are also commonly reported in both sexes [5]. Overall, bicycle-related injuries are estimated to cost more than $8 billion in the United States alone [6].

Recent studies in men bicyclists have also suggested an association between bicycling and neurological symptoms (numbness and hypoaesthesia) and erectile dysfunction (ED) [7–12]. To date, there are no studies that have evaluated the effects of prolonged or frequent bicycling on neurological and sexual function in women.

Aims

Based on previous findings of saddle-induced numbness and ED in men bicycling patrol officers [10], this collaborative study between the Albert Einstein School of Medicine and the National Institute for Occupational Safety and Health was conducted to investigate the relationship between frequent and/or endurance bicycling on neurological and sexual function in women.

Methods

After Institutional Review Board approval was obtained, competitive women bicyclists and runners (controls) were recruited using flyers, posters, newsletters, the Internet, and oral presentations at cycling and running competitions. Healthy volunteers older than 18 years were invited to participate. Women bicyclists who consistently rode, on average, at least 10 miles per week, 4 weeks per month were eligible for participation. The minimal riding distance (10 miles/week) and frequency of riding (4 weeks/month) were arbitrarily chosen as inclusion criteria to ensure that the study group reflected avid, competitive cyclists, rather than intermittent, recreational bicyclists who have participated in competitions. Women who ran at least 1 mile daily or 5 miles weekly at least twice per week were considered for the control group. We chose runners as our control group because they represent an active group of women who are not exposed to direct pressure in the perineal region. Additionally, running is a popular sport in the metropolitan area, making recruitment more feasible. Exclusion criteria were pregnancy, menopause, known HIV-positive status, a prior cerebral vascular accident, peripheral neuropathy unrelated to riding, diabetes mellitus, hypertension requiring medications, and active vulvar lesions. Menopause was defined as the cessation of menses for at least 1 year or absent menses for at least 3 months with a follicular-stimulating hormone level >20 IU/L. The study was limited to persons who could fluently read, speak, and write English, to avoid any bias that might have been introduced by oral or written translation of the sensitive material found in the sexual function questionnaires. Interested participants were prescreened through a telephone interview. Eligible participants were invited to the urogynecology suite at our institution. Following a verbal explanation of the study, persons agreeing to participate, who provided written informed consent and who had a negative urine pregnancy test were enrolled. All those enrolled were compensated with $50 for their time and transportation expenses.

Medical and Bicycling History Evaluation

After consenting to participate, eligible subjects underwent a detailed interview regarding their medical, surgical, and psychiatric histories. Subjects were also asked to complete two questionnaires: (i) a reproductive history questionnaire that included information about parity, prior gynecologic surgeries, and genital injuries, and (ii) a bicycling history questionnaire that inquired about bicycling practices, previous bicycling injuries, and bicycling-related neurological symptoms.

Sexual Function Assessment

Evaluation of the participant's sexual performance status was obtained using two validated instruments designed to evaluate sexual function in women. The Dennerstein Personal Experience Questionnaire—short form (SPEQ) is designed to provide an abbreviated, direct method for assessing sexual function [13]. Women were instructed to circle the appropriate number on a 5-point Likert scale (0 "not at all" to 4 "a great deal") to determine the frequency at which they have positive sexual experiences. This instrument is a nine-item questionnaire with six domains. Using the technique validated by the original authors, the SPEQ composite scores were derived by summing the responses for domains 2, 3, and 4 (sexual responsivity, sexual frequency, and libido, respectively) for a maximum possible score of 25. Composite scores and sexual response domain scores were compared between the two groups. Composite scores ≤7 were used to define female sexual dysfunction (FSD) [13].

The Female Sexual Distress Scale (FSDS) is designed to evaluate patient distress resulting from sexual dysfunction [14]. Subjects report on the frequency of negative feelings by circling responses on a 5-point Likert scale (0 "never" to 4 "always") for 12 directed questions on sexuality. Responses on the questionnaires were summed, and using criteria set by the original authors, subjects were grouped according to their perception of sexual functioning. Scores <20 were considered as normal perception of sexual function, and scores ≥20 were used to define sexually related personal distress [14].

Procedures for Questionnaire Administration

To avoid order bias, 16 variations of the sequence of four questionnaires (reproductive history, bicycling history, SPEQ, and FSDS) were implemented to ensure that no more than five participants received the questionnaires in the same order. The medical screening questionnaire was orally administered by one of the investigators and was always completed first. After completing the medical screening, subjects were directed to a private room where the remaining questionnaires were administered by one of the investigators. Verbal and written instructions were provided, and subjects were encouraged to ask questions if necessary. An opaque envelope for completed questionnaires was provided to all subjects prior to commencement. Subjects who were not actively engaging in intercourse, masturbation, or foreplay in the last month were excluded from the sexual function subanalysis, because these instruments were validated by evaluating sexual function over this time period.

Neurological Assessment

Biothesiometry was performed, using the Medoc Model Vibratory Sensory Analyzer 3000 (VSA, Advanced Medical Systems, Ramat Yishai, Israel) to measure vibratory sensation. Sensory testing was performed on eight genital regions known to be supplied by the pudendal nerve (sacral sensory dermatomes): the clitoris, right and left perineum, distal anterior and posterior vagina, right and left labia majora, and external urethra meatus. Prior to commencing, patients were told which areas would be evaluated, and a demonstration was performed on the patient's hand to ensure a thorough understanding of the sensations to be reported. The study was conducted with the patient in the lithotomy position and blinded to the voltage of the instrument being applied. The VSA was mounted on its base, and the probe was placed flush against the designated skin regions, using the minimal pressure necessary to maintain the positioning. After appropriate positioning of the probe was confirmed, the computerized program was used to gradually increase the stimulus intensity until the participant clicked on a hand-held Patient Response Unit to indicate when the vibratory sensation was first noted. This response amplitude that designated the minimal energy needed to distinguish between vibration and static touch was recorded in microns and defined as the vibratory threshold (VT). Ascending VTs were chosen to evaluate biosthesiometry findings because this method was found to have better reliability, validity, and reproducibility than other modalities [15]. In order to improve statistical accuracy, the program is designed to repeat the test six times at each site, with a 4-second intermission between each cycle.

Biothesiometry assessments were performed by four of the investigators (M.G., K.C., A.W., and J.L.). The first 10 enrolled patients underwent testing performed by M.G. and K.C. to confirm standardization of the technique. Subsequent exams were performed with at least two examiners present, initially with M.G. and K.C. serving as supervising examiners. After 25 exams had been performed, two of the aforementioned examiners performed the exams in varying sequence.

Statistical Analysis

A power analysis was conducted using VTs as the primary outcome measure and the study group as the primary independent variable. We determined that 45 subjects would be required for each group to detect a ≥30% difference between bicyclists and controls for all biothesiometry endpoints, assuming a two-sided alpha of 0.05 and 80% power.

Questionnaire and biothesiometry data were entered with verification. Statistical analyses were performed with SAS 9.1 (SAS Institute, Cary, NC) and Microsoft Excel 2003. A preliminary examination of the study variables for implausible values, departures from normality, missing values, and outliers was conducted. Descriptive statistics (means, standard deviations, percentages) for demographic, medical, reproductive, sexual, bicycling, and running characteristics were generated for bicyclists and controls. Bivariate statistical comparisons of independent variables by group (bicyclists vs. controls) were conducted using statistical tests (Wilcoxon rank sum [two-sided], chi-square, or Fisher's exact [two-sided]). Each test was selected based on the type and distribution of the two variables being compared. When analyzing the biothesiometry results, the median VT of the six repeated values at a given site was used to represent the participant's VT for that site. Median VT endpoints were transformed (log or reciprocal transformations) to correct nonnormal distributions, and missing independent variable values were replaced by means or modes in preparation for multivariate analysis.

Physiologically relevant independent variables that approached significance ($P < 0.15$) with VT endpoints in bivariate analysis were considered as potential candidate covariates for the biothesiometry multivariable analysis. Separate multivariable regression analyses were conducted for each of the eight VT site endpoints to examine the effect of the bicyclist and control group with simultaneous adjustment for age and the interaction (product term) of bicyclist vs. control group and age (full model). Hierarchical backward stepwise elimination of the variables was conducted, and only variables that were statistically significant ($P < 0.05$) were retained in the final models [16]. Regression diagnostics were conducted to verify that the data fit the multivariate assumptions of the models.

For bicyclists only (N = 48), an exploratory examination of bivariate relationships (Spearman rank correlations) between VT medians at each site and bicycling history variables was also conducted. Additional multivariable models of each VT site endpoint were also analyzed among the bicyclists for each site to explore the potential influence of miles biked per week on VTs in bicyclists. The full models for this subanalysis included miles biked per week, age, and the interaction term.

Main Outcome Measures

The primary outcome measure was genital VTs determined by biothesiometry. Our secondary outcome measures were sexual function and sexually related personal distress. These outcomes were determined using two validated questionnaires: the SPEQ and FSDS. All outcome measures were compared between bicyclists and controls.

Results

Forty-eight bicyclists and 22 controls were recruited for participation. Demographic data and information about the participants' medical and reproductive histories are provided in Table 1.

Table 1 Demographics, medical, and reproductive history of study participants

	Bicyclists		Runners		
Variable	N	Mean (SD) or %	N	Mean (SD) or %	*P* value
Age (years)	48	35.98 (6.90)	22	27.09 (7.31)	<0.0001*
BMI (kg/m^2)	48	22.55 (3.15)	22	20.93 (1.89)	0.0104*
Education					
High school/college	22	45.83%	12	54.54%	
Graduate/professional	26	54.17%	9	40.91%	0.3872†
Hx depression	47	21.28%	22	4.55%	0.0918‡
Using libido-reducing drugs	48	10.42%	22	4.55%	0.6572‡
Hx vaginal deliveries					
None	42	89.36%	19	95.00%	
One	2	4.26%	0	0.00%	
Two	3	6.38%	0	0.00%	
Three	0	0.00%	1	5.00%	0.6573‡§
Hx genital injury	48	10.42%	22	4.55%	0.6572‡
Hx genital pain, numbness, tingling	48	62.50%	22	4.55%	<0.0001‡
Hx sexual abuse	48	4.17%	21	0.00%	1.0000‡
Currently have a sexual partner	48	77.08%	21	52.38%	0.0402†
Relationship duration (years)	48	2.76 (4.61)	22	1.78 (2.74)	0.3392*
Sexual orientation					
Bisexual	3	6.25%	0	0.00%	
Heterosexual	34	70.83%	21	100.00%	0.0036‡¶
Lesbian	11	22.92%	0	0.00%	

*Wilcoxon rank sum test (two-sided).
†Chi-squared test.
‡Fisher's exact test (two-sided).
§Test compared proportion of those having no vaginal births and ≥1 vaginal birth.
¶Test compared proportion of heterosexual and nonheterosexual (bisexual and lesbian combined).
BMI = body mass index; Hx = history; SD = standard deviation.

Table 2 Mean vibratory thresholds for bicyclists and runners dichotomized at the median age

		Bicyclists		Runners	
Genital site	Age group	N	Vibratory threshold Mean (SD)	N	Vibratory threshold Mean (SD)
Clitoris	≤33	21	1.566 (1.338)	18	0.988 (0.285)*
	>33	26	1.376 (0.669)	4	1.738 (1.293)
Left perineum	≤33	19	3.038 (3.679)	17	1.597 (1.009)
	>33	27	3.862 (4.254)	4	2.575 (3.385)
Right perineum	≤33	20	3.095 (3.628)	17	1.606 (0.858)
	>33	26	4.202 (3.995)	4	4.206 (6.580)
Anterior vagina	≤33	21	2.314 (1.059)	18	1.432 (0.443)*
	>33	27	3.243 (2.838)	4	1.856 (1.716)
Posterior vagina	≤33	21	1.912 (1.048)	18	1.136 (0.325)*
	>33	27	3.462 (4.739)	4	1.106 (0.664)
Left labia	≤33	20	2.494 (1.554)	18	1.611 (0.684)
	>33	26	2.646 (2.197)	4	1.981 (0.450)
Right labia	≤33	21	2.429 (1.338)	16	1.336 (0.511)*
	>33	27	4.395 (5.859)	4	2.281 (1.512)
Urethra	≤33	21	2.455 (1.496)	18	1.519 (0.685)*
	>33	27	3.627 (3.859)	4	2.363 (1.686)

*$P < 0.05$.
Comparisons were made using Wilcoxon rank sum test (two-sided).
SD = standard deviation.

When compared to controls, the bicyclists were older, had higher body mass indices (BMIs), were more diverse in their sexual orientation, and were more likely to have a current partner. More than 80% of the subjects were nulliparous, and more than 40% attended graduate or professional school. A small proportion of subjects in each group sustained a prior genital injury. Conversely, more than 60% of our bicyclists reported genital pain, tingling, or numbness in the last month. These findings were significantly higher in the bicyclists compared to the controls (Table 1).

The bicyclists rode an average of 28.3 ± 19.7 miles/day (range 4–100), 3.8 ± 1.5 days/week, for an average of 2.1 ± 1.8 hours/ride. The mean number of years riding was 7.9 ± 7.1 years (range 0.5–30). Subjects in the control group ran an average of 4.65 ± 2.1 miles/day (range 1.5–8), 5.0 ± 1.2 days/week. Eighty-six percent (N = 19) reported that they did not ride, whereas three subjects in the control group reported intermittent riding, ranging from 0 to 6.8 miles/week (mean 0.69).

Biothesiometry was conducted on all subjects; however, there was a reduction in sample size at some of the tested sites, due to a limited number of recording errors. On bivariate analysis, bicyclists had significantly higher VTs (worse neurological function) at all genital sites ($P < 0.05$). Relationships and interactions between VTs and the variables, bicycling group and age, were explored descriptively. Means and standard deviations of VTs by age, dichotomized at the median value, were examined for each site, in bicyclists and controls (Table 2). In younger bicyclists, significantly higher thresholds were observed in five of the eight sites, compared to age-matched controls. In older women, there were too few controls to perform bivariate analysis; however, VTs in bicyclists appeared higher than in controls, for all sites except the clitoris and right perineum. Table 3 provides unadjusted and age-adjusted mean VTs for bicyclists and controls. After age-adjustment, mean VTs remained higher for the bicyclists compared to controls with the exception of the right perineum, where VTs were lower for

Table 3 Means and age-adjusted means for biothesiometry sites by group

	Bicyclists		Runners	
Genital site	N	Vibratory threshold Mean	N	Vibratory threshold Mean
Clitoris	47	1.461	22	1.124
Age adjusted		1.401		1.253
Left perineum	46	3.522	21	1.783
Age adjusted		3.160		2.576
Right perineum	46	3.721	21	2.101
Age adjusted		3.190		3.264
Anterior vagina	48	2.837	22	1.509
Age adjusted		2.524		2.190
Posterior vagina	48	2.784	22	1.131
Age adjusted		2.416		1.934
Left labia	46	2.580	22	1.678
Age adjusted		2.503		1.840
Right labia	48	3.535	20	1.525
Age adjusted		3.270		2.162
Urethra	48	3.114	22	1.673
Age adjusted		2.727		2.518

Table 4 Correlations between vibratory thresholds, bicycling practices, and body mass index (BMI) among bicyclists (N = 48)

Bicycling-related variables	Spearman correlations and *P* values by genital site							
	Clitoris	Left perineum	Right perineum	Anterior vagina	Posterior vagina	Right labia	Left labia	Urethra
Mean reported miles biked/week	0.07 (0.624)	−0.02 (0.844)	−0.11 (0.479)	0.13 (0.371)	0.03 (0.382)	0.11 (0.443)	0.12 (0.447)	0.13 (0.371)
Duration of riding in years	−0.08 (0.610)	0.15 (0.332)	0.20 (0.175)	0.12 (0.432)	0.08 (0.587)	0.08 (0.589)	0.02 (0.894)	0.04 (0.788)
BMI	0.24 (0.109)	0.05 (0.725)	−0.26 (0.087)	−0.18 (0.234)	−0.20 (0.164)	−0.01 (0.923)	0.13 (0.372)	−0.10 (0.502)

Table 5 Regression models of vibratory thresholds and group (bicyclists vs. runners) by genital site*

Genital site	Final model†	N	Adjusted R^2	Beta‡	*P* value
Clitoris	Age	69	0.099	0.026	0.005
Left perineum	Group	67	0.126	1.738	0.002
Right perineum	Group	67	0.085	1.620	0.010
Anterior vagina	Age	70	0.132	0.122	0.001
Posterior vagina	Group	70	0.194	1.653	<0.001
Left labia	Group	68	0.060	0.902	0.025
Right labia	Group	68	0.113	2.010	0.003
Urethra	Age	70	0.212	0.145	<0.001

*Group, age, and group–age interaction covariates included in the full model for each site.
†Only statistically significant ($P \leq 0.05$) covariates retained in final models.
‡Betas based on nontransformed models for interpretability.

bicyclists. Table 4 describes bivariate correlations between VTs and bicycling-related variables among bicyclists. For the subset of bicyclists, there were no statistically significant correlations between VTs and miles biked per week, duration of riding, or increasing BMI.

Results from the multivariate models of VTs and the bicycling group variable are presented in Table 5. There was a significant correlation between increasing VTs at the left and right perineum, posterior vagina, left, and right labia. In contrast to these five sites, increasing VTs at the clitoris, anterior vagina, and urethra were associated with age alone, independent of group assignment.

Table 6 highlights the findings from the alternate multivariable models of VTs and miles biked per week. In these models, the bicycling subset of women ($n = 48$) was analyzed separately. A positive correlation was found between increasing VTs and age at the anterior vagina and the urethra. Miles biked per week was not associated with VTs at any of the sites.

Table 7 provides comparative data for sexual function parameters between the bicyclists and controls. Mean SPEQ composite scores (range 10–23) and scores for the sexual response domain (range 6–15) were higher for bicyclists compared to controls, although the differences were not significant. Furthermore, the scores for both groups indicated that all of the sexually active subjects had normal sexual function. Similarly, all but five subjects had a normal perception of sexual functioning (FSDS score <20). Four of the five subjects reporting sexually related distress were bicyclists. All the five subjects (one runner and four bicyclists) reported that they were not satisfied with their current sexual life. However, upon review of

Table 6 Regression models of vibratory thresholds and miles biked/week by genital site among bicyclists*

Genital site	Final model†	N	Adjusted R^2	Beta‡	*P* value
Clitoris	Age	47	0.003	0.007	0.296
Left perineum	Age	46	0.024	0.141	0.155
Right perineum	Age	46	0.034	0.194	0.116
Anterior vagina	Age	48	0.067	0.151	0.042
Posterior vagina	Age	48	0.031	0.197	0.120
Left labia	Miles biked/week	46	–0.016	–0.000	0.605
Right labia	Age	48	–0.006	0.127	0.407
Urethra	Age	48	0.131	0.175	0.007

*Mean reported miles biked/week, age, and mean reported miles biked/week–age interaction covariates included in the full model for each site.
†Only statistically significant ($P \leq 0.05$) covariates retained in final models.
‡Betas based on nontransformed models for interpretability.

the 12-item FSDS questionnaires, there was no uniform reason for why these women experienced sexual distress.

Discussion

Evidence suggests that recruitment and stimulation of nerve fibers originating from the sacral roots of the spinal cord are essential components of the normal female sexual response [17]. Similarly, local vasocongestion, which is mediated by parasympathetic autonomic neurons, is an essential element of genital arousal [17,18]. Thus, any alterations in the integrity of the sacral nerve or vascular tracts could potentially lead to FSD.

While seated on a bicycle, the pudendal nerve (S2-4) and artery are directly compressed. It is possible that chronic compression of the female genital area may lead to compromised blood flow and ischemic nerve injury, due to disruption of the blood–nerve barrier. An analogous condition to this type of pudendal injury is carpal tunnel syndrome (CTS), a well-studied disease of chronic nerve compression. As the length of compression time increases, the large myelinated fibers undergo segmental demyelination, which is then followed by Wallerian degeneration [19]. These changes result in sensory deficits evidenced by increased vibratory and pressure thresholds [20], which appear to be directly related to the degree and duration of compression. These changes are often accompanied by sensory complaints of intermittent parasthesias that later progress to numbness [19].

Only limited descriptive reports have documented neurological symptoms in women bicyclists [5,21,22]. In one study, 80% of the 180 women bicyclists evaluated reported genital burning or pain, and 70% reported genital numbness. A larger study of 282 women bicyclists found that only 34% of the participants had symptoms of genital pain and numbness; however, only 11% of these women were competitive bicyclists. In comparison, our study consists only of competitive bicyclists, and 62% of the participants reported symptoms of genital pain, numbness, and tingling. These high numbers of hypoaesthesias and paresthesias in women bicyclists are concerning. These symptoms are identical to the early warning sign of compression-related neurological injury seen in CTS, and similar symptoms were reported in men bicyclists with ED.

Table 7 Relationships between group (runners vs. bicyclists) and SPEQ and FSDS scores

	Mean score (SD)		
Instrument	Bicyclists	Runners	*P* values†
Currently sexually active subgroup (bicyclists N = 39; runners N = 13)			
Total SPEQ*§	18.19 (2.95)	17 (2.31)	0.191‡
SPEQ sexual response domain	13.10 (2.19)	12.31 (1.84)	0.099
How often during sexual activities do you feel aroused or excited?	4.59 (0.64)	4.46 (0.52)	0.316
Do you currently experience orgasm (climax) during sex activity?	4.13 (1.20)	3.69 (1.03)	0.080
Total FSDS	8.26 (7.75)	6.54 (6.81)	0.560

*Bicyclists N = 46 for total SPEQ.
†SPEQ values ≤7 and FSDS scores ≥20 reflect abnormal sexual function.
‡Wilcoxon rank sum test (two-sided).
§*T*-test (two-sided) for total SPEQ only (normally distributed).
FSDS = Female Sexual Distress Scale; SD = standard deviation; SPEQ = Dennerstein Personal Experience Questionnaire–short form.

A recent case report of a male bicyclist complaining of penile numbness identified electromyographic evidence of bilateral pudendal nerve injury [7]. To our knowledge, the present study is the first one to evaluate and identify pudendal nerve changes in women bicyclists. Our findings of increased VTs and complaints of pain, numbness, and tingling in the genital region in bicyclists compared to controls indicate that pudendal nerve alterations also exist in women bicyclists. This is consistent with reports from other authors that have identified alterations in VTs in CTS, where chronic compression plays a causative role [20]. One would expect a correlation with increased VTs and frequency or duration of bicycling if chronic compression truly causes neurological injuries in women bicyclists. We did not find such associations in our sample of bicyclists; however, these results should be interpreted with caution because our study was not powered to evaluate these associations. Larger studies would be needed to confirm the role of chronic compression in neurological alterations associated with bicycling; however, the similarities between the subjective and objective neurological pathologies in CTS and bicycling suggest similar etiologic pathways.

Although higher VTs in the bicyclists may have resulted from compression injury, age could also may have contributed to these findings. In a previous study, we showed that VTs increase with increasing age [23]; however, in the regression models in this study, an independent relationship between age and VTs was noted only at the clitoris, anterior vagina, and urethra. We suspect that age-related changes in VTs may exist in bicyclists and runners. However, the limited number of subjects above the median age (33 years) and our failure to achieve our desired power preclude further evaluation of these associations.

Increasing BMI may cause more compression against the saddle and potentially worsened sensory deficits in heavier bicyclists. However, we would not expect the VTs to be affected in runners with higher BMIs. Therefore, BMI is not considered as a potential confounding variable in our models. For this reason, BMI was not included in the multivariable analysis, even though our bicyclists had significantly higher BMIs than controls. The lack of association between higher VTs and increasing BMI in the subset analysis of bicyclists (Table 4) also suggests that it does not confound the relationship between bicycling and VTs. However, these findings must be interpreted cautiously because our study was not powered to detect a significant association between these variables.

There were no statistically significant differences in the composite SPEQ scores or the sexual responsivity domain scores between bicyclists and controls. Additionally, the SPEQ scores were in the normal range for the both groups, and mean FSDS scores revealed normal perceptions of sexual function for bicyclists and controls. In Laumann et al.'s epidemiologic study of FSD [24], sexual problems tended to decrease with increasing age. In our cohort, it is plausible that the slight (nonsignificant) increase in the SPEQ scores in bicyclists reflects the normal trend for women in their age group, because the mean age for the bicyclists was 35.98 ± 6.90 years and that of the controls was 27.09 ± 7.31. Although our sample population comprised a predominately Caucasian group of educated, premenopausal women, similar to the original populations tested for instrument validation [13,14], it is conceivable that the SPEQ may have been too insensitive to detect subtle differences in sexual function that may have existed in our bicyclists, because the instrument was validated in women with FSD severe enough to seek professional assistance. However, based on the results from this instrument, it appears that this young, healthy, premenopausal cohort represents a low-risk population.

The results from our study are especially compelling because erectile dysfunction has been well described in men bicyclists. Reports by Schrader et al. [10] and Sommer et al. [8] noted that men who developed ED rode an average of 5.4 hours/day or 248.6 miles/week. The women bicyclists in our cohort rode substantially less (mean 2.3 ± 1.7 hours/day and 99.2 ± 74.1 miles/week), which could account for the differences seen in sexual function between men and women in these studies. In contrast, the Massachusetts Male Aging Study [25] indicated that bicycling more than 3 hours/week could predispose men to an increased risk of ED. In our cohort, women bicyclists rode an average of 8.5 ± 6.0 hours/week; however, all of the women in our bicycling group had normal sexual function. The reasons for the discrepancy in sexual function between men and women are not clear and may be better outlined in intersex studies.

Based on our findings, we theorize that higher VTs are an early marker of altered nerve function that could potentially result in a time-dependent development of FSD. This hypothesis is further strengthened by our findings from a previous study that established an association between increased VTs and sexual dysfunction in women [26]. It is also possible that our study participants from both groups represent women who may be more comfortable with their sexuality and bodies than symptomatic women who may have chosen not to participate due to the sensitive nature of this topic. Therefore, a selection bias could have precluded our ability to compare FSD between the two groups. We were unable to achieve our sample size requirement of 45 control subjects after exhausting the pool of qualified and interested candidates with active recruitment for almost 2 years in our metropolitan area. This may have contributed to our inability to detect significant differences in sexual function between the two groups, and to the lack of associations between miles biked per week and VTs. In spite of the limited sample size, however, higher VTs were consistently present in women bicyclists when compared to controls. A larger, longitudinal study would be necessary to determine whether a time-dependent relationship exists between bicycling, altered VTs, and the development of FSD.

Conclusion

There is an association between bicycling and decreased genital sensation in competitive women bicyclists. Our cross-sectional study design precluded us from determining the long-term effects of increased VTs on sexual function among bicyclists. However, negative effects on sexual function and quality of life were not apparent in our young, healthy, premenopausal cohort using the SPEQ and FSDS. Furthermore, these endpoints may be better studied using validated instruments that identify early, milder dysfunctions in this population. Expansion of this study to include recreational bicyclists is also indicated to determine whether our findings of altered neurological function among bicyclists are applicable to the general bicycling population.

The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the National Institute for Occupational Safety and Health.

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