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Original Research

Impact of Constipation and Perineal Length on Longitudinal Trajectories of Urinary Incontinence in Nulliparous Women

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Abstract

Background: Urinary incontinence is a prevalent obstetric morbidity that substantially compromises quality of life. However, the longitudinal impact of modifiable pelvic biomechanical factors, such as constipation and perineal remodeling, remains poorly characterized. We aimed to investigate the longitudinal progression of urinary symptoms from the first trimester through the first postpartum month in nulliparous women and to identify independent clinical predictors of symptom burden, with particular emphasis on the contributions of constipation and perineal length. **Methods:** This prospective longitudinal cohort study enrolled 103 nulliparous pregnant women. Participants were evaluated at four time points: the first, second, and third trimesters, as well as the first postpartum month. Urinary symptom severity was assessed using the Urogenital Distress Inventory-6 (UDI-6), and constipation was classified according to the Rome III diagnostic criteria. Longitudinal data were analyzed using multivariable generalized estimating equation (GEE) models. **Results:** UDI-6 scores progressively increased throughout pregnancy, peaking in the third trimester, and remained elevated above baseline levels during the first postpartum month. During the third trimester, all participants reported at least some degree of urge- and stress-related urinary symptoms on UDI-6 items 2 and 3, respectively; these symptoms persisted postpartum in 68.0% and 82.5% of participants, respectively. Multivariable GEE analysis demonstrated that Rome III-defined constipation ($p < 0.001$), increased perineal length ($p = 0.002$), smoking status ($p < 0.001$), and maternal age ($p = 0.019$) were significantly associated with higher UDI-6 scores, although constipation was strongly collinear with gestational progression. **Conclusions:** Beyond advancing gestational age, constipation, smoking history, and perineal body length were associated with greater urinary symptom severity. Given the collinearity between constipation and gestational progression, future studies utilizing continuous measures of bowel symptoms are needed to establish true independent risk.

Keywords: urinary incontinence; pregnancy; UDI-6; constipation; perineal length; longitudinal study

1. Introduction

Pregnancy and the postpartum are characterized by significant anatomical and physiological changes in the lower urinary tract, pelvic floor, and perineum. These alterations increase the susceptibility of women to a range of urinary symptoms, most prominently stress urinary incontinence (SUI) and urge urinary incontinence (UUI), which may either manifest de novo during pregnancy or persist postpartum. The clinical impact of the pregnancy-associated lower urinary tract symptoms (LUTS) is considerable; prevalence estimates for urinary incontinence during pregnancy range from 30% to over 60%, with a considerable proportion of affected women experiencing ongoing symptoms in the postpartum period [1,2].

The pathophysiology of pregnancy-associated LUTS is multifactorial. Progressive uterine enlargement increases mechanical pressure on the bladder and urethra, while hormonal influences—particularly elevated progesterone and relaxin levels—alter smooth muscle tone and the compliance of connective tissue throughout pregnancy [3]. Concurrently, the pelvic floor musculature and perineal body undergo significant biomechanical remodeling to accommodate fetal descent, with perineal elongation serving as a measurable correlates of these structural adaptations [4]. Despite growing recognition of LUTS as a prevalent obstetric morbidity, longitudinal data characterizing the temporal trajectory of urinary symptoms from early pregnancy through the postpartum period remain limited.

Among the factors proposed to modulate the risk of pregnancy-related LUTS, constipation has received relatively little systematic attention. Constipation affects a substantial proportion of pregnant women, with estimates ranging from 11% to 38% depending on diagnostic criteria and gestational age at assessment [5]. Straining during defecation increases intra-abdominal pressure and imposes repetitive mechanical stress on the pelvic floor, potentially compromising urethral support mechanisms and detrusor stability over time [6]. Whether constipation independently pre-

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dicts the severity of urinary symptoms during pregnancy, after accounting for established risk factors such as advancing gestational age, maternal body mass index (BMI), and parity, has not been rigorously evaluated in a prospective longitudinal cohort study.

The perineal body, a fibromuscular structure located between the vaginal introitus and the anal canal, serves as a central convergence point for multiple pelvic floor muscle groups. Perineal body length has been proposed as a surrogate marker of pelvic floor integrity and biomechanical competence, and reductions in perineal body length have been associated with pelvic organ prolapse and fecal incontinence in non-pregnant populations [7]. However, the longitudinal trajectory of perineal body length during pregnancy and the postpartum period, and its potential relationship to urinary symptom severity, have not been prospectively characterized in nulliparous women.

Validated patient-reported outcome instruments are the preferred method for systematically quantifying the clinical impact of urinary symptoms. The Urogenital Distress Inventory-6 (UDI-6) is a widely used, psychometrically validated robust six-item questionnaire that assesses the presence and severity of urinary symptoms including obstructive voiding, urge incontinence, and stress incontinence [8]. Its brevity and validated scoring algorithm make it particularly suitable for repeated-measures assessments a multiple gestational timepoints.

This study aimed to analyze the progression of urinary symptoms, as measured by the UDI-6, from the first trimester through the first month postpartum in nulliparous women. Additionally, it sought to identify independent clinical predictors of symptom severity using generalized estimating equation (GEE) analyses. The study specifically investigated the roles of perineal body length and Rome III-defined constipation, in conjunction with established maternal and obstetric factors, in influencing the longitudinal trajectory of urinary symptoms.

2. Methods

2.1 Study Design and Patient Population

This prospective longitudinal cohort study enrolled nulliparous pregnant women presenting for routine antenatal care. Participants were followed at four predetermined time points: the first trimester (8–12 gestational weeks), the second trimester (20–24 gestational weeks), the third trimester (32–36 gestational weeks), and the postpartum first month.

A total of 183 nulliparous pregnant women were initially screened and enrolled in the first trimester. Due to voluntary withdrawals (n = 35), pregnancy loss (missed abortion, n = 20), and loss to follow-up during the postpartum period (n = 25), a final cohort of 103 participants successfully completed all four predetermined assessment time points (detailed in Fig. 1). The primary longitudinal analyses and GEE models were conducted as a complete-case analysis restricted strictly to the 103 participants who completed all four assessment visits.

Inclusion criteria comprised nulliparous singleton pregnancy, gestational age between 8 and 12 weeks at enrollment, and willingness to participate in all follow-up assessments. Exclusion criteria included gravidity of two or more; prior bladder or lower urinary tract surgery; urological anomalies including horseshoe kidney or polycystic kidney disease; multiple gestation; and inability to provide informed consent.

All perineal length measurements (from the posterior fourchette to the anal verge) were performed in the lithotomy position using a standard centimeter ruler. To maintain standardization, a single physician conducted all measurements throughout the study.

Participant selection and baseline (first trimester) assessments were carried out between start month, June 2024 and end month, April 2026. Follow-up assessments, carried out throughout the second and third trimesters and culminating in assessments during the first month postpartum, were fully completed by April 2026, when the postpartum follow-up of the last participant ended. Following the completion of this primary prospective cohort study, a secondary data analysis aimed at specific objectives of the current study was initiated in June 2026, after obtaining approval from the Supplementary Ethics Committee.

2.2 Data Collection and Clinical Assessments

At each study visit, participants underwent standardized clinical evaluation including assessment of urinary symptoms, obstetric measurements, and patient-reported outcome measures. Demographic and obstetric characteristics recorded at baseline included maternal age, educational attainment, smoking status, and BMI, and at enrollment.

Urinary symptoms were evaluated at each visit using the UDI-6, a validated six-item patient-reported outcome instrument. Transformed UDI-6 scores were calculated on a 0–100 scale, with higher scores indicating greater urinary symptom burden. Clinically significant urinary distress was defined as a transformed UDI-6 score greater than 33.33. The presence of self-reported urge urinary symptoms was defined as a response greater than zero on UDI-6 item 2, while self-reported stress urinary symptoms were defined as a response greater than zero on UDI-6 item 3. These variables were used as symptom-based indicators rather than diagnostic definitions of urinary incontinence. Constipation was classified using the Rome III diagnostic criteria. Perineal body length was measured by standardized clinical examination at each visit.

2.3 Statistical Analysis

The normality of continuous variables was assessed using the Shapiro-Wilk test along with visual inspection of histograms and normal Q-Q plots. Categorical variables are presented as counts and percentages, whereas contin-

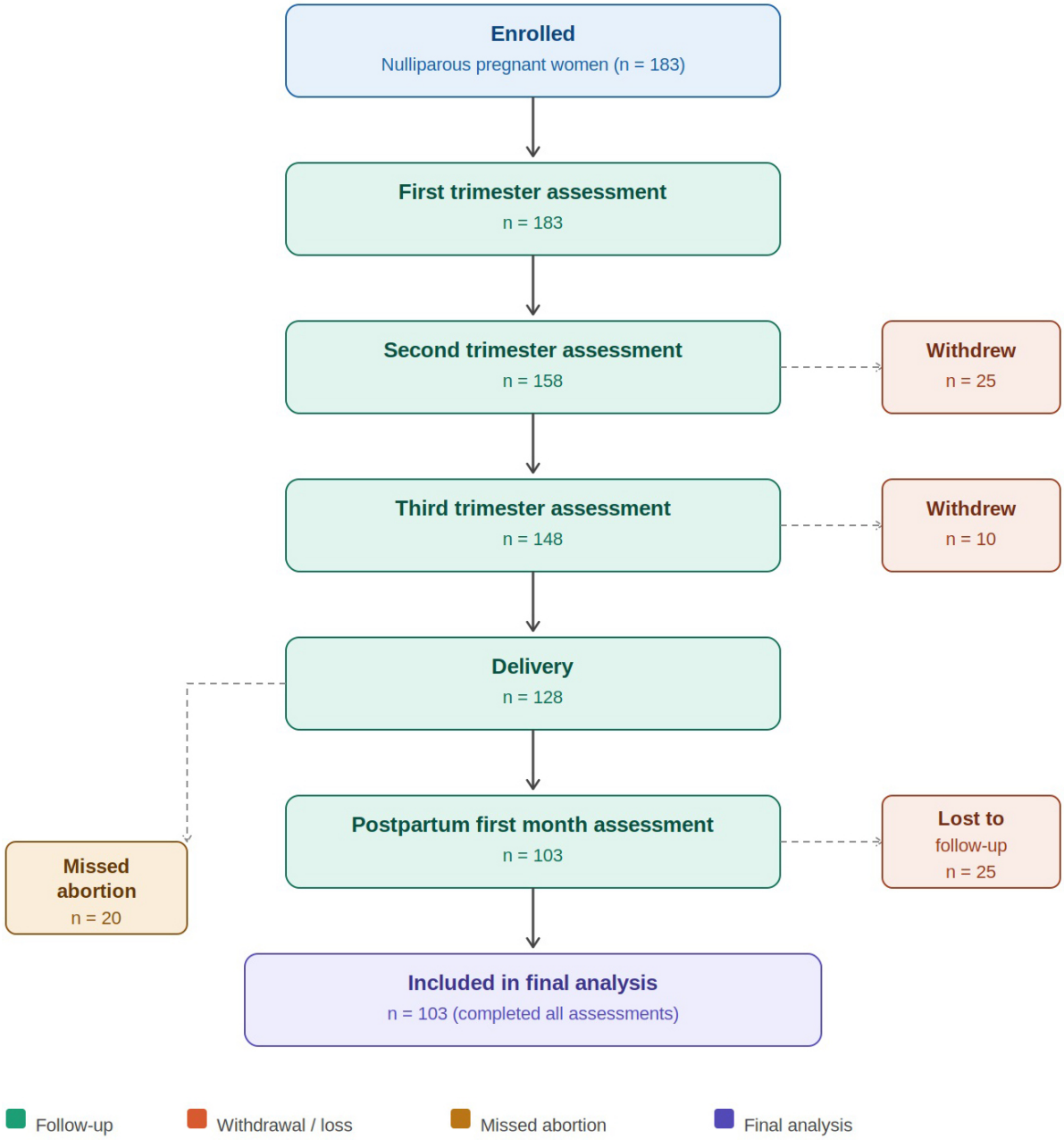


Fig. 1. Study flowchart.

uous variables are expressed as medians with ranges (or interquartile ranges) due to their non-normal distribution. Longitudinal changes in categorical outcomes were analyzed using Cochran's Q test, and pairwise post-hoc comparisons were conducted using Bonferroni-corrected McNemar tests. Longitudinal changes in continuous outcomes were evaluated using the Friedman test, followed by post-hoc Wilcoxon signed-rank tests with Bonferroni correction.

To ensure high data fidelity and minimize potential assessment or response bias, all patient-reported outcome measures, including the UDI-6 and Rome III questionnaires, were administered following a strictly standardized protocol. Prior to completion, participants received detailed, face-to-face instructions from a single dedicated clinical investigator regarding how to accurately distinguish between urge and stress urinary symptoms, as well as specific bowel habit definitions. To prevent misinterpretation or recall errors, all questionnaires were completed individually in a quiet clinical setting during routine appointments. Furthermore, the evaluating clinician cross-checked every completed questionnaire on-site for completeness and logical consistency before data entry. Dual-entry verification and routine range checks were executed during dataset compilation to maintain data quality control.

Residual diagnostics, including normal Q-Q plots and residual-versus-predicted plots, confirmed adequate model

fit without severe departures from linearity, and all model-predicted UDI-6 scores remained strictly within the plausible 0–100 range.

The primary outcome of the study was longitudinal change in total UDI-6 scores. To identify factors independently associated with worsening urinary symptom burden during pregnancy and the postpartum period, multivariable GEE analyses were performed using transformed UDI-6 scores (0–100 scale) as the dependent variable, accounting for within-subject correlation across repeated measurements. Independent variables included study period (trimester/postpartum), perineal length, Rome III-defined constipation, maternal age, BMI, and smoking status.

To address the right-skewed and zero-inflated distribution of total UDI-6 scores in early pregnancy, residual diagnostics including Q-Q plots and residual-versus-predicted plots were examined to ensure the robustness of the linear GEE models. The GEE models were specified using an exchangeable working correlation structure with robust Huber-White sandwich estimators to provide valid standard errors despite deviations from normality.

Secondary analyses were performed separately for self-reported urge-related and stress-related urinary symptoms using multivariable logistic GEE models. Because both outcomes were universally present during the third trimester, third-trimester data were excluded from these models due to complete separation. An additional exploratory logistic GEE analysis was performed for clinically significant urinary distress, restricted to second-trimester and postpartum assessments due to the absence of variability at the remaining time points.

A formal a priori sample size calculation was not performed for this secondary analysis; all available participants from the prospective cohort completing all four visits (n = 103) were included.

Due to the universal prevalence (100%) of both urge-related and stress-related urinary symptoms during the third trimester, complete separation occurred within the longitudinal binary logistic GEE models. Standard Generalized Estimating Equation algorithms within IBM SPSS Statistics (v26.0, IBM Corp., Armonk, NY, USA) do not natively support penalized maximum likelihood estimation (e.g., Firth's penalized likelihood) or exact logistic regression under a repeated-measures clustered framework. Consequently, to achieve model convergence and avoid unstable or infinite parameter estimates, third-trimester assessments were excluded from the multivariable logistic GEE models for urge and stress symptoms, restricting those specific binary analyses to the first trimester, second trimester, and postpartum period.

For the postpartum subgroup analyses, since the distribution of UDI-6 scores was highly skewed, non-parametric tests (the Mann-Whitney U test for dichotomous variables such as delivery mode and episiotomy, and the Kruskal-Wallis test for categorical variables) were utilized.

All statistical analyses were performed using IBM SPSS Statistics version 26.0. A two-sided p-value of less than 0.05 was considered statistically significant.

3. Results

3.1 Study Population

A total of 103 nulliparous pregnant women were prospectively followed from the first trimester through the postpartum first month. Baseline characteristics of the study population are summarized in Table 1. The median maternal age was 26 years (IQR: 22.5–30; range: 18–42), and the median BMI was 24.3 kg/m^2 (IQR: 22.3–27.5; range: 17.5–42.3). Regarding educational attainment, 5.8% of participants had elementary-level education, 49.5% had secondary education, and 44.7% had higher education. Six participants (5.8%) were active smokers.

Table 1. Baseline characteristics of the study population (N = 103).

Variable	Value
Age (years), median (interquartile range)	26 (22.5–30)
BMI (kg/m^2), median (interquartile range)	24.3 (22.3–27.5)
Education level	
Elementary	6 (5.8%)
Secondary	51 (49.5%)
Higher education	46 (44.7%)
Smoking	6 (5.8%)

Continuous variables are presented as median (interquartile range); categorical variables as number (percentage).
Abbreviations: BMI, body mass index.

3.2 Longitudinal Changes in Urinary Symptoms During Pregnancy and Postpartum

UDI-6 scores demonstrated a progressive longitudinal increase throughout pregnancy, with the highest symptom burden observed during the third trimester and postpartum period. Median (IQR) UDI-6 scores increased from 0.0 (0.0–5.6) in the first trimester to 5.6 (0.0–22.2) in the second trimester, peaked at 61.1 (44.4–66.7) in the third trimester, and partially declined to 27.8 (11.1–38.9) during the postpartum first month ($p < 0.001$). Longitudinal changes across all study time points are presented in Table 2.

Clinically significant urinary distress, defined as a transformed UDI-6 score >33.33, was absent during the first trimester, present in 2.9% of participants during the second trimester, universal during the third trimester, and persisted in 24.3% (n = 25) of participants postpartum ($p < 0.001$).

Urge-related urinary symptoms on UDI-6 item 2 progressively increased across pregnancy, rising from 3.9% in the first trimester to 25.2% in the second trimester and

Table 2. Longitudinal changes in urinary symptoms across pregnancy and the postpartum period (N = 103).

Variable	1st Trimester	2nd Trimester	3rd Trimester	Postpartum 1st Month	Test statistic	df	*p*-value
UDI-6 score (0–100 scale), median (interquartile range)	0.0 (0.0–5.6)	5.6 (0.0–22.2)	61.1 (44.4–66.7)	27.8 (11.1–38.9)	χ^2: 268.151	3	<0.001[a]
Clinically significant urinary distress*	0 (0%)	3 (2.9%)	103 (100%)	25 (24.3%)	Q = 248.371	3	<0.001[b]
Urge-related urinary symptoms	4 (3.9%)	26 (25.2%)	103 (100%)	70 (68.0%)	Q = 199.394	3	<0.001[b]
Stress-related urinary symptoms	2 (1.9%)	27 (26.2%)	103 (100%)	85 (82.5%)	Q = 218.598	3	<0.001[b]
Rome III constipation	1 (1.0%)	36 (35.0%)	103 (100%)	103 (100%)	Q = 248.088	3	<0.001[b]
Perineal length (cm), median (interquartile range)	3.4 (3.3–3.8)	3.9 (3.6–4.2)	4.4 (4.0–4.9)	4.0 (3.5–4.2)	χ^2: 240.820	3	<0.001[a]

[a] Friedman test; [b] Cochran's Q test.

* Clinically significant urinary distress was defined as a transformed UDI-6 score >33.33.

Abbreviations: UDI-6, Urogenital Distress Inventory-6.

reaching 100% in the third trimester, before partially declining to 68.0% postpartum ($p < 0.001$). Stress-related urinary symptoms on UDI-6 item 3 followed a similar trajectory, increasing from 1.9% in the first trimester to 26.2% in the second trimester and 100% in the third trimester, with persistent postpartum symptoms observed in 82.5% of participants ($p < 0.001$).

Rome III-defined constipation also demonstrated marked longitudinal progression, increasing from 1.0% in the first trimester to 35.0% in the second trimester and becoming universal during both the third trimester and the postpartum period ($p < 0.001$). In parallel, median perineal length progressively increased throughout pregnancy, reaching its maximum value during the third trimester, followed by partial postpartum regression ($p < 0.001$).

Additional postpartum analyses demonstrated no significant association between transformed postpartum first-month UDI-6 scores and delivery mode ($p = 0.757$, Mann-Whitney U test), episiotomy status ($p = 0.108$, Mann-Whitney U test), or the presence of perineal lacerations ($p = 0.579$, Mann-Whitney U test).

3.3 Independent Correlates of Higher UDI-6 Scores

Multivariable GEE analysis identified several independent correlates urinary symptom burden during pregnancy and the postpartum period (Table 3). Third-trimester status was independently associated with significantly higher UDI-6 scores ($\beta = +37.28$, $p < 0.001$), while postpartum assessment also remained significantly associated with increased symptom burden ($\beta = +10.89$, $p < 0.001$).

Increased perineal length independently predicted higher UDI-6 scores ($\beta = +3.11$, $p = 0.002$). Rome III-defined constipation emerged as a strong independent correlates urinary symptoms ($\beta = +13.83$, $p < 0.001$). Increasing maternal age ($\beta = +0.19$, $p = 0.019$) and smoking status ($\beta = +5.94$, $p < 0.001$) were also independently associated with higher UDI-6 scores. In contrast, BMI was not independently associated with urinary symptom severity ($\beta = +0.04$, $p = 0.702$). Post-estimation residual diagnostics confirmed no systematic deviation from linearity, with all model-predicted UDI-6 scores remaining strictly within the plausible 0–100 range.

3.4 Independent Correlates of Urge Urinary Incontinence

Separate multivariable logistic GEE analyses were performed to evaluate independent correlates of urge-related urinary symptoms (UDI-6 question 2 >0). Because urge-related urinary symptoms were universally present during the third trimester, this time point was excluded from multivariable modeling due to complete separation. Results are presented in Table 4.

Both the second trimester (OR: 4.24, $p = 0.010$) and the postpartum period (OR: 16.97, $p < 0.001$) were independently associated with increased odds of urge-related urinary symptoms compared with the first trimester. Rome III-defined constipation emerged as the strongest independent correlates (OR: 6.43, $p < 0.001$). Increased BMI (OR: 1.10, $p = 0.019$) and smoking status (OR: 3.73, $p = 0.032$) were also independently associated with urge-related urinary symptoms. Perineal length and maternal age were not independently associated with urge–related urinary symptoms in multivariable analysis.

3.5 Independent Correlates of Stress-Related Urinary Symptoms

A separate multivariable logistic GEE model was constructed for stress-related urinary symptoms (UDI-6 question 3 >0). As with urge-related urinary symptoms, third-trimester data were excluded because stress-related urinary symptoms were universally present during this period. Results are presented in Table 5.

Postpartum assessment was independently associated with markedly increased odds of stress-related urinary symptoms compared with the first trimester (OR: 33.84, $p < 0.001$). Rome III-defined constipation was also identified as a strong independent correlates (OR: 23.97, $p <$

Table 3. Multivariable generalized estimating equation (GEE) analysis of factors associated with higher UDI-6 scores.

Variable	β Coefficient (95% CI)	*p*-value
Third trimester (ref: first trimester)	+37.28 (32.61–41.94)	<0.001
Postpartum period (ref: first trimester)	+10.89 (6.53–15.23)	<0.001
Perineal length (cm)	+3.11 (1.17–5.00)	0.002
Rome III-defined constipation	+13.83 (10.02–17.61)	<0.001
Maternal age (years)	+0.19 (0.03–0.36)	0.019
Smoking	+5.94 (2.76–9.12)	<0.001
BMI (kg/m^2)	+0.04 (−0.17–0.24)	0.702

Reference category for study period: first trimester.

Abbreviations: BMI, body mass index; GEE, generalized estimating equation; UDI-6, Urogenital Distress Inventory-6.

Note: Due to the universal prevalence of constipation in the 3rd trimester and postpartum period, this coefficient reflects a strong longitudinal association confounded by gestational progression, rather than an isolated baseline effect.

Table 4. Multivariable logistic GEE analysis of factors associated with urge-related urinary symptoms.

Variable	Odds Ratio (95% CI)	*p*-value
Postpartum vs. first trimester	16.97 (4.93–58.42)	<0.001
Second trimester vs. first trimester	4.24 (1.41–12.82)	0.010
Rome III-defined constipation	6.43 (2.94–14.03)	<0.001
BMI (kg/m^2)	1.10 (1.02–1.19)	0.019
Smoking	3.73 (1.12–12.38)	0.032
Perineal length (cm)	1.54 (0.80–2.97)	0.195
Maternal age (years)	1.05 (0.99–1.12)	0.117

Third-trimester data were excluded from the model because urge-related urinary symptoms were universally present during this period (complete separation).

Reference category for study period: first trimester.

Abbreviations: BMI, body mass index; GEE, generalized estimating equation; OR, odds ratio.

Note: Due to the universal prevalence of constipation in the 3rd trimester and postpartum period, this coefficient reflects a strong longitudinal association confounded by gestational progression, rather than an isolated baseline effect.

0.001). Second-trimester status demonstrated a borderline association with stress-related urinary symptoms (OR: 4.26, $p = 0.061$). Maternal age, BMI, smoking status, and perineal length were not independently associated with stress-related urinary symptoms in multivariable analysis.

4. Discussion

In this prospective longitudinal cohort study, urinary symptom burden, assessed using the UDI-6, gradually increased throughout pregnancy, reaching its peak in the third trimester and demonstrating a partial regression while remaining substantially elevated compared with baseline in the first postpartum month. These findings are broadly consistent with prior longitudinal reports documenting a progressive increase in urinary incontinence across pregnancy, including in nulliparous women [1]. Notably, the widespread prevalence of both stress and urge-related urinary symptoms during the third trimester, with partial but incomplete resolution at one month postpartum, underscores the clinical relevance of this period and highlights the need for systematic symptom evaluation beyond the delivery phase.

The progressive rise in UDI-6 scores across trimesters observed in our cohort appears to reflect, at least in part, the mechanical consequences of uterine enlargement on the lower urinary tract. As the gravid uterus enlarges, it exerts increasing pressure on the bladder base and proximal urethra, potentially impairing urethral closure mechanisms and reducing functional bladder capacity [3]. The third trimester demonstrated the steepest symptom escalation in our cohort. This finding may correspond with the period of maximal fetal descent into the pelvis and peak mechanical load on pelvic floor supporting structures. Prior studies have similarly reported that the prevalence of urinary incon-

Table 5. Multivariable logistic GEE analysis of factors associated with stress-related urinary symptoms.

Variable	Odds Ratio (95% CI)	*p*-value
Postpartum vs. first trimester	33.84 (6.28–182.30)	<0.001
Rome III-defined constipation	23.97 (11.25–51.06)	<0.001
Second trimester vs. first trimester	4.26 (0.93–19.45)	0.061
Perineal length (cm)	0.92 (0.41–2.08)	0.839
Maternal age (years)	1.02 (0.95–1.09)	0.646
BMI (kg/m^2)	1.00 (0.93–1.08)	0.962
Smoking	0.78 (0.24–2.50)	0.671

Third-trimester data were excluded from the model because stress-related urinary symptoms were universally present during this period (complete separation).

Reference category for study period: first trimester.

Abbreviations: BMI, body mass index; GEE, generalized estimating equation; OR, odds ratio.

Note: Due to the universal prevalence of constipation in the 3rd trimester and postpartum period, this coefficient reflects a strong longitudinal association confounded by gestational progression, rather than an isolated baseline effect.

tinence increases substantially between the second and third trimesters [1,2], lending further support to a mechanically longitudinal association.

A notable finding of the present study was that Rome III-defined constipation was among of the strongest independent correlates of urinary symptom severity across all three multivariable models. Constipation was associated with markedly higher UDI-6 scores (β = +13.83) and substantially increased odds of both urge-related (OR: 6.43) and stress –related (OR: 23.97) urinary symptoms. Although the relationship between bowel dysfunction and urinary symptoms has long been appreciated in clinical practice, prospective longitudinal evidence specifically implicating constipation as an independent correlates of LUTS severity during pregnancy remains limited [5]. The magnitude of the association observed here is noteworthy and may reflect shared biomechanical pathways: repeated straining at defecation elevates intra-abdominal pressure, imposes chronic mechanical stress on the pelvic floor musculature and fascial supports, and may progressively compromise urethral support and detrusor stability over time [9] whether this relationship is causal or partly mediated by shared pelvic floor vulnerability warrants investigation in future studies with more granular assessment of bowel symptoms.

A significant finding and a notable structural limitation of our study is the exceptionally high prevalence of Rome III-defined constipation during the third trimester and postpartum period, which reached 100% in our cohort. Although this prevalence is unexpectedly high relative to typical epidemiological variation, it may be attributable to strict questionnaire interpretation or specific dietary/lifestyle patterns in our single-center population. Statistically, this lack of variance at later time points introduces potential collinearity or perfect confounding with the study-period dummy variables in the GEE models. Consequently, the calculated regression coefficients and odds ratios for constipation (e.g., in Tables 3,4,5) should be interpreted with caution as indicators of a robust longitudinal association rather than precise mathematical weights. Future studies should employ continuous severity scales for bowel habits to circumvent this analytical constraint.

In our GEE analysis, increased perineal body length was identified as an independent predictor of higher UDI-6 scores, with each additional centimeter associated with an average increase of 3.11 score units. This finding runs contrary to the assumption that a longer perineal body indicates better pelvic floor integrity. A plausible explanation is that perineal elongation during pregnancy is a marker of the pelvic floor changes accompanying advancing gestation, rather than an intrinsic protective factor; prospective studies of nulliparous women have documented increases in perineal body length and genital hiatus as pregnancy progresses [10]. It is also plausible that the association between perineal length and UDI-6 scores is substantially confounded by gestational age, given that both parameters increase in parallel across trimesters. The absence of a significant association between perineal length and the binary outcomes of urge or stress incontinence in multivariable models may support this interpretation. These findings should be regarded as exploratory and require replication in larger cohorts with standardized protocols for perineal measurement.

Furthermore, it is critical to consider the potential collinearity between increasing gestational age and perineal body elongation. As both variables tend to evolve concurrently during pregnancy due to hormonal and biomechanical changes, the independent contribution of perineal length in the total UDI-6 GEE model reflects the broader impact of gestational progression rather than representing a distinct anatomical risk factor.

Interestingly, perineal length has also emerged as a modifiable target in interventional research: antenatal perineal massage protocols have been shown to reduce the incidence and severity of perineal trauma [11], and a systematic review and meta-analysis confirmed its efficacy in preventing perineal injury during the second stage of labor. However, effects on urinary outcomes remain less consistent [12]. Interestingly, perineal length has also emerged as a potentially modifiable target in interventional research. Antenatal perineal massage has been shown to reduce the incidence and severity of perineal trauma [13], and a recent systematic review and meta-analysis confirmed its efficacy in reducing perineal injury and postpartum faecal and flatus incontinence; however, no significant effect on postpartum urinary incontinence was observed [14]. By contrast, antenatal pelvic floor muscle training has been shown to reduce the risk of urinary incontinence in late pregnancy and the

postpartum period [15]. Taken together, these findings suggest that the perineal tissue characteristics captured by our length measurements may be amenable to targeted physiotherapy rather than representing a fixed anatomical risk factor, although the specific intervention and outcome should be carefully matched.

Smoking status and advancing maternal age were independently associated with higher urinary symptom burden in our multivariable-analysis. The association between smoking and LUTS is biologically plausible, as chronic cough resulting from tobacco use increases intra-abdominal pressure episodes, and nicotine may directly influence bladder smooth muscle contractility and urethral mucosal health [16]. The modest yet statistically significant relationship between maternal age and UDI-6 scores may reflect age-related variations in connective tissue elasticity, pelvic floor muscle strength, and estrogen receptor density, factors that could make older nulliparous women somewhat more prone to gestational urinary symptoms [17]. Conversely, body mass index was not independently correlated with urinary symptom severity in our cohort, which may be due to the narrow BMI range of the study population or to the dominant effect of gestational factors that potentially mask BMI influence at the sample sizes analyzed.

Postpartum persistence of urinary symptoms was a prominent finding in the results. At the one-month postpartum assessment, 82.5% of participants reported stress-related urinary symptoms and 68.0% reported urge-related urinary symptoms, with approximately one-fourth of women (24.3%) meeting criteria for clinically significant urinary distress. These figures are somewhat higher than those reported in several population-based studies [1,18], which may reflect the relatively early postpartum time point of our assessment, as pelvic floor recovery continues for several months after delivery. Importantly, in our exploratory analyses, postpartum UDI-6 scores were not significantly associated with delivery mode, episiotomy status, or perineal laceration. While these null findings should be interpreted with caution given the limited sample size and the single postpartum timepoint, they are consistent with emerging evidence suggesting that the relationship between intrapartum events and postpartum urinary symptoms may be less deterministic than previously assumed [19,20]. The contribution of antepartum factors—including the duration and severity of gestational LUTS—to postpartum symptom persistence warrants further longitudinal investigation.

The current study possesses several methodological strengths worth highlighting. Its prospective design, featuring four standardized measurement time points, enabled detailed characterization of symptom progression within individuals over time.

Additionally, the use of GEE analyses effectively addressed within-subject correlation across repeated measurements. The application of a validated patient-reported outcome instrument (UDI-6) alongside standardized diagnostic criteria for constipation (Rome III) enhances the reproducibility and comparability of the results. Moreover, all perineal measurements were performed by a single examiner using a standardized technique, minimizing inter-observer variability.

Limitations

This study also presents several limitations that should be considered when interpreting the results. The cohort was restricted to nulliparous women attending a single center, which may limit the generalizability of the findings to multiparous women or to populations with different baseline characteristics. The postpartum assessment was conducted only at one month, precluding evaluation of longer-term symptom trajectories. Additionally, although the UDI-6 is a widely validated instrument, it does not capture all dimensions of pelvic floor dysfunction, and objective urodynamic assessment was beyond the scope of the present study. Therefore, urge- and stress-related urinary symptoms were derived from responses to individual UDI-6 items and do not represent clinically confirmed diagnoses of urinary incontinence. Future research with extended follow-up and urodynamic endpoints would be valuable for clarifying the mechanisms underlying the associations identified here.

Our study also faces the limitation of potential residual confounding. Crucial clinical parameters, including gestational weight gain, fetal birth weight, neonatal birth weight, presence of gestational diabetes, maternal physical activity levels, and prior or concurrent pelvic floor muscle training (PFMT) were not comprehensively monitored or adjusted for in our multivariable GEE models, which might have altered the observed risk trajectories.

Furthermore, because the final analysis was restricted to participants who completed all four visits (n = 103), potential attrition bias resulting from the loss to follow-up of 80 initial enrollees cannot be entirely excluded. Additionally, the absence of an a priori sample size calculation specifically tailored to multivariable repeated-measures GEE modeling represents a methodological limitation.

The assessment in the first postpartum month captures only the acute phase of pelvic floor involution, which is a notable limitation, as physiological recovery continues for several months after delivery. Additionally, while the longitudinal shifts in UDI-6 scores were statistically significant, assessing whether these changes exceed the threshold for minimal clinically important differences (MCID) remains challenging due to the lack of validated baseline cut-off in acute postpartum cohorts. Thus, our results highlight transient or early persistent distress rather than long-term morbidity.

Additionally, active tobacco use was reported by only six participants (5.8%), and status remained unchanged across visits. Consequently, although statistically significant, the precision of the estimated effect size for smoking is constrained by the small subgroup size and should be interpreted with caution.

The exclusion of third-trimester observations due to complete separation should be acknowledged as an important limitation because it removes the period of greatest symptom burden from the binary outcome analyses.

5. Conclusions

In conclusion, this prospective longitudinal study demonstrates that urinary symptom burden increases progressively throughout pregnancy and remains substantially elevated at one month postpartum in nulliparous women. Beyond advancing gestational age, constipation, smoking, and perineal body length were independently associated with greater symptom severity. These findings suggest that routine assessment of bowel function and smoking status may be clinically relevant in the antenatal care of nulliparous women presenting with urinary symptoms. Prospective studies with longer postpartum follow-up and objective pelvic floor assessments are warranted to further elucidate these relationships.

Availability of Data and Materials

For the data used in the study and further information, please contact the corresponding author.

Author Contributions

HA, PA, HY and KA conceptualized the study, conducted the literature review, performed data curation and synthesis, and drafted the manuscript. YB, PA, RM and GU supervised the study, contributed to the editing, data interpretation and critical review of the article, and provided expert advice. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

The study protocol was approved by the Clinical Research Ethics Committee of Mersin University. This study was based on data collected from a prospectively followed cohort that had received prior Institutional Ethics Committee approval (Approval No: 2024/525). An additional Ethics Committee approval was obtained for the present secondary analysis and new research objective (Approval No: 2026/335) and conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants prior to enrollment.

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Conflicts of Interest

The authors declare no conflicts of interest.

Supplementary Material

Supplementary material associated with this article can be found, in the online version, at https://doi.org/10.31083/CEOG54863.

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