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Association between overactive bladder and female sexual frequency: a cross-sectional analysis of the National Health and nutrition examination survey data

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Abstract

Background Overactive bladder (OAB) and female sexual dysfunction (FSD) are both common problems in women, but the association between OAB and FSD lacks a large sample study. The purpose of this cross-sectional study was to investigate the association between OAB and FSD.

Methods Data for this study were obtained from the 2007–2016 National Health and Nutrition Examination Survey (NHANES) for women aged 20–59 years. OAB was qualified with the aid of the overactive bladder symptom score (OABSS), which was obtained by adding the nocturia score and the urge urinary incontinence score, and participants with a total score ≥ 3 were considered to suffer from OAB. The FSD was defined as a sexual frequency of less than 12 times per year. After adjusting for covariates including basic demographic information, social information (e.g., marital status), gynecological (e.g., abnormal menstruation), and significant medical comorbidities, the association between OAB and FSD was assessed using survey-weighted logistic regression mode. In addition, subgroup analysis and sensitivity analysis were used to further assess the reliability of the findings.

Results A total of 5590 women aged 20–59 were eligible in the final analysis from 2007 to 2016 NHANES. 30.43% of participants ($n=1701$) were identified as FSD reporting sexual frequency of 0–11 times/year, while 69.57% of participants ($n=3889$) were identified as normal female sexual function reporting sexual frequency > 11 times/year. We performed logistic regression analysis to examine the association between OAB and FSD. The results demonstrated that participants with OAB (OABSS < 3) were 23% more likely to report lower sexual frequency (≤ 11) than those without OAB (OABSS ≥ 3) after adjusting fully for demographics, social history, gynecologic history and significant medical conditions (OR: 1.23, 95%CI: 1.01–1.49, $P=0.040$).

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Conclusion The study demonstrated the positive association between OAB and FSD measured by low sexual frequency among women 20–59 years old in the U.S. population; it is necessary to perform more comprehensive cohort studies to gain more profound understanding of the association between them.

Keywords Overactive bladder, Female sexual dysfunction, NHANES, Overactive bladder symptom score, Sexual frequency

Introduction

Overactive bladder (OAB) syndrome, defined as urinary urgency, is one of the common functional bladder disorders. OAB is often accompanied by frequent urination and/or nocturia, with or without urinary incontinence, and in the absence of urinary tract infection or any other obvious diseases [1, 2]. The prevalence of OAB has increased in recent years, possibly attributed to rising social stress and changing lifestyle habits [3, 4]. According to a prospective investigation in European, the overall prevalence of OAB is 11.8% among 19,000 adults, and is more prevalent in female adults than male adults (12.8% vs. 10.8%) [5]. Similar epidemiological findings have been reported in the United States with a prevalence of 16.0% for males and 16.9% for females [6]. As a globally prevalent chronic disease, OAB could have a substantial negative effect on quality of life, impacting both physical and mental health [7, 8]. However, the majority of existing literature predominantly concentrates on examining the effects of OAB on patients' quality of life, social embarrassment, and sleep patterns [9–11]. There is a relative scarcity of studies addressing the sexual activity of OAB patients, particularly among female patients.

Sexual activity is a crucial aspect of the overall quality of life in contemporary societies, and it exerts a substantial impact on physical and mental health [12, 13]. Female Sexual Dysfunction (FSD) is characterized by bothersome difficulties in achieving any stage of normal sexual activity, encompassing desire, arousal, lubrication, orgasm, or experiencing pain during intercourse [14]. According to the National Health and Social Life Survey, the prevalence of FSD is higher than that of male sexual dysfunction (43% vs. 31%) [15]. Sexual frequency is an important evaluation of FSD, and inability to engage in sexual activity could affect women's health, increasing the risk of stroke [16]. On the contrary, frequent sexual activity has been linked to a decreased risk of fatal coronary events and breast cancer [17, 18], as well as greater enjoyment of life [19]. These associations suggest a potential protective effect of sexual activity on physical and mental health and a normal aspect of human functioning. Therefore, sexual frequency is an important, albeit imperfect, measure of FSD, with lower sexual frequency being associated with a higher risk of FSD [20].

Several studies have explored the association between urinary incontinence and female sexual function and demonstrated that women with urinary incontinence tend to report impaired sexual function [21–23]. These women reported experiencing urine loss at some point during sexual activity, which could lead to decreased libido, more vaginal dryness, and more pain during intercourse [24]. However, there is limited research on the effect of OAB on female sexual activity, and some studies tend to focus more on specific patient populations, such as patients with multiple sclerosis [25] and fibromyalgia [26]. A study enrolling 267 women was conducted to investigate the association between severity of OAB and risk of FSD [27]. However, the reliability of its conclusions is limited due to the small sample size and the limited inclusion of covariates. They concluded that interrupting sexual intercourse to urinate, or experiencing urine leakage during the sex act, can lead to significant embarrassment, resulting in decreased sexual activity [27]. Therefore, the association between OAB and FSD requires larger sample studies for confirmation, aiming to increase awareness among healthcare professionals regarding the sexual activity of OAB patients.

To address these limitations, we intended to explore the association between OAB and FSD through a cross-sectional study based on the large dataset National Health and Nutrition Examination Survey (NHANES). To our knowledge, our study is the first one to enroll largest sample to investigate the association between OAB and FSD, where the FSD was evaluated by measure of low sexual frequency. We hypothesized that women with OAB have lower sexual frequency indicating FSD.

Methods

Study design and population

The NHANES is an ongoing series of stratified, cross-sectional, and multistage population-based surveys undertaken by the Centers for Disease Control and Prevention's National Center for Health Statistics in the United States. NHANES involves a variety of health and nutrition survey of the civilian noninstitutionalized population to evaluate their health and nutritional status, including demographic and nutritional information, physical examinations, laboratory tests, and questionnaires. All data are collected in a specially equipped mobile examination center through extensive household interviews, laboratory tests, and physical examinations. The NHANES database has been made available on the NHANES website for free download and analysis every other year since 1999. Additionally, the documentation detailing the recruitment of

study participants, study design, and measurement of study data can also be accessed on the NCHS website. The research project was reviewed and approved by the Ethics Review Board of the National Center for Health Statistics, and written informed consent was signed by all participants. Given this situation, no additional ethical approval is required for this study. This study adhered to the revised 2013 Declaration of Helsinki. We strictly followed the Strengthening the Reporting of Observational Studies in Epidemiology (STORBE) reporting guideline to ensure accurate reporting and interpretation of our results.

Our study combined five surveys period from 2007 to 2016, which included a total of 50,588 participants. Only female participants with complete data on sexual frequency were potentially eligible for the analysis ($N = 7158$). Among these, we excluded 386 participants without information for diagnosis of OAB. A series of exclusion criteria were established for selection: (1) participants who are pregnant ($n = 218$); (2) participants with relevant cancer history of urinary system, reproductive system, and neurologic system ($n = 328$); (3) participants with stroke ($n = 82$); (4) participants with missing information for covariates ($n = 654$). Finally, a total of 5590 female participants aged between 20 and 59 years old were enlisted in the final analysis. The detailed selection process was showed in Fig. 1.

Measurement of sexual frequency

According to the previous study, the sexual frequency is collected as a key variable in scales assessing FSD, with fewer sexual encounters signifying decreased sexual function [28]. During the physical examination, the sexual behavior questionnaires was completed in the mobile examination center using the Audio Computer Assisted Self Interview (ACASI) system. Respondents hear questions through earphones and read them on the computer screen using the ACASI system. Subjects proceed at their own pace, indicating their answers by touching the screen. The items included age at first sexual intercourse, number of sexual partners, sexual frequency, sexual orientation, circumcision status (men), and history of sexually transmitted diseases. We focused our study on the question "In the past 12 months, how many times have you had vaginal or anal sex?" The FSD was defined as a sexual frequency of less than 12 times per year, based on previous study [28].

Assessment of overactive bladder

According to the International Continence Society, OAB is a symptom syndrome characterized by the simultaneity of urinary urgency, typically accompanied by frequency and nocturia, with or without urge urinary incontinence (UUI), and in the absence of urinary tract infection or other obvious pathology [29]. So, OAB is diagnosed in patients exhibiting relevant clinical manifestations, including urgency, nocturia, and urge urinary incontinence (UUI), with UUI serving as a specific indicator of urgency. All these information acquired here could extracted from the Kidney Conditions-Urology questionnaire in NHANES. The following three questions were used for the diagnosis of OAB: (1) During the past 12 months, have you leaked or lost control of even a small amount of urine with an urge or pressure to urinate and you couldn't get to the toilet fast enough? (2) How frequently does this occur? (3) During the past 30 days, how many times per night did you most typically get up to urinate, from the time you went to bed at night until the time you got up in the morning? The former two were used to assess the severity of urge incontinence, and the latter was used to assess the gravity of nocturia. Additionally, OAB was qualified with the aid of the overactive bladder symptom score (OABSS), which was obtained by adding the nocturia score and the urge urinary incontinence score. The Table 1 exhibited the specific scoring criteria to quantify the overactive bladder symptoms based on the Criteria for Conversion of Symptom Frequencies Recorded in NHANES and Overactive Bladder Symptom Score (OABSS) Scores [30, 31]. Consequently, participants with a total score ≥ 3 were considered to suffer from OAB.

Study covariates

Demographic and social information, including age, race and/or ethnicity, education level, marital status, poverty to income ratio (PIR), smoking status, and alcohol use were collected. The age was classified as <50y and ≥ 50y. The race was divided into 5 categories according to NHANES as Mexican American, Non-Hispanic white, Non-Hispanic black, Other Hispanic, and Other races. The educational level was divided into below high school, high school, and above high school. The marital status was divided into married or with a partner and live alone according to their answer to the question that whether they are married or living with their partner. The PIR was used to reflect the socioeconomic status, classified as <2 and ≥ 2 [32]. The smoking status was evaluated by the answers to the question of "Have you smoked at least 100 cigarettes in your entire life" and "Do you now smoke cigarettes?" A participant was regarded as never smoker if he/she responded "No" to both questions, and current smoker if he/she responded "Yes" to both questions. The remaining participants were considered as former smokers. The alcohol use was assessed the average number of alcoholic drinks per day over the past week, month, or year. Female participants consuming more than one drink per day were confined as alcohol use. The body mass index (BMI) was collected as well, and classified as <30 kg/m^2, and ≥ 30 kg/m^2.

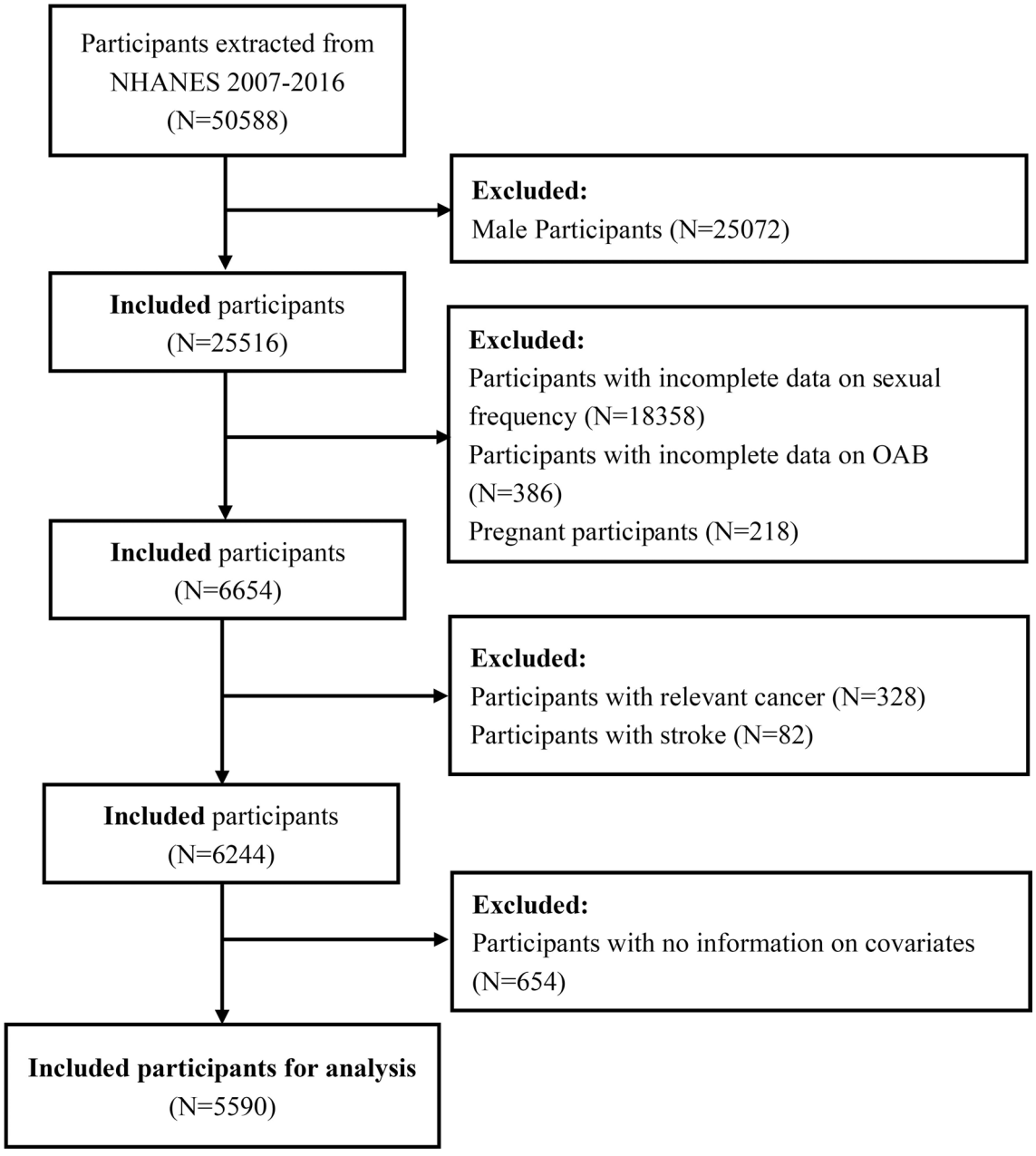

Fig. 1 Flowchart showing the selection of study participants, OAB: overactive bladder

Medical comorbidities including diabetes mellitus, hypertension, depressive symptoms, and cardiovascular disease were collected. The presence of medical comorbidities was assessed mainly based on self-reported diagnoses by a physician, rather than relying on medications usage, which aligns with the similar studies in the field [33]. The cardiovascular diseases were diagnosed by self-reported diagnosis by physician of heart attack, coronary heart disease, congestive heart failure, or angina. The Patient Health Questionnaire-9 (PHQ-9), which is a self-reported assessment based on the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition*, was used to evaluate the presence of depressive disorders. A person was defined as being positive for having depressive symptoms of the total score of PHQ-9 ≥ 10 [34]. And the depression status was classified as no depression symptom (PHQ-9 < 10) and some depression symptom (PHQ-9 ≥ 10). In addition, the trouble sleeping was determined based on the response to the question, "Have you ever informed a doctor or other health professional that you have trouble sleeping?"

Gynecological and pelvic floor health history were collected, including abnormal menstruation, history of pregnancy, history of hysterectomy or oophorectomy, and the

Table 1 Criteria for conversion of symptom frequencies recorded in NHANES and OABSS scores

According to NHANES score	According to OABSS score
Urge urinary incontinence frequency	Urge urinary incontinence score
Never	0
Less than once a month	1
A few times a month	1
A few times a week	2
Every day and/or night	3
Nocturia frequency Nocturia score	Nocturia frequency Nocturia score
0	0
1	1
2	2
3	3
4	3
5 or more	4

Notes: NHANES: National Health and Nutrition Examination Survey; OABSS: Overactive Bladder Symptom Score

use of birth control or female hormones. Abnormal menstruation was assessed based on self-reported presence of abnormal menstruation in the past 12 months. Additionally, the history of pregnancy, hysterectomy or oophorectomy, and the use of birth control or female hormones were also self-reported.

Statistical analysis

Appropriate 10-year sample weights were applied during the formal analysis to obtain prevalence estimates that were representative of the US population [35]. The eligible participants were categorized into two groups based on the FSD diagnosis. The categorical variables were reported as proportions, while the continuous variables were reported as mean ± standard error (SE). Weighted prevalence comparisons were performed using the chi-squared test for categorical variables, Student's t-test for continuous variables, and the Mann-Whitney U test for continuous non-normally distributed variables.

To explore the associations between OAB and FSD, the logistic regression analyses were performed, adapting various models with adjustments for different covariates. Model 1 was adjusted for age, race, educational level, and marital status. In model 2, adjustments included all variables in Model 1 plus BMI, abnormal menstruation, history of pregnancy, hysterectomy, oophorectomy, birth control, and the use of female hormones. Model 1 was adjusted for all included covariates. The two set of logistic regression analysis were conducted for sensitivity analysis. The first was performed using FSD as outcome variable (>11 vs. 0-11encounters/year), and the OAB as exposure variable (<3 vs. ≥3 OABSS). The second was done using OAB (<3 vs. ≥3 OABSS) as outcome variable, and the FSD (>11 vs. 0-11encounters/year) as exposure variable. We employed the same multi-model approach with same variable placements into each model. All results were reported as odds ratio (ORs) and 95% confidence intervals (CI).

To analyze the effect of different stratifications of the study population on the association between OAB and FSD, the subgroup analyses were conducted based on age, race, marital status, PIR, educational level, BMI, hypertension, diabetes, CVD, trouble sleeping, and depressive symptoms. Each subgroup analysis was performed separately using logistic regression models, with adjustments made for all covariates included in Model 3. Interactions within subgroups, calculated by incorporating multiplicative terms in the logistic regressions, were indicated by p-values. The participants were stratified into two groups based on age: age < 50years, and age ≥ 50years, considered that women aged 50 years or older were more likely to be postmenopausal. Based on BMI, the participants were stratified into two groups as BMI < 30 kg/m^2 (nonobese), and BMI ≥ 30 kg/m^2 (obese). Based on PIR, the participants were stratified into two groups as PIR < 2 and PIR ≥ 2. Other remained stratified variables were analyzed in subgroup analysis based on all possible values they could take.

All statistical analyses were performed on R 4.0 (http://www.R-project.org) and EmpowerStats (http://www.empowerstats.com; X&Y Solutions, Inc.). All statistical tests were 2-sided, and the significance threshold was set at $P \leq 0.05$.

Results

Basic characteristics of study participants

After a series of selection process outlined in Fig. 1, a total of 5590 women aged 20–59 were eligible in the final analysis from 2007 to 2016 NHANES. 30.43% of participants ($n = 1701$) were identified as FSD reporting sexual frequency of 0–11 times/year, while 69.57% of participants ($n = 3889$) were identified as normal female sexual function reporting sexual frequency > 11 times/year. The mean age of the FSD group was 41.79 years, higher than that of the group with normal female sexual function (37.27 years). In comparison to participants with a lower frequency of sexual activity (0–11 times/year), those with a higher sexual frequency (>11 times/year) were more likely to be white, higher educational level, married or living with a partner, higher socioeconomic status, and more frequently use alcohol or birth control. On the contrary, participants with a lower sexual frequency were more likely to be obese, more medical comorbidities and depressive symptoms, and more abnormal gynecological and pelvic floor history. More importantly, participants with low sexual frequency reported a higher prevalence of OAB compared to participants with a higher sexual frequency (OAB: 16.26% vs. 10.33%). The detailed characteristics of the study population according to sexual frequency are presented in Table 2.

Table 2 Baseline characteristics of the study population, stratified by lower sexual frequency (FSD: 0–11 encounters/year) and increased sexual frequency (non-FSD: >11 encounters/year), weighted

Characteristics	Total participants	Sexual Frequency per year		*P*-value
		Non-FSD (> 11)	FSD (0–11)	
Number, n	5590	3889	1701	
Age, year	38.55 ± 0.27	37.27 ± 0.28	41.79 ± 0.43	< 0.0001
BMI, kg/m^2	28.86 ± 0.16	28.53 ± 0.19	29.72 ± 0.23	< 0.0001
Race, %				< 0.0001
Mexican American	8.70	8.80	8.42	
Other Hispanic	6.10	6.08	6.15	
Non-Hispanic White	65.41	67.03	61.31	
Non-Hispanic Black	12.61	10.92	16.90	
Other races	7.18	7.16	7.21	
Educational level, %				0.0212
Below high school	12.27	11.53	14.13	
High school	19.52	19.04	20.73	
Above high school	68.21	69.43	65.14	
Marital status, %				< 0.0001
Married or living with a partner	68.45	72.92	57.13	
Living alone	31.55	27.08	42.87	
BMI status				< 0.001
BMI < 30 kg/m^2	63.74	65.58	59.08	
BMI ≥ 30 kg/m^2	36.26	34.42	40.92	
Age range				< 0.0001
< 50	79.53	83.73	68.90	
≥ 50y	20.47	16.27	31.10	
PIR, %				0.0054
PIR < 2	35.00	33.54	38.69	
PIR ≥ 2	65.00	66.46	61.31	
Alcohol intake, %				0.003
No	11.06	10.22	13.18	
Yes	88.94	89.78	86.82	
Smoking, %				0.8326
Never	62.23	62.18	62.33	
Former	16.30	16.50	15.79	
Now	21.48	21.31	21.88	
History of diabetes, %				< 0.0001
No	95.12	96.24	92.29	
Yes	4.88	3.76	7.71	
History of hypertension, %				< 0.001
No	80.62	82.04	77.03	
Yes	19.38	17.96	22.97	
History of CVD, %				< 0.0001
No	98.18	98.80	96.63	
Yes	1.82	1.20	3.37	
Depression				< 0.001
No	90.36	91.50	87.47	
Yes	9.64	8.50	12.53	
Trouble sleeping				0.0133
No	72.57	74.01	68.94	
Yes	27.43	25.99	31.06	
Abnormal Menstruation				< 0.0001
No	25.89	21.66	36.56	
Yes	74.11	78.34	63.44	
History of Pregnancy				0.815

Table 2 (continued)

Characteristics	Total participants	Sexual Frequency per year		*P*-value
		Non-FSD (> 11)	FSD (0–11)	
No	21.66	21.75	21.41	
Yes	78.34	78.25	78.59	
Hysterectomy				< 0.001
No	95.10	96.05	92.72	
Yes	4.90	3.95	7.28	
Oophorectomy				< 0.0001
No	89.21	90.70	85.45	
Yes	10.79	9.30	14.55	
Birth Control				0.0014
No	18.62	17.39	21.73	
Yes	81.38	82.61	78.27	
Female Hormones				0.0016
No	89.88	91.11	86.79	
Yes	10.12	8.89	13.21	
Overactive bladder, %				< 0.0001
No	87.99	89.67	83.74	
Yes	12.01	10.33	16.26	

Notes: FSD: female sexual dysfunction, BMI: body mass index, PIR: poverty to income ratio, CVD: cardiovascular disease

Association between FSD and OAB

We performed logistic regression analysis to examine the association between OAB and FSD. The results demonstrated that participants with OAB (OABSS < 3) were 23% more likely to report lower sexual frequency (≤ 11) than those without OAB (OABSS ≥ 3) after adjusting fully (model 3) for demographics, social history, gynecologic history and significant medical conditions (OR: 1.23, 95%CI: 1.01–1.49, $P = 0.040$). The association between OAB and FSD remained essential in model 1 and model 2. The sensitivity analyses results illustrated that the significant association between FSD and OAB remained even when we considered FSD as exposure and OAB as outcome (OR: 1.24, 95%CI: 1.01–1.51, $P = 0.038$). All logistic regression results were showed in Table 3.

Subgroup analysis

Our subgroup analysis stratified by age showed a significant association between OAB and FSD only in group of participants age < 50 years (OR: 1.32, 95%CI: 1.02–1.72, $P = 0.040$). Our subgroup analyses stratified by marital status showed a significant association between OAB and FSD in participants married or living with a partner (OR: 1.32, 95% CI: 1.00-1.75, $P = 0.05$). Stratified by PIR, women with PIR < 2 had significant association between OAB and FSD (OR: 1.43, 95% CI: 1.11–1.84, $P = 0.01$). On the contrary, women with PIR ≥ 2 had no significant association between OAB and FSD (OR: 1.03, 95% CI: 0.77–1.37, $P = 0.85$). and there were significant interactions between OAB and PIR in the association with FSD ($P = 0.025$). In addition, our subgroup analyses stratified by BMI exhibited a significant association between OAB

Table 3 Association between OAB (No vs. Yes) and lower sexual frequency (≤ 11 encounters/ year vs. > 11 encounters/ year) *, weighted

Exposure	Adjusted Model 1		Adjusted Model 2		Adjusted Model 3	
	OR (95%CI)	P value	OR (95%CI)	P value	OR (95%CI)	P value
OAB						
No	Ref		Ref		Ref	
Yes	1.34(1.11,1.62)	0.003	1.26(1.04,1.53)	0.020	1.23(1.01,1.49)	0.040
FSD						
No	Ref		Ref		Ref	
Yes	1.36(1.12,1.64)	0.002	1.28(1.06,1.56)	0.013	1.24(1.01,1.51)	0.038

Model 1: age, race, education level, and marital status;

Model 2: Model 1 + BMI + Female Hormones + Hysterectomy + Oophorectomy + Birth Control + Female Hormones + Pregnancy;

Model 3: All covariate adjusted

*: Low sexual frequency signifies female sexual dysfunction;

FSD: female sexual dysfunction, OAB: overactive bladder, OR: odds ratio, CI: confidential interval

and FSD in participants BMI ≥ 30 kg/m^2 (OR: 1.35, 95% CI: 1.00-1.82, $P = 0.05$). There were no significant interactions between OAB and stratified variables except PIR in the association with FSD (all P for interaction > 0.05). Subgroup analyses results are described in Table 4; Fig. 2.

Discussion

In this large cross-sectional study of U.S. women aged 20–59 years, our results demonstrated a significant association between OAB and lower sexual frequency of measured FSD, which remained significant even after adjusting for covariates including basic demographic information, social information (e.g., marital status), gynecological (e.g., abnormal menstruation), and significant medical comorbidities. Subgroup and sensitivity analyses further indicated the stability of this association. Our study is the first large-scale study using nationally representative data to investigate the relationship between OAB and FSD.

In this study, we used sexual frequency as an assessment criterion for FSD. Unlike NHANES 2001–2004, which investigated specific questions about erectile dysfunction in men, NHANES did not include specific questions about FSD. But there is a rationale for assessing FSD through sexual frequency. First, five of the seven scales that were developed based on direct patient input and that have been fully validated use sexual frequency as a key variable in identifying female sexual desire disorder [20]. Especially in Western and European countries, FSD is significantly associated with lower sexual frequency [36, 37]. Additionally, the U.S. Food and Drug Administration (FDA) has been recommending the number of satisfactory sexual activities per month as an assessment of the effectiveness of FSD treatment [20, 38]. Sexual frequency as a measure of FSD was reported in one study [28].

Our results were consistent with previous literature. A prospective study showed that women with OAB due to urethral instability had significantly lower sexual function scores compared to women with stress incontinence and controls [39]. Some form of sexual dysfunction has been reported in about 25% of women with OAB, but orgasm or sexual arousal is not associated with distress from urge incontinence [40]. In another study, two-thirds of women with OAB were at risk for FSD, suggesting that OAB deeply affects sexual quality of life [27]. There are many possible factors to explain the association between OAB and FSD. First, in women experiencing urge incontinence, the unpredictable and unavoidable leakage can lead to discomfort and distress [41]. Second, women with OAB frequently experience the need to visit the bathroom, may feel the urge to urinate during intercourse, and might even encounter urine leakage during orgasm [42]. This situation can cause great embarrassment to the OAB patients, thus reducing their sexual interest, and over time, they will avoid having sex and lead to a decline in sexual functioning. Third, people with OAB may experience difficulty urinating, suprapubic discomfort or pain, increased pain during intercourse, and other sex-related problems that can cause sexual dysfunction [27, 41]. Finally, women with urinary incontinence feel a degree of uncleanness and unwelcome, and the fear of leakage

Table 4 Subgroup analysis of the association between OAB and lower sexual frequency (≤ 11 encounters/ year vs. > 11 encounters/ year) *, weighted

Subgroup	OR (95%CI)	*P* value	*P* for interaction
Age			0.385
< 50y	1.32(1.02,1.72)	0.04	
≥ 50y	0.98(0.63,1.53)	0.92	
Race			0.634
Mexican American	1.32(0.88,1.98)	0.17	
Other Hispanic	1.05(0.58,1.90)	0.87	
Non-Hispanic White	1.30(0.98,1.72)	0.07	
Non-Hispanic Black	1.04(0.76,1.44)	0.79	
Other races	1.09(0.45, 2.68)	0.84	
Marital status			0.516
Married or living with a partner	1.32(1.00,1.75)	0.05	
Living alone	1.09(0.81,1.47)	0.57	
PIR			0.025
PIR < 2	1.43(1.11,1.84)	0.01	
PIR ≥ 2	1.03(0.77,1.37)	0.85	
Educational level			0.904
Below high school	1.37(0.91,2.07)	0.13	
High school	1.37(0.95,1.96)	0.09	
Above high school	1.16(0.86,1.55)	0.32	
BMI			0.704
<30 kg/m^2	1.12(0.83,1.51)	0.46	
≥30 kg/m^2	1.35(1.00,1.82)	0.05	
Hypertension			0.909
No	1.22(0.93,1.60)	0.14	
Yes	1.22(0.76,1.98)	0.40	
Diabetes			0.930
No	1.17(0.95,1.44)	0.13	
Yes	1.27(0.61,2.65)	0.50	
CVD			0.788
No	1.20(0.99,1.46)	0.07	
Yes	0.58(0.16, 2.14)	0.40	
Trouble sleeping			0.852
No	1.24(0.93,1.65)	0.13	
Yes	1.17(0.81,1.69)	0.41	
Depression			0.731
No	1.23(0.97,1.56)	0.08	
Yes	1.11(0.75,1.64)	0.58	

FSD: female sexual dysfunction, OAB: overactive bladder, OR: odds ratio, CI: confidential interval, BMI: body mass index, PIR: poverty to income ratio, CVD: cardiovascular disease

*: Low sexual frequency signifies female sexual dysfunction;

Subgroup	Adjusted OR (95% CI)	P value	P for interaction
Age			**0.385**
<50y	**1.32 (1.02, 1.72)**	**0.04**	
>=50y	**0.98 (0.63, 1.53)**	**0.92**	
Race			**0.634**
Mexican American	**1.32 (0.88, 1.98)**	**0.17**	
Other Hispanic	**1.05 (0.58, 1.90)**	**0.87**	
Non-Hispanic White	**1.30 (0.98, 1.72)**	**0.07**	
Non-Hispanic Black	**1.04 (0.76, 1.44)**	**0.79**	
Other races	**1.09 (0.45, 2.68)**	**0.84**	
Marital status			**0.516**
Married or living with a partner	**1.32 (1.00, 1.75)**	**0.05**	
Living alone	**1.09 (0.81, 1.47)**	**0.57**	
PIR			**0.025**
PIR<2	**1.43 (1.11, 1.84)**	**0.01**	
PIR>=2	**1.03 (0.77, 1.37)**	**0.85**	
Educational level			**0.904**
Below high school	**1.37 (0.91, 2.07)**	**0.13**	
High school	**1.37 (0.95, 1.96)**	**0.09**	
Above high school	**1.16 (0.86, 1.55)**	**0.32**	
BMI			**0.704**
<30 kg/m2	**1.12 (0.83, 1.51)**	**0.46**	
>=30 kg/m2	**1.35 (1.00, 1.82)**	**0.05**	
Hypertension			**0.909**
No	**1.22 (0.93, 1.60)**	**0.14**	
Yes	**1.22 (0.76, 1.98)**	**0.4**	
Diabetes			**0.93**
No	**1.17 (0.95, 1.44)**	**0.13**	
Yes	**1.27 (0.61, 2.65)**	**0.5**	
CVD			**0.788**
No	**1.20 (0.99, 1.46)**	**0.07**	
Yes	**0.58 (0.16, 2.14)**	**0.4**	
Trouble sleeping			**0.852**
No	**1.24 (0.93, 1.65)**	**0.13**	
Yes	**1.17 (0.81, 1.69)**	**0.41**	
Depression			**0.731**
No	**1.23 (0.97, 1.56)**	**0.08**	
Yes	**1.11 (0.75, 1.64)**	**0.58**	

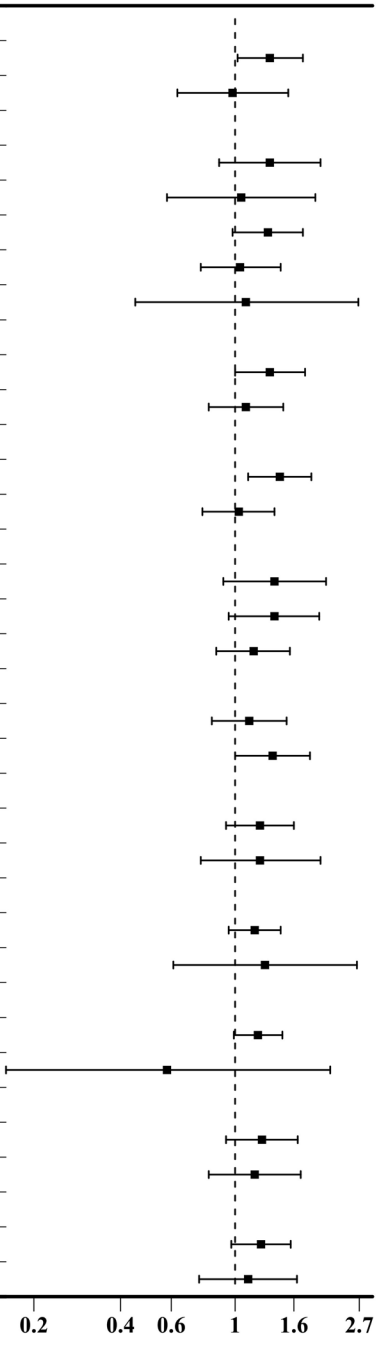

Fig. 2 Association between sexual frequency and OAB by subgroups adjusted in Model 3, Low sexual frequency signifies female sexual dysfunction, OAB: overactive bladder

during intercourse can cause decreased desire, loss of self-confidence, and dysfunctional sexual arousal [43].

In contrast to the above factors, the association between OAB and FSD is mediated by a marked decline in estrogen levels in postmenopausal women. The decline in estrogen causes symptoms of bladder irritation (e.g., urinary urgency, frequency, nocturia, and incontinence), which are part of the basis for the clinical diagnosis of OAB [44, 45]; estrogen depletion also leads to vaginal atrophy and sexual dysfunction [46]. The association between OAB and vaginal dryness and FSD has been well established. Therefore, the above factors may explain the association between OAB, FSD and menopause.

The results of our stratified analyses showed a significant association between OAB and the risk of FSD, especially among women with OAB who were < 50 years of age,

married or living with a partner, had a PIR < 2, and had a BMI ≥ 30 kg/m2, implying that it is particularly important to screen for FSD in these patients with OAB. For younger (< 50 years old) and married or living with a partner with OAB, their sexual needs are skewed, and the disruption of sexuality by the presence of OAB may be more pronounced. As mentioned above, women with urinary incontinence feel somehow unclean and unwelcome, and leakage during sexual intercourse can have an impact on sexual functioning [43], which is magnified by the fact that younger women may be more concerned about their self-image [47]. According to previous studies [48, 49], there is a significant association between obesity (BMI ≥ 30 kg/m2) and both OAB and FSD. In addition, our results found a significant interaction between PIR-stratified analyses, which may be explained by the fact that one study reported a significant association between lower socioeconomic status (as assessed by PIR) and lower female sexual frequency [28].

The present study still has some limitations. First, this study is a cross-sectional research design that only revealed the association between OAB and FSD and could not prove causality. Second, the data for this study were derived from the NHANES questionnaire, which may be subject to recall bias. Finally, because the specific question of FSD was not investigated in NHANES, we used the sexual frequency of women per year to assess FSD, which resulted in an inability to assess nonpenetrative sexual activity or other sexual problems that prevented sexual activity.

Conclusion

The study demonstrated the positive association between OAB and FSD measured by low sexual frequency among women 20–59 years old in the U.S. population. Our results showed that women participants with OAB reported lower sexual frequency with implications that clinical practitioners should assess the sexual function of patients with OAB and promptly address potentially existing FSD issues to promote the sexual health of the patients. However, it is necessary to perform more comprehensive cohort studies to gain more profound understanding of the association between them. Additionally, basic studies were needed to deeply uncover the pathological mechanisms linking OAB and FSD.

Abbreviations

ACASI	Audio computer-assisted self-interview
BMI	Body mass index
CI	Confidence interval
FDA	Food and Drug Administration
FSD	Female sexual dysfunction
NHANES	National Health and Nutrition Examination Survey
OAB	Overactive bladder
OABSS	Overactive bladder symptom score
OR	Odds ratio
PHQ-9	Patient health questionnaire-9
PIR	Poverty to income ratio
SE	Standard error
STORBE	Strengthening the reporting of observational studies in epidemiology
UUI	Urge urinary incontinence

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Author contributions

Conceptualization: Bo Zhang, Yi Gu, Yiming Chen, and Xingliang Feng; Data curation: Bo Zhang Yi Gu, and Yuanyuan Li; Formal analysis: Bo Zhang, Yiming Chen, and Xingliang Feng; Investigation: Bo Zhang, Yi Gu; Methodology: Bo Zhang, Yi Gu, and Yuanyuan Li; Writing– original draft: Bo Zhang, Yi Gu, Yiming Chen, Yuanyuan Li, and Xingliang Feng; Writing– review & editing: Bo Zhang and Xingliang Feng; Project administration: Bo Zhang and Xingliang Feng; Funding acquisition: Xingliang Feng. All authors have thoroughly reviewed and approved the final version of the manuscript.

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Data availability

The National Health and Nutrition Examination Survey dataset can be accessed publicly through the National Center for Health Statistics, a division of the Centers for Disease Control and Prevention (https://www.cdc.gov/nchs/nhanes/index.html). For those interested, the supplementary R code utilized in this study is available upon reasonable request from the corresponding author.

Declarations

Ethics approval and consent to participate

The NHANES study protocol (NCHS IRB/ERB Protocol No. #2011-17) underwent thorough review and approval by the NCHS Research Ethics Review Committee. Written informed consent was obtained from all participants. Given the de-identified nature of the publicly available data, additional approval from the institutional review committee is deemed exempt.

Competing interests

The authors declare no competing interests.

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