

Menstrual-urinary symptom overlap and bladder ultrasound correlates among reproductive-aged Nigerian university students: an exploratory cross-sectional study

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Abstract

Background

Menstrual health research in young women often focuses on uterine and ovarian symptoms, while urinary and bowel-related pelvic symptoms remain less frequently integrated with objective ultrasound measures. This study characterized renal morphometry and bladder filling/emptying indices and examined their associations with pelvic visceral and menstrual symptoms among reproductive-aged Nigerian university students.

Methods

This exploratory cross-sectional analysis used data from a larger ultrasound and menstrual health assessment project conducted among female students at the College of Health Sciences, Nnamdi Azikiwe University, Nigeria. Participants who reported menstruation within the preceding 12 months constituted the primary analytic cohort. Questionnaire data captured biodemographic, lifestyle, menstrual, urinary, and bowel-related symptoms. Transabdominal ultrasonography assessed kidney length, bladder wall thickness, pre-void bladder volume, and post-void bladder volume. Derived indices included voided volume, post-void residual ratio, and bladder emptying efficiency. Associations between urinary pain and pelvic visceral symptoms were examined using logistic regression.

Results

Of 347 participant records, 330 met the primary analytic criterion. Urinary pain was reported by 93 participants (28.2%), bowel-emptying pain by 99 (30.0%), flatus-related pain by 82 (24.8%), and pelvic pain by 207 (62.7%). Mean right and left kidney lengths were 9.51 ± 0.97 cm and 9.82 ± 0.77 cm, respectively. In unadjusted comparisons, participants with urinary pain had lower median pre-void bladder volume than those without urinary pain (227.00 mL vs 291.50 mL; $p = 0.029$) and higher overall menstrual and pelvic visceral symptom burden. In multivariable analysis, bowel-emptying pain (adjusted OR = 5.49; 95% CI: 2.96–10.18) and flatus-related pain (adjusted OR = 3.82; 95% CI: 2.03–7.21) remained associated with urinary pain. Adjusted associations between urinary pain and bladder ultrasound parameters were limited.

Conclusion

Urinary pain co-occurred strongly with bowel-related pelvic symptoms in this cohort, while objective bladder emptying indices showed limited independent association with urinary pain. These findings support integrated assessment of urinary, bowel, and menstrual symptoms in young women and provide preliminary ultrasound-based data from an understudied African student population.

Introduction

Menstrual health is increasingly recognized as an integral component of reproductive, sexual, and general health, encompassing not only bleeding patterns but also physical, psychological, social, and environmental dimensions of wellbeing [1]. The menstrual cycle has been described as a clinical vital sign, and contemporary frameworks for abnormal uterine bleeding emphasize standardized characterization of cycle timing, flow, and associated symptoms [2, 3]. In university-aged populations, menstrual symptoms may intersect with academic demands, psychosocial stressors, and health-seeking barriers, making this group important for reproductive and pelvic-health research.

Dysmenorrhea is among the most frequently reported menstrual complaints in young women. A systematic review and meta-analysis of 38 studies involving 21,573 young women estimated a high pooled prevalence of dysmenorrhea and documented adverse effects on school and university participation [4]. However, menstrual pain rarely occurs in isolation. Painful menstruation may coexist with pelvic pain, urinary discomfort, bowel-related pain, bloating, fatigue, and other somatic symptoms, suggesting that a narrow focus on uterine bleeding or menstrual pain alone may underestimate the broader symptom burden experienced by young women.

Urinary pain and bowel-related pain are clinically relevant because pelvic visceral organs are anatomically proximate and share overlapping sensory pathways. Lower urinary tract symptoms are conventionally described from the individual's perspective and may include storage, voiding, and post-micturition symptoms [5]. Although this study did not diagnose bladder pain syndrome, standardized lower urinary tract symptom terminology and bladder pain frameworks provide useful clinical context for interpreting self-reported urinary discomfort in young women [5, 6]. In gynecological practice, conditions such as endometriosis can present with dysmenorrhea, pelvic pain, dyschezia, and dysuria, although these symptoms are not disease-specific and may occur in individuals without a confirmed gynecological diagnosis [7].

Mechanistic literature on pelvic pain supports the plausibility of symptom overlap across the bladder, bowel, and reproductive tract. Cross-organ sensitization describes a process in which irritation or nociceptive input from one visceral organ may influence sensory processing in adjacent or functionally related organs through shared peripheral and central neural pathways [8, 9]. Although such mechanisms cannot be inferred directly from cross-sectional symptom data, they provide a biologically coherent rationale for examining urinary, bowel, and menstrual symptoms together rather than as independent complaints.

Ultrasound provides a non-invasive means of characterizing selected urinary and renal parameters alongside pelvic reproductive assessment. Kidney length is a widely used sonographic morphometric measure and has been described in adult Nigerian populations, with left-right differences and anthropometric influences reported in prior work [10]. Bladder ultrasound measures, including pre-void volume and post-void residual volume, provide objective information on bladder filling and emptying, although they are influenced by hydration, voiding behavior, scan timing, and measurement context. Few

studies from sub-Saharan Africa have integrated menstrual symptom profiles with renal morphometry and bladder emptying indices in young, community-based female populations. In particular, there is limited community-based evidence from sub-Saharan Africa linking urinary and bowel-related menstrual symptoms with objective bladder filling and emptying measures.

The present study therefore aimed to characterize renal morphometry and bladder filling/emptying indices among reproductive-aged Nigerian university students and to examine whether urinary pain overlaps with bowel-related, pelvic, and menstrual symptoms. We further explored whether urinary pain was associated with bladder ultrasound parameters and whether renal and bladder measurements varied by menstrual characteristics. The analysis was designed as exploratory and hypothesis-generating, with emphasis on effect estimates, symptom co-occurrence, and cautious interpretation of ultrasound findings.

Methods

Study design and setting

This exploratory cross-sectional study was conducted among reproductive-aged female students at the College of Health Sciences, Nnamdi Azikiwe University, Nnewi Campus, Anambra State, Nigeria. The present analysis was derived from a larger ultrasound and menstrual health assessment project designed to evaluate menstrual characteristics, pelvic visceral symptoms, and abdominopelvic ultrasound parameters among female students. The study was designed and reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for cross-sectional studies [11].

Study population and eligibility criteria

The source population comprised female students aged 15–49 years who had attained menarche and were enrolled within the College of Health Sciences. Participants were recruited across academic programmes within the College and were eligible for the parent study if they provided informed consent and were willing to complete the study questionnaire and undergo abdominopelvic ultrasound assessment.

For the present analysis, a population-based analytic framework was adopted. Participants were eligible for inclusion in the primary analytic cohort if they had consented to participate in the parent project and reported menstruation within the preceding 12 months. Participants were not excluded on the basis of menstrual irregularity, menstrual symptoms, lifestyle exposures, prior contraceptive use, or prior gynecological diagnoses, as these variables were considered part of the natural variability of the study population. Participants with no report of menstruation within the preceding 12 months were excluded from the primary analytic cohort. Variable-specific denominators were used for analyses involving renal,

bladder, menstrual-phase, and symptom variables because not all parameters were available or valid for every participant.

Sample size determination and analytic sample

For the present manuscript, which focused specifically on pelvic visceral symptom overlap, bladder filling/emptying indices, and renal morphometry, the minimum sample size was determined using the single-population proportion formula for cross-sectional studies [$n = Z^2 p(1 - p) / d^2$] where n is the minimum required sample size, Z is the standard normal deviate at a 95% confidence level, p is the expected prevalence of the primary symptom domain, and d is the desired margin of error. Because urinary and bowel-related pelvic symptoms are closely related to menstrual pain and the present manuscript examined symptom overlap within a broader menstrual health framework, the expected prevalence was based on the pooled prevalence of primary dysmenorrhea among women in sub-Saharan Africa. A recent systematic review and meta-analysis of 65 cross-sectional studies involving 28,813 participants from 12 sub-Saharan African countries reported a pooled prevalence of primary dysmenorrhea of 73.49% (95% CI: 70.95–76.03) [12]. Using this prevalence estimate, a 95% confidence level ($Z = 1.96$), and a 5% margin of error, the minimum sample size was calculated as follows:

$$n = (1.96)^2 \times 0.7349 \times (1 - 0.7349) / (0.05)^2; n = 299.37$$

Thus, the minimum required sample size was approximately 300 participants. After allowing for a 10% non-response, incomplete-response, or invalid-measurement rate, the adjusted minimum sample size was: $n = 300 / (1 - 0.10) = 333$

Accordingly, a minimum target sample size of 333 participants was considered adequate for the present manuscript's primary descriptive and symptom-association objectives. The parent dataset contained 347 participant records, exceeding the adjusted minimum sample size. For the present analysis, participants were included in the primary analytic cohort if they reported menstruation within the preceding 12 months. This yielded 330 participants for the main analysis.

All eligible records from the parent dataset were included rather than selecting a separate subsample. Variable-specific denominators were used for renal morphometry, bladder ultrasound parameters, menstrual-phase analyses, and symptom-based models because missing, non-informative, or implausible values were excluded from the relevant analyses. Therefore, analyses were conducted using the maximum number of participants with valid data for each outcome or exposure.

Data collection and study variables

Data were collected using a structured, pretested online questionnaire administered through Google Forms. The questionnaire captured biodemographic characteristics, menstrual history, menstrual symptoms, pelvic visceral symptoms, lifestyle factors, reproductive history, and prior gynecological

diagnoses. Variables extracted for the present analysis included age, age group, age at menarche, menstrual cycle regularity, menstrual cycle length, menstrual symptoms, pelvic visceral symptoms, smoking status, alcohol use, exercise level, perceived stress level, and menstrual phase at the time of ultrasound assessment.

Menstrual cycle regularity was based on participants' self-reported consistency of menstrual cycles over the preceding 12 months and categorized as regular or irregular. Cycle length was categorized as normal or abnormal using the FIGO framework for normal and abnormal uterine bleeding symptoms, with abnormal cycle length defined as < 24 days or > 38 days [3]. Age at menarche was analyzed as a continuous variable and categorized into normative and non-normative menarcheal timing. Normative menarcheal timing was defined as menarche between 11 and 15 years, while early menarche (≤ 10 years) and later menarche (≥ 16 years) were combined as non-normative menarcheal timing.

Lifestyle variables included alcohol use, smoking, exercise level, and perceived stress level. Exercise level was dichotomized as low exercise for participants who reported never or rarely exercising, and higher exercise for those reporting occasional or regular exercise. Stress level was categorized from self-reported responses, with high stress analyzed as a binary indicator for regression modelling.

Anthropometric measurements

Height and weight were measured using standardized procedures. Height was measured to the nearest 0.1 cm using a stadiometer, with participants standing upright without footwear. Weight was measured to the nearest 0.1 kg using a calibrated digital scale. Body mass index was calculated as weight in kilograms divided by height in metres squared. BMI was analyzed as a continuous variable and categorized according to World Health Organization classifications as underweight (< 18.5 kg/m²), normal weight (18.5–24.9 kg/m²), overweight (25.0–29.9 kg/m²), or obese (≥ 30.0 kg/m²) [13].

Menstrual phase classification

Menstrual phase at the time of ultrasound assessment was classified using self-reported last menstrual period and expected cycle timing. Participants were categorized into four calendar-estimated menstrual phases: menstruation, follicular phase, ovulation, and luteal phase. Menstruation corresponded to cycle days 1–5, the follicular phase to days 6–12, ovulation to days 13–15, and the luteal phase to days 16–28. Records with missing, invalid, or non-informative phase information were treated as missing for menstrual-phase analyses. Because phase assignment was based on self-reported menstrual dates and a single-visit ultrasound assessment and was not confirmed using serial ultrasonography or hormonal assays, menstrual phase was treated as calendar-estimated.

Ultrasound assessment

Abdominopelvic ultrasonography was performed using a transabdominal approach with a 3.5–5.0 MHz curvilinear transducer on a GE Logiq V2 ultrasound machine. Participants were examined in the supine position. A full bladder was required to optimize the acoustic window for pelvic visualization, and participants were supported with on-site water intake when necessary. All scans were performed by a Board-certified radiologist using a standardized scanning approach, which minimized inter-observer variability. Formal intra-observer reliability testing was not performed.

For the present analysis, ultrasound variables included right kidney length, left kidney length, bladder wall thickness, pre-void bladder volume, and post-void bladder volume. Kidney length was recorded in centimetres for each side. Mean kidney length was calculated as the average of available valid right and left kidney length measurements. Absolute renal asymmetry was calculated as the absolute difference between valid right and left kidney lengths and was restricted to participants with valid bilateral kidney measurements. Paired left–right kidney length difference was calculated as left kidney length minus right kidney length.

Bladder ultrasound parameters included bladder wall thickness, pre-void bladder volume, and post-void bladder volume. Derived bladder emptying indices were calculated among participants with valid pre-void and post-void bladder volume measurements. Voided volume was calculated as pre-void bladder volume minus post-void bladder volume. Post-void residual ratio was calculated as post-void bladder volume divided by pre-void bladder volume and expressed as a percentage. Bladder emptying efficiency was calculated as voided volume divided by pre-void bladder volume and expressed as a percentage.

Pelvic visceral and menstrual symptom measures

The primary symptom outcome for this analysis was urinary pain, defined as self-reported pain before, during, or after passing urine. This variable was analyzed as a self-reported urinary pain symptom and was not treated as a clinical diagnosis of dysuria, urinary tract infection, or bladder pain syndrome. Other pelvic visceral symptoms included pain before, during, or after bowel emptying; pain before or during passage of flatus; pelvic pain; and bloating or indigestion.

Menstrual symptoms included painful menstruation, menstrual pain severity, menstrual cramps, fatigue, and other menstrual-associated symptoms captured in the questionnaire. Moderate or severe painful menstruation was analyzed as a binary symptom indicator. Menstrual cycle regularity and cycle length were analyzed separately as menstrual characteristics rather than as components of symptom burden.

Overall menstrual symptom burden was calculated as the sum of recorded menstrual-associated symptom indicators for each participant. Pelvic visceral symptom burden was calculated as the sum of five binary symptom indicators: urinary pain, bowel-emptying pain, flatus-related pain, pelvic pain, and bloating or indigestion. For each symptom-burden score, individual symptoms were coded as 1 if present and 0 if absent, with higher scores indicating a greater number of reported symptoms. These scores were used as descriptive symptom-burden indices and were not intended to represent validated

diagnostic scales. In this manuscript, “symptom clustering” refers to co-occurrence, correlation, and regression-based association among self-reported symptoms rather than a formal latent class, factor analytic, or cluster-analysis model.

Data cleaning and analytic cohorts

The dataset was reviewed and cleaned before analysis. Numeric renal and bladder ultrasound variables were converted to continuous values, and non-numeric entries were treated as missing. Records with missing or non-informative responses were excluded from variable-specific analyses but retained for analyses of variables with valid data. Implausible ultrasound entries were treated as missing using prespecified range and consistency checks. Kidney length values outside physiologically plausible adult limits were excluded. Bladder wall thickness, pre-void bladder volume, and post-void bladder volume were also reviewed for implausible values. Derived bladder emptying indices were calculated only when both pre-void and post-void bladder volume measurements were valid and internally consistent.

The primary analytic cohort comprised participants who reported menstruation within the preceding 12 months. Renal morphometry analyses used participants with at least one valid kidney length measurement, while bilateral renal asymmetry analyses were restricted to participants with valid right and left kidney length measurements. Bladder emptying analyses were restricted to participants with valid pre-void and post-void bladder volume measurements. Menstrual-phase analyses were restricted to participants with valid calendar-estimated menstrual phase classification.

Statistical analysis

All analyses were conducted using Python version 3.10. Data preprocessing and management were performed using pandas and numpy. Statistical analyses were conducted using scipy and statsmodels, and figures were generated using matplotlib.

Categorical variables were summarized using frequencies and percentages. Continuous variables were summarized using mean $\pm$ standard deviation and median with interquartile range. Variable-specific denominators were reported where data were missing or invalid. Prevalence estimates for pelvic visceral and menstrual symptoms were reported with 95% confidence intervals using Wilson methods.

Right and left kidney lengths were compared among participants with valid bilateral measurements using the Wilcoxon signed-rank test. Pearson correlation was used to assess linear correlation between right and left kidney lengths, while Spearman correlation was used to assess monotonic correlation. Correlations between renal morphometry and bladder ultrasound indices were assessed using Spearman rank correlation.

Comparisons of renal and bladder ultrasound parameters by urinary pain status were performed using Mann–Whitney U tests because several ultrasound and symptom-burden variables were non-normally distributed. Renal and bladder ultrasound parameters were also compared across calendar-estimated

menstrual phases using Kruskal–Wallis tests and by menstrual cycle regularity using Mann–Whitney U tests. These phase- and regularity-based analyses were treated as secondary analyses.

Unadjusted associations between urinary pain and selected pelvic visceral and menstrual symptoms were assessed using logistic regression models and reported as odds ratios with 95% confidence intervals. Phi correlation coefficients were calculated to assess pairwise co-occurrence between binary pelvic visceral and menstrual symptoms, and the resulting correlation matrix was displayed as a heatmap.

A multivariable logistic regression model was fitted to examine independent associations between selected pelvic visceral symptoms and urinary pain. The dependent variable was urinary pain. Candidate predictors included bowel-emptying pain, flatus-related pain, pelvic pain, bloating or indigestion, moderate/severe painful menstruation, age group, BMI, menstrual cycle regularity, low exercise level, and high stress level. Results were reported as adjusted odds ratios with 95% confidence intervals and p-values.

Adjusted linear regression models were fitted to examine associations between urinary pain and bladder ultrasound parameters. Outcomes included pre-void bladder volume, post-void bladder volume, post-void residual ratio, bladder emptying efficiency, and bladder wall thickness. Models adjusted for age group, BMI, menstrual cycle regularity, low exercise level, high stress level, and calendar-estimated menstrual phase.

All statistical tests were two-sided, and $p < 0.05$ was considered statistically significant. Given the exploratory nature of the study and the use of multiple related outcomes, emphasis was placed on the magnitude, direction, and precision of estimates rather than statistical significance alone.

Ethical considerations

Ethical approval

for the parent study was obtained from the Nnamdi Azikiwe University Teaching Hospital Health Research Ethics Committee (protocol number: NAUTH/CS/66/VOL.17/VER.3/117/2024/262). All study procedures were conducted in accordance with institutional ethical standards and the principles of the Declaration of Helsinki [14]. Written informed consent was obtained from all participants before data collection.

Results

Participant characteristics and analytic sample

The dataset comprised 347 participant records. Of these, 330 participants reported menstruation within the preceding 12 months and constituted the primary analytic cohort for this study. Participant biodemographic, menstrual, lifestyle, and menstrual-phase characteristics are summarized in Table 1.

The mean age of participants was 21.06 ± 3.33 years. Most participants were aged 16–20 years (46.1%) or 21–25 years (47.9%), while 6.1% were aged 26 years or older. The mean body mass index was 23.15 ± 4.35 kg/m². Normal BMI was observed in 216 participants (65.5%), while 53 (16.1%) were overweight and 21 (6.4%) were obese.

Regular menstrual cycles were reported by 205 participants (62.1%). The mean age at menarche was 13.28 ± 1.78 years. A total of 275 of 319 participants (86.2%) reported normative menarcheal timing, while 44 of 319 participants (13.8%) had non-normative menarcheal timing. Alcohol use was reported by 72 participants (21.8%), smoking by 17 participants (5.2%), low exercise level by 179 participants (54.2%), and high stress level by 64 participants (19.4%). Valid menstrual phase classification was available for 235 participants; the luteal phase accounted for the largest proportion of classified participants (136/235; 57.9%), followed by menstruation (51/235; 21.7%), ovulation (34/235; 14.5%), and the follicular phase (14/235; 6.0%).

Table 1
Biodemographic, menstrual, and lifestyle characteristics of participants

Variable	Category/statistic	n (%) or mean $\pm$ SD
Participants	—	330
Age, years	—	21.06 $\pm$ 3.33
Age group	16–20 years	152 (46.1)
	21–25 years	158 (47.9)
	$\geq$ 26 years	20 (6.1)
BMI, kg/m ²	—	23.15 $\pm$ 4.35
BMI category	Underweight	25 (7.6)
	Normal weight	216 (65.5)
	Overweight	53 (16.1)
	Obese	21 (6.4)
Menarcheal age, years	—	13.28 $\pm$ 1.78
Menarcheal timing	Normative	275/319 (86.2)
	Non-normative	44/319 (13.8)
Menstrual cycle regularity	Regular	205 (62.1)
Alcohol use	Yes	72 (21.8)
Smoking	Yes	17 (5.2)
Low exercise level	Yes	179 (54.2)
High stress level	Yes	64 (19.4)
Menstrual phase	Menstruation	51/235 (21.7)
	Follicular	14/235 (6.0)
	Ovulation	34/235 (14.5)
	Luteal	136/235 (57.9)

Data are presented as n (%) for categorical variables and mean $\pm$ standard deviation for continuous variables. Percentages were calculated using the primary analytic cohort unless otherwise indicated by variable-specific denominators. Normative menarcheal timing was defined as menarche between 11 and 15 years; non-normative timing included early and later menarcheal timing. Low exercise level refers to participants reporting never or rarely exercising. High stress level was based on self-reported perceived

stress. Menstrual phase was calendar-estimated from self-reported menstrual timing and was available only for participants with valid phase classification.

Renal and bladder morphometry

Renal morphometry and bladder ultrasound parameters are presented in Table 2. Valid right and left kidney length measurements were available for 322 participants each. The mean right kidney length was 9.51 ± 0.97 cm, with a median of 9.60 cm [IQR: 8.90–10.10]. The mean left kidney length was 9.82 ± 0.77 cm, with a median of 9.80 cm [IQR: 9.40–10.30]. Mean kidney length was available for 327 participants and had a mean of 9.67 ± 0.77 cm and median of 9.75 cm [IQR: 9.15–10.15].

Among 317 participants with valid bilateral kidney measurements, the mean absolute right-left renal length difference was 0.72 ± 0.58 cm, with a median of 0.60 cm [IQR: 0.30–1.00]. The median paired left-right renal length difference was 0.30 cm, and the left kidney was longer than the right kidney in paired analysis ($p < 0.001$). Right and left kidney lengths were positively correlated using Pearson correlation ($r = 0.532$, $p < 0.001$) and Spearman correlation ($\rho = 0.484$, $p < 0.001$).

Valid bladder wall thickness measurements were available for 318 participants. The mean bladder wall thickness was 0.35 ± 0.11 cm, with a median of 0.30 cm [IQR: 0.30–0.40]. Pre-void bladder volume was available for 325 participants and had a mean of 301.36 ± 191.10 mL and median of 278.00 mL [IQR: 156.00–400.00]. Post-void bladder volume was available for 285 participants and had a mean of 27.08 ± 33.32 mL and median of 14.00 mL [IQR: 4.00–40.00].

Among 282 participants with complete pre-void and post-void bladder volume data, the mean voided volume was 281.82 ± 187.13 mL, with a median of 250.50 mL [IQR: 133.50–387.12]. The mean post-void residual ratio was $9.94 \pm 12.63\%$, with a median of 5.99% [IQR: 1.95–12.77]. Mean bladder emptying efficiency was $90.06 \pm 12.63\%$, with a median of 94.01% [IQR: 87.23–98.05]. Renal and bladder ultrasound parameters across calendar-estimated menstrual phases and by menstrual cycle regularity are presented in Supplementary Tables 1 and 2, respectively.

Table 2
Renal morphometry and bladder ultrasound parameters

Parameter	Valid n	Mean $\pm$ SD	Median [IQR]
Right kidney length, cm	322	9.51 $\pm$ 0.97	9.60 [8.90–10.10]
Left kidney length, cm	322	9.82 $\pm$ 0.77	9.80 [9.40–10.30]
Mean kidney length, cm	327	9.67 $\pm$ 0.77	9.75 [9.15–10.15]
Absolute renal asymmetry, cm	317	0.72 $\pm$ 0.58	0.60 [0.30–1.00]
Bladder wall thickness, cm	318	0.35 $\pm$ 0.11	0.30 [0.30–0.40]
Pre-void bladder volume, mL	325	301.36 $\pm$ 191.10	278.00 [156.00–400.00]
Post-void bladder volume, mL	285	27.08 $\pm$ 33.32	14.00 [4.00–40.00]
Voided volume, mL	282	281.82 $\pm$ 187.13	250.50 [133.50–387.12]
Post-void residual ratio, %	282	9.94 $\pm$ 12.63	5.99 [1.95–12.77]
Bladder emptying efficiency, %	282	90.06 $\pm$ 12.63	94.01 [87.23–98.05]

Values are presented as mean $\pm$ standard deviation and median [interquartile range]. Variable-specific denominators reflect available valid ultrasound measurements after data cleaning. Mean kidney length was calculated from available right and left kidney length measurements. Absolute renal asymmetry was calculated as the absolute difference between right and left kidney length among participants with valid bilateral measurements. Voided volume, post-void residual ratio, and bladder emptying efficiency were calculated only among participants with valid pre-void and post-void bladder volume measurements.

Pelvic visceral and menstrual symptoms

The prevalence of selected pelvic visceral and menstrual symptoms is shown in Fig. 1. Pain before, during, or after passing urine was reported by 93 participants (28.2%; 95% CI: 23.6–33.3). Pain before, during, or after bowel emptying was reported by 99 participants (30.0%; 95% CI: 25.3–35.2), while pain before or during passage of flatus was reported by 82 participants (24.8%; 95% CI: 20.5–29.8). Pelvic pain was reported by 207 participants (62.7%; 95% CI: 57.4–67.8), and bloating or indigestion was reported by 160 participants (48.5%; 95% CI: 43.1–53.9).

Any painful menstruation was reported by 282 participants (85.5%; 95% CI: 81.2–88.9), while moderate or severe painful menstruation was reported by 209 participants (63.3%; 95% CI: 58.0–68.4). The mean overall menstrual symptom burden score was 8.24 $\pm$ 3.57, with a median of 8.00 [IQR: 6.00–11.00]. The mean pelvic visceral symptom burden score was 1.94 $\pm$ 1.44, with a median of 2.00 [IQR: 1.00–3.00].

Horizontal bars show the prevalence of selected pelvic visceral and menstrual symptoms among participants in the primary analytic cohort. Error bars represent 95% confidence intervals. Urinary pain was

defined as pain before, during, or after passing urine. Bowel-emptying pain was defined as pain before, during, or after bowel emptying. Flatus-related pain was defined as pain before or during passage of flatus.

Renal and bladder ultrasound parameters by urinary pain status

Differences in bladder volume and symptom burden by urinary pain status are shown in Fig. 2, with the full comparison of renal, bladder, and symptom parameters provided in Supplementary Table 3. In unadjusted comparisons, participants with urinary pain had a lower median pre-void bladder volume than participants without urinary pain (227.00 mL [IQR: 131.00-350.00] vs 291.50 mL [IQR: 156.75-420.75], $p = 0.029$). Median voided volume was 220.00 mL [IQR: 127.00-352.00] among participants with urinary pain and 260.00 mL [IQR: 137.00-406.00] among those without urinary pain ($p = 0.098$).

Post-void bladder volume, post-void residual ratio, bladder emptying efficiency, and bladder wall thickness did not differ significantly by urinary pain status (Supplementary Table 3). Renal morphometric parameters were also similar between participants with and without urinary pain (Supplementary Table 3).

Participants with urinary pain had a higher median overall menstrual symptom burden score than those without urinary pain (11.00 [IQR: 8.00–13.00] vs 7.00 [IQR: 5.00–10.00], $p < 0.001$). Median pelvic visceral symptom burden score was also higher among participants with urinary pain (3.00 [IQR: 3.00–5.00] vs 1.00 [IQR: 1.00–2.00], $p < 0.001$), as shown in Fig. 2. Adjusted associations between urinary pain and bladder ultrasound parameters are presented in Supplementary Table 4.

Boxplots show the distribution of selected bladder volume and symptom burden parameters stratified by urinary pain status. The horizontal line within each box represents the median, and the box represents the interquartile range. Whiskers show the expected range based on 1.5 times the interquartile range. P-values were obtained using Mann–Whitney U tests comparing participants with and without urinary pain. Urinary pain was defined as self-reported pain before, during, or after passing urine.

Co-occurrence of urinary pain with pelvic visceral and menstrual symptoms

Unadjusted associations between selected pelvic visceral and menstrual symptoms and urinary pain are presented in Fig. 3. Urinary pain was associated with pain before, during, or after bowel emptying (OR = 6.83, $p < 0.001$), pain before or during passage of flatus (OR = 5.46, $p < 0.001$), pelvic pain (OR = 2.59, $p < 0.001$), bloating or indigestion (OR = 1.94, $p = 0.010$), moderate/severe painful menstruation (OR = 2.15, $p = 0.005$), menstrual cramps (OR = 2.45, $p = 0.013$), and fatigue (OR = 2.45, $p = 0.004$). Urinary pain was not significantly associated with abnormal menstrual cycle length (OR = 1.63, $p = 0.529$).

Forest plot showing unadjusted odds ratios and 95% confidence intervals for associations between selected pelvic visceral and menstrual symptoms and urinary pain. The vertical dashed line represents an

odds ratio of 1. Values to the right of the reference line indicate higher odds of urinary pain. Odds ratios were estimated using unadjusted logistic regression models.

Phi correlation analysis showed positive correlations between urinary pain and bowel-emptying pain ($\phi = 0.413$), flatus-related pain ($\phi = 0.357$), pelvic pain ($\phi = 0.190$), fatigue ($\phi = 0.160$), moderate/severe painful menstruation ($\phi = 0.155$), bloating or indigestion ($\phi = 0.147$), and menstrual cramps ($\phi = 0.137$). The full correlation heatmap is presented in Supplementary Fig. 1.

Multivariable associations between pelvic visceral symptoms and urinary pain

Multivariable associations between pelvic visceral symptoms and urinary pain are presented in Table 3. Bowel-emptying pain and flatus-related pain remained associated with urinary pain. Participants with bowel-emptying pain had higher odds of urinary pain than those without bowel-emptying pain (adjusted OR = 5.49; 95% CI: 2.96–10.18; $p < 0.001$). Participants with flatus-related pain also had higher odds of urinary pain (adjusted OR = 3.82; 95% CI: 2.03–7.21; $p < 0.001$). Pelvic pain had an adjusted OR of 1.76 (95% CI: 0.91–3.40; $p = 0.094$). Bloating or indigestion, moderate/severe painful menstruation, age group, BMI, menstrual regularity, exercise level, and high stress were not significantly associated with urinary pain in the multivariable model.

Table 3
Multivariable associations between pelvic visceral symptoms and urinary pain

Predictor	Adjusted OR	95% CI	p-value
Bowel-emptying pain	5.49	2.96–10.18	< 0.001
Flatus-related pain	3.82	2.03–7.21	< 0.001
Pelvic pain	1.76	0.91–3.40	0.094
Bloating/indigestion	1.05	0.57–1.92	0.881
Moderate/severe painful menstruation	0.95	0.49–1.86	0.889
Age 21–25 years	1.28	0.70–2.32	0.420
Age ≥ 26 years	0.47	0.14–1.63	0.235
BMI	1.01	0.94–1.08	0.823
Regular menstrual cycle	0.86	0.47–1.57	0.620
Low exercise level	1.16	0.65–2.08	0.607
High stress level	1.48	0.71–3.09	0.294

Adjusted odds ratios were estimated using multivariable logistic regression with urinary pain as the dependent variable. The number of predictors in the multivariable model was limited to variables

considered clinically relevant to urinary pain and symptom co-occurrence. The model included bowel-emptying pain, flatus-related pain, pelvic pain, bloating/indigestion, moderate/severe painful menstruation, age group, body mass index, menstrual cycle regularity, low exercise level, and high stress level. Urinary pain was defined as pain before, during, or after passing urine. CI, confidence interval; OR, odds ratio; BMI, body mass index.

Discussion

Principal findings

In this exploratory ultrasound-based study of reproductive-aged Nigerian university students, urinary pain was reported by more than one-quarter of participants and co-occurred most strongly with bowel-emptying pain and flatus-related pain. Participants with urinary pain also had higher overall menstrual symptom burden and pelvic visceral symptom burden. Bladder ultrasound differences by urinary pain status were limited: pre-void bladder volume was lower in unadjusted analysis, but adjusted models did not show statistically significant associations between urinary pain and bladder ultrasound parameters. Renal morphometry was largely descriptive, with modest right-left asymmetry and limited evidence that renal measurements were related to urinary pain or symptom burden. Thus, the dominant signal in this study was symptom co-occurrence rather than a consistent structural or emptying abnormality on single-visit ultrasound.

Interpretation in relation to menstrual and pelvic pain literature

The high frequency of painful menstruation in this cohort is consistent with the wider literature showing that dysmenorrhea is common among young women and may affect daily functioning and academic participation [4]. However, the present findings extend beyond dysmenorrhea alone by showing that urinary and bowel-related pain symptoms were common and interrelated. This supports a broader menstrual-health framework in which pelvic symptoms are not restricted to uterine bleeding or pain but may include urinary and bowel-related discomfort.

Urinary-bowel symptom overlap

The strongest adjusted associations with urinary pain were bowel-emptying pain and flatus-related pain. This pattern is consistent with the concept that pelvic organs may share overlapping sensory pathways and that symptoms arising from the bladder, bowel, and reproductive tract may co-occur [8, 9]. The present study did not diagnose specific pelvic pain disorders and cannot determine whether shared mechanisms such as cross-organ sensitization were present. Nevertheless, the observed symptom pattern suggests that asking about bowel-related pain may be clinically relevant when urinary pain is reported in young women. These findings should not be interpreted as evidence of cross-organ sensitization at the individual participant level, but rather as epidemiologic support for examining pelvic

visceral symptoms together in future studies. In practical terms, young women presenting with urinary pain in menstrual-health settings may benefit from brief screening for bowel-emptying pain, flatus-related pain, dysmenorrhea, and pelvic pain.

Bladder ultrasound findings

The association between urinary pain and lower pre-void bladder volume in unadjusted analysis was modest and did not remain statistically significant after adjustment. This finding should therefore be interpreted cautiously. Pre-void bladder volume is influenced by hydration, timing of last void, willingness to hold urine, scan logistics, and symptom-related behavior. The absence of clear adjusted associations with post-void residual volume, residual ratio, bladder emptying efficiency, or bladder wall thickness suggests that urinary pain in this cohort was more strongly expressed as part of a symptom cluster than as a consistent bladder emptying abnormality detectable by single-visit transabdominal ultrasound.

Renal morphometry

Renal morphometry served primarily as an anatomical ultrasound domain in the present study. The left kidney was slightly longer than the right kidney in paired analysis, and right and left kidney lengths were moderately correlated. These findings are compatible with prior sonographic observations that adult renal length varies by side and individual body characteristics [10]. The renal measurements did not form the central symptom signal in this analysis, and the findings should not be interpreted as evidence of menstrual-cycle-related renal change.

Strengths and limitations

This study has several strengths. It used a relatively large student cohort from an understudied sub-Saharan African setting and combined questionnaire-based menstrual and pelvic visceral symptom data with objective ultrasound measurements of renal and bladder parameters. The analysis also distinguished between unadjusted symptom co-occurrence, adjusted symptom associations, and secondary ultrasound comparisons. These features strengthen the internal coherence of the study while maintaining an appropriately exploratory interpretation.

The limitations should be considered when interpreting the findings. The cross-sectional design precludes causal inference and cannot determine whether urinary pain preceded, followed, or developed concurrently with other pelvic symptoms. Symptoms were self-reported and were not confirmed by clinical examination, urine testing, cystoscopy, diagnostic laparoscopy, or standardized pain instruments. The study did not diagnose urinary tract infection, bladder pain syndrome, endometriosis, irritable bowel syndrome, or other clinical pelvic pain disorders. Menstrual phase was calendar-estimated and not hormonally confirmed. Bladder volume measurements were based on a single ultrasound visit and may have been affected by hydration, voiding behavior, and participant comfort. Some analyses used variable-specific denominators because of missing or invalid ultrasound data. Finally, the cohort consisted of university students from a single academic setting, which may limit generalizability to other populations.

Implications and future research

These findings support a broader approach to menstrual health assessment in young women, in which urinary and bowel-related pain symptoms are considered alongside menstrual symptoms. In research settings, integrating pelvic visceral symptom questions with reproductive health assessments may help identify clinically meaningful symptom clusters. Future studies should use longitudinal designs, standardized pelvic pain instruments, urinalysis or microbiological testing where appropriate, and clinically confirmed diagnostic outcomes to determine whether menstrual-urinary-bowel symptom overlap predicts persistent pelvic pain or identifiable gynecological, urological, or gastrointestinal conditions.

Conclusion

Urinary pain was common among reproductive-aged Nigerian university students and co-occurred most strongly with bowel-emptying and flatus-related pain. Bladder ultrasound indices showed limited independent associations with urinary pain after adjustment, while renal morphometry was primarily descriptive. These findings support integrated assessment of menstrual, urinary, and bowel-related symptoms in young women and provide preliminary ultrasound-based data from an understudied African student population.

Abbreviations

aOR

Adjusted Odds Ratio

BMI

Body Mass Index

CI

Confidence Interval

FIGO

International Federation of Gynecology and Obstetrics

IQR

Interquartile Range

LMP

Last Menstrual Period

OR

Odds Ratio

PVR

Post-Void Residual

SD

Standard Deviation

STROBE

Declarations

Ethics approval and consent to participate

Ethical approval for the study was obtained from the Nnamdi Azikiwe University Teaching Hospital Health Research Ethics Committee (Protocol No. NAUTH/CS/66/VOL.17/VER.3/117/2024/262). All procedures were conducted in accordance with institutional ethical standards and the principles of the Declaration of Helsinki. Written informed consent was obtained from all participants before data collection and ultrasound assessment.

Consent for publication

Not applicable.

Availability of data and materials

The dataset analyzed during the current study is available in an online data repository (<https://doi.org/10.5281/zenodo.19008084>).

Competing interests

The authors declare no competing interests.

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Author's contributions

IAO designed the study with contributions from ACE and KCI. IAO, ACE, KCI, KOA, ECN and KMU collected the data while IAO, KCI, ODG and FCA performed the data analysis. All the authors reviewed the analysis, interpreted the data, and contributed to the writing of the first draft. All the authors contributed to the revision of the first draft and approved the final manuscript.

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Figures

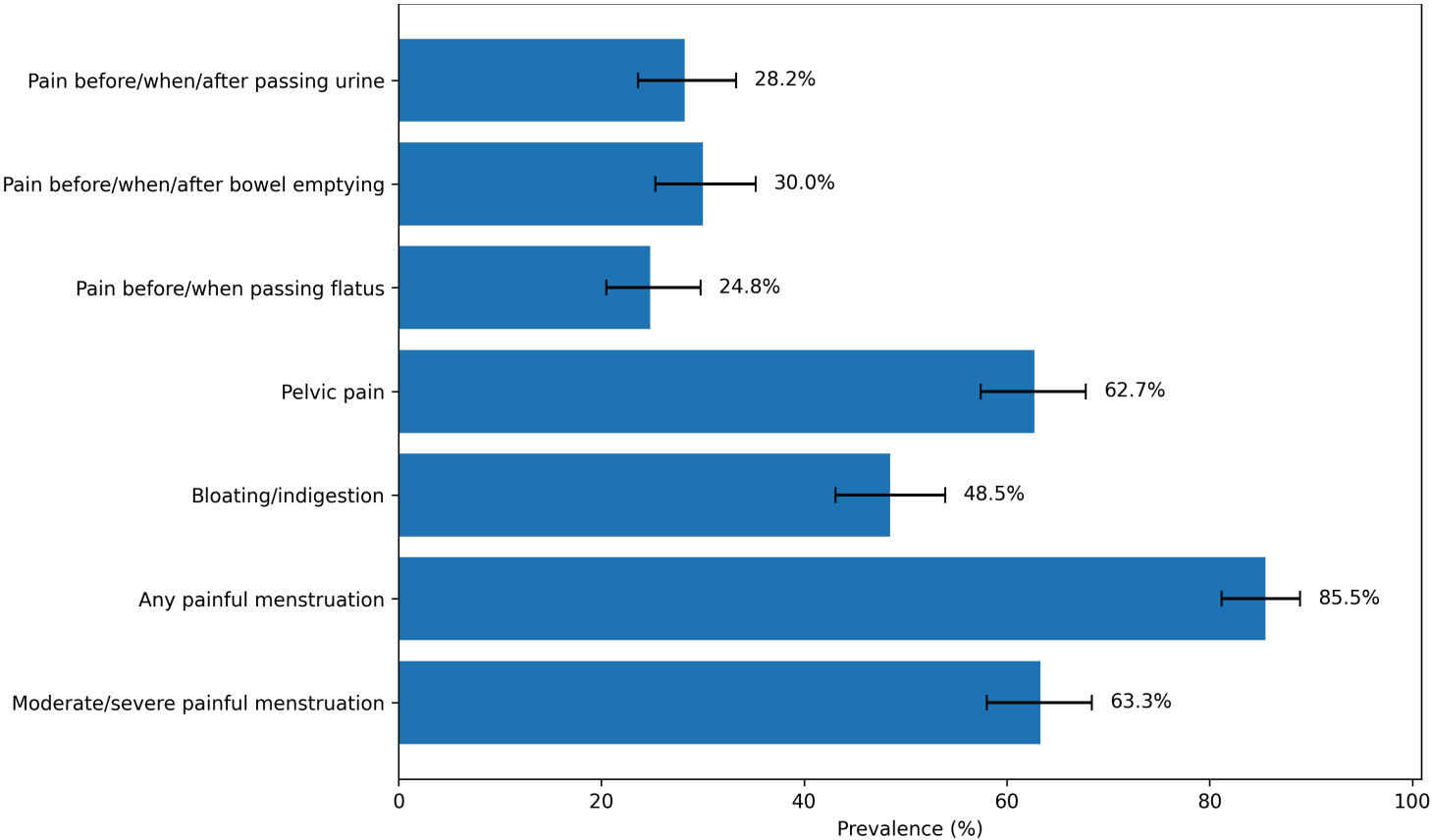


Figure 1

Prevalence of pelvic visceral and menstrual symptoms

Horizontal bars show the prevalence of selected pelvic visceral and menstrual symptoms among participants in the primary analytic cohort. Error bars represent 95% confidence intervals. Urinary pain was defined as pain before, during, or after passing urine. Bowel-emptying pain was defined as pain before, during, or after bowel emptying. Flatus-related pain was defined as pain before or during passage of flatus.

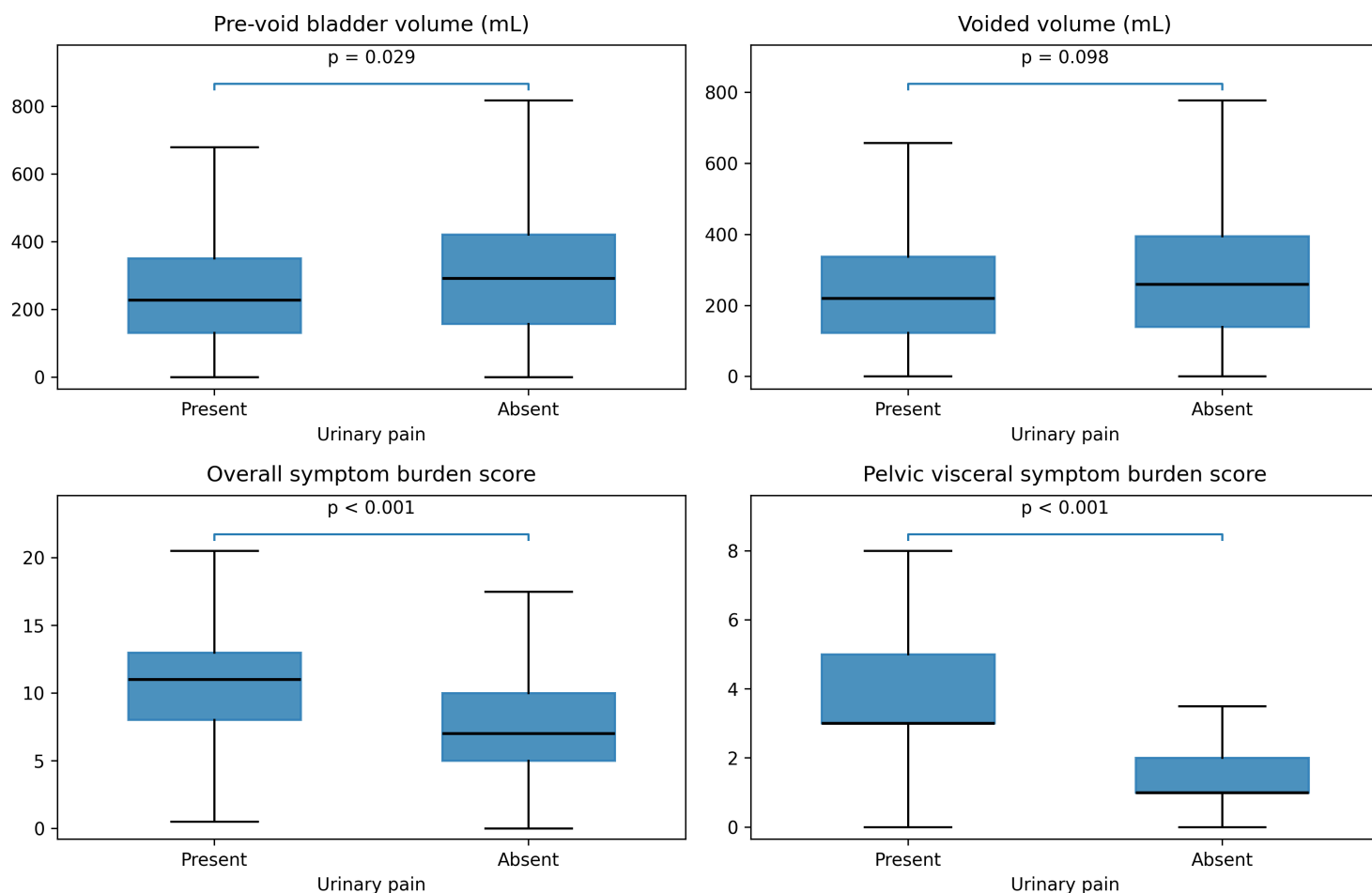


Figure 2

Bladder volume and symptom burden by urinary pain status

Boxplots show the distribution of selected bladder volume and symptom burden parameters stratified by urinary pain status. The horizontal line within each box represents the median, and the box represents the interquartile range. Whiskers show the expected range based on 1.5 times the interquartile range. P-values were obtained using Mann–Whitney U tests comparing participants with and without urinary pain. Urinary pain was defined as self-reported pain before, during, or after passing urine.

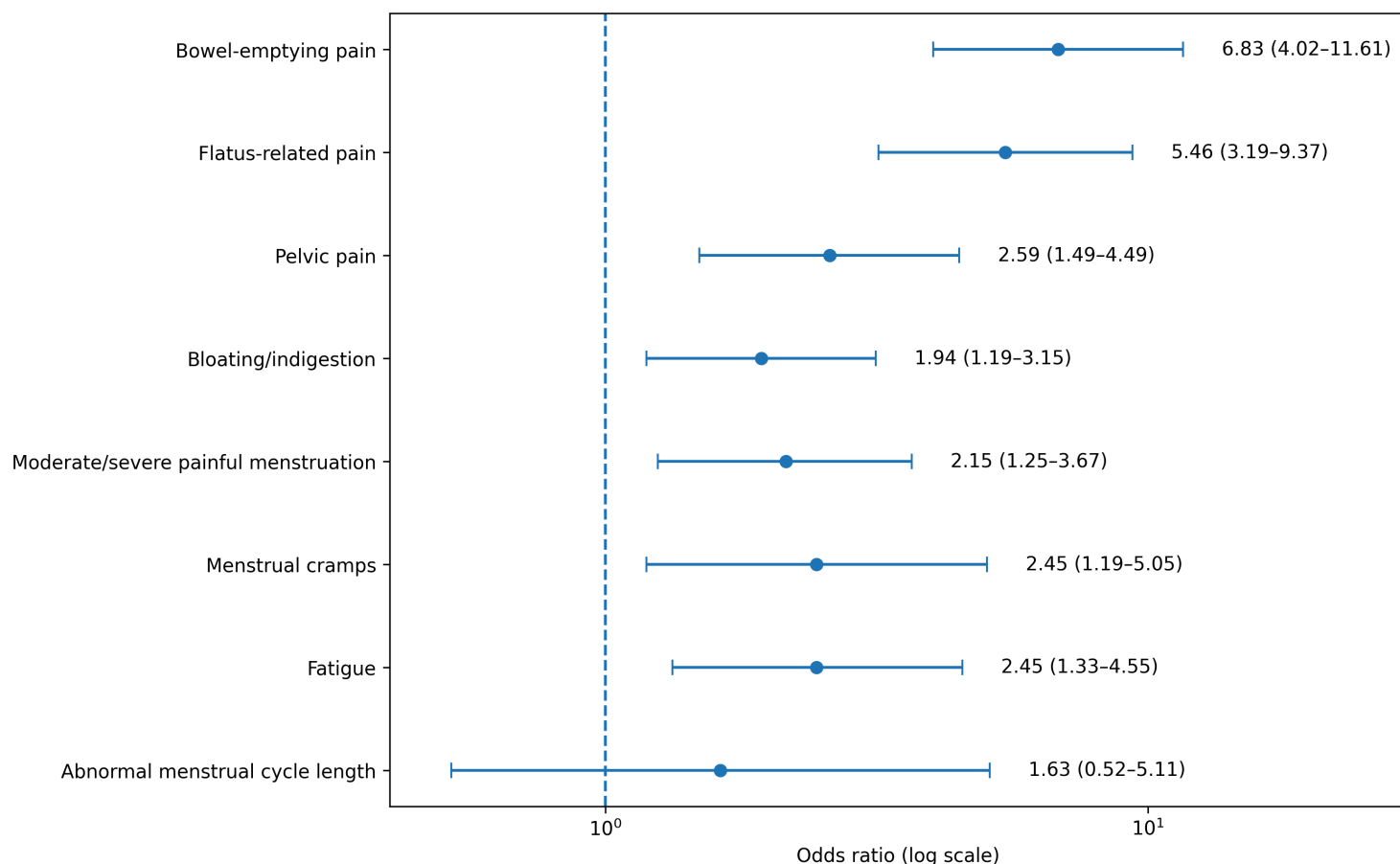


Figure 3

Forest plot of symptom associations with urinary pain

Forest plot showing unadjusted odds ratios and 95% confidence intervals for associations between selected pelvic visceral and menstrual symptoms and urinary pain. The vertical dashed line represents an odds ratio of 1. Values to the right of the reference line indicate higher odds of urinary pain. Odds ratios were estimated using unadjusted logistic regression models.

Supplementary Files

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- [Supplementarytables14andFigure1.xlsx](#)