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A CROSS SECTIONAL STUDY TO ASSESS THE ASSOCIATION BETWEEN MATERNAL BODY MASS INDEX AND UMBILICAL ARTERY PULSATALITY

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ABSTRACT

Background: Maternal adiposity may increase fetoplacental vascular resistance measurable by the umbilical artery pulsatility index (UA-PI), but evidence in routine, late-pregnancy surveillance remains limited from India. Objective: To evaluate the relationship between maternal body mass index (BMI) and UA-PI, comparing means across BMI categories and quantifying the continuous association.**Methods:** Analytical cross-sectional study in the Obstetrics & Gynaecology department of a tertiary hospital. Consecutive antenatal women with singleton, viable pregnancies at 28–40 weeks were enrolled after consent. Height and weight were measured using calibrated equipment; BMI was calculated (kg/m²) and categorized per WHO. UA-PI was recorded from a free-floating cord loop at rest, avoiding fetal breathing, with insonation angle ≤30°, and averaged over three uniform waveforms. Data were summarized as mean±SD or n (%). One-way ANOVA with Bonferroni post-hoc testing compared UA-PI across BMI categories. Univariable linear regression estimated the association of UA-PI with BMI, height, weight, and parity (two-sided α=0.05; SPSS v23).**Results:** Two hundred twenty-five women were analyzed: mean BMI 22.93±5.96 kg/m²; mean UA-PI 0.779±0.113. BMI distribution was underweight 33.3%, normal 31.6%, overweight 22.2%, obese 12.9%. Mean UA-PI increased stepwise: underweight 0.709±0.054 (n=75), normal 0.762±0.093 (n=71), overweight 0.824±0.096 (n=50), obese 0.926±0.130 (n=29); ANOVA F=47.19, p<0.001. Post-hoc: overweight>normal (p=0.003), obese>overweight (p=0.004); comparisons involving underweight vs other groups and normal vs obese were p<0.001. Regression showed UA-PI rose with BMI (β=0.0117 per 1 kg/m²; 95% CI 0.0097–0.0136; p<0.001; R²=0.378); height was inversely associated (β=−0.0032, p=0.001); weight was positively associated (β=0.0045, p<0.001); parity was not significant (p=0.396). **Conclusions:** Increasing maternal BMI is associated with higher UA-PI in late pregnancy, suggesting greater fetoplacental vascular resistance and supporting BMI-contextualized interpretation of Doppler findings.

KEYWORDS

Body mass index; Doppler; Pregnancy; Umbilical artery pulsatility index.crumb rubber, utilization, compressive strength, low cost, sustainable

INTRODUCTION

Maternal overweight and obesity have risen markedly over recent decades; a 2024 analysis estimates that the prevalence of obesity in pregnancy has more than tripled since before 1990 to ~16% by 2010–2019————.

In the United States, national vital statistics for 2020 show 27.2% of women entering pregnancy were overweight and 30.0% had obesity, highlighting the scale of adiposity-related risk at the start of gestation – .

Umbilical artery Doppler, particularly the pulsatility index (UA-PI), provides a non-invasive assessment of fetoplacental vascular resistance and is an established component of fetal surveillance in selected clinical scenarios . Elevated UA-PI is a recognized marker of placental insufficiency and often precedes deterioration in other fetal tests, supporting its use when impaired placentation is suspected . Emerging evidence links maternal adiposity with higher UA-PI: obese gravidae have demonstrated higher UA Doppler indices compared with normal-weight women, suggesting increased fetoplacental resistance .

In fetal growth restriction cohorts, rising maternal BMI correlates with more abnormal UA Dopplers, reinforcing the biological plausibility of an adiposity–placental resistance association.Physiologic studies further indicate that vascular Doppler trajectories across gestation are influenced by maternal obesity and fetal sex, highlighting the need for context-specific data – .

The present study aims to evaluate the relationship between maternal body mass index (BMI) and umbilical artery pulsatility index (UA-PI) in late pregnancy. Specifically, we set out (i) to compare mean UA-PI across BMI categories (underweight, normal weight, overweight, obese) and (ii) to quantify the association between continuous BMI and UA-PI using linear regression

MATERIALS AND METHODS

Study design and setting

Analytical cross-sectional, hospital-based study was conducted in the Department of Obstetrics & Gynaecology (OBG), A.J. Institute of Medical Sciences & Research Centre, Mangaluru. Recruitment spanned the defined study period using consecutive sampling.

Sample size and sampling

Based on a reported UA-PI standard deviation of 0.01, with 95% confidence and precision 20% of the SD (E=0.002), n≈75 per group was estimated for three BMI strata, yielding a total sample size of 225; recruitment used non-probability consecutive sampling.

Study Participants

Inclusion criteria were antenatal women with singleton, viable pregnancies between 28–40 weeks undergoing routine ultrasound in OBG; written informed consent was obtained. Exclusions: multiple gestation; hypertensive disorders of pregnancy; pre-gestational diabetes or GDM requiring pharmacotherapy; fetal growth restriction (<10th centile) or major congenital anomaly.

Study variables and measurements

Height and weight were measured using calibrated equipment; BMI was calculated (kg/m²) and categorized per WHO (underweight <18.5; normal 18.5–24.9; overweight 25.0–29.9; obese ≥30.0). Umbilical artery Doppler was obtained from a free-floating cord loop with the mother at rest, absent fetal breathing/movement, insonation angle ≤30°, and three uniform waveforms captured; UA-PI was the machine-derived mean of three readings. Parity was recorded as primigravida or multigravida.

Statistical analysis

Continuous variables were summarized as mean ± SD; categorical variables as n (%). UA-PI differences across BMI categories were tested using one-way ANOVA. Univariable linear regressions quantified associations of UA-PI with BMI, height, weight, and parity. Two-sided p<0.05 defined statistical significance. Analyses were performed in IBM SPSS Statistics v23.

Ethical considerations

Institutional ethics approval was sought prior to study initiation; the study involved only routine, non-invasive assessments and adhered to confidentiality safeguards.

RESULTS

A total of 225 antenatal women were analyzed. Baseline anthropometry and umbilical artery Doppler measures are presented in Table 1, with parity and BMI category distribution in Table 2. Subsequent analyses compare UA-PI across BMI strata and evaluate univariable associations of maternal characteristics with UA-PI.

Anthropometry and Umbilical Artery Doppler Indices

Table 1 shows the baseline continuous measures of the participants, with a mean (SD) height of 156.98 ± 7.66 cm and weight of 56.20 ± 13.79 kg. The corresponding mean (SD) BMI was 22.93 ± 5.96 kg/m², indicating an overall profile centred in the normal range with moderate dispersion. The umbilical artery pulsatility index (UA-PI) averaged 0.779 ± 0.113, providing a stable reference for subsequent between-group comparisons and regression analyses.

Table 1. Baseline continuous measures

BMI category	n	UA-PI (mean ± SD)	ANOVA (F)	P value
Underweight	75	0.709 ± 0.054	47.19	<0.001
Normal weight	71	0.762 ± 0.093		
Overweight	50	0.824 ± 0.096		
Obese	29	0.926 ± 0.130		

Distribution of Parity and BMI

Table 2 shows the distribution of parity and BMI categories among participants, with primigravida 103 (45.8%) and multigravida 122 (54.2%), indicating a slight predominance of multigravidae. By BMI, the largest group was underweight 75 (33.3%), followed by normal weight 71 (31.6%), overweight 50 (22.2%), and obese 29 (12.9%).

Table 2. Distribution of Parity and BMI among study participants

Characteristic	Summary (mean ± SD)
Height (cm)	156.98 ± 7.66
Weight (kg)	56.20 ± 13.79
BMI (kg/m²)	22.93 ± 5.96
Umbilical artery PI	0.779 ± 0.113

Association of Maternal BMI with Umbilical Artery PI

Table 3 shows a clear, graded increase in umbilical artery pulsatility index (UA-PI) across maternal BMI categories, from 0.709 ± 0.054 in the underweight group (n=75) to 0.762 ± 0.093 in normal weight (n=71), 0.824 ± 0.096 in overweight (n=50), and 0.926 ± 0.130 in obese women (n=29). The overall between-group difference was highly significant (ANOVA F = 47.19, $p < 0.001$), indicating progressively higher fetoplacental vascular resistance with increasing BMI.

Table 3. Umbilical artery PI across BMI categories

Characteristic	Category	n (%)
Parity	Primigravida	103 (45.8)
	Multigravida	122 (54.2)
BMI category	Underweight (<18.5)	75 (33.3)
	Normal weight (18.5–24.9)	71 (31.6)
	Overweight (25.0–29.9)	50 (22.2)
	Obese (≥30.0)	29 (12.9)

Figure 1 displays the correlation between BMI & UA-PI, with a least-squares regression line overlaid. UA-PI shows a positive linear association with BMI, rising steadily from lower to higher BMI values (β = 0.0117 per 1 kg/m²; 95% CI 0.0097–0.0136; $p < 0.001$; $R^2 = 0.378$). Points are more densely clustered around mid-range BMI, with modest dispersion at higher BMI, and there is no evident curvature, supporting a linear fit.

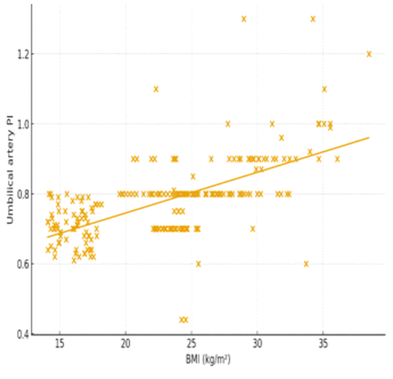

Figure 1. Scatterplot showing BMI–UA-PI Relationship

Association of Maternal Characteristics with Umbilical Artery Pulsatility Index — Univariable Linear Regression

Table 4 shows the Univariable Linear Regression of UA-PI on Maternal Variables. UA-PI increased with BMI (β=0.0117; 95% CI 0.0097–0.0136; p<0.001) and weight (β=0.0045; 95% CI 0.0036–0.0054; p<0.001), and decreased with height (β=−0.0032; 95% CI −0.0051 to −0.0013; p<0.001). Parity (primigravida vs multigravida) showed no significant association (β=−0.0129; 95% CI −0.0427 to 0.0170; p=0.396). R^2 values indicate the proportion of UA-PI variance explained by each predictor in separate models.

Table 4. Univariable linear regression of UA-PI (outcome) on maternal variables

Predictor	β (slope)	R²	95% CI	p-value
BMI (per 1 kg/m²)	0.0117	0.378	0.0097 to 0.0136	<0.001
Height (per 1 cm)	-0.0032	0.048	-0.0051 to 0.0013	<0.001
Weight (per 1 kg)	0.0045	0.304	0.0036 to 0.0054	<0.001
Primigravida vs Multigravida	-0.0129	0.003	-0.0427 to 0.0170	0.396

DISCUSSION

UA-PI increased progressively from underweight to obese categories and showed a positive linear association with BMI; height was inversely related and parity was not associated. These consistent signals across groupwise and continuous analyses suggest that higher maternal adiposity relates to higher feto-placental vascular resistance in late pregnancy.

Our category-wise gradient and positive BMI–UA-PI slope agree with reports in uncomplicated pregnancies, where obese women demonstrated higher UA-PI than normal-weight women [8]. In FGR populations, higher BMI has been linked to abnormal UA Dopplers and elevated UA-PI, aligning with the direction of our findings even though our sample excluded FGR by design [6]. A recent observational report likewise found that elevated maternal BMI was associated with abnormal UA Doppler parameters in FGR, reinforcing the plausibility of an adiposity-resistance link [9].

Not all signals are uniform across vascular beds and populations. A prospective study assessing physiological Doppler adaptation reported that the drop in UA-PI across gestation differed by fetal sex and was not modified by maternal BMI, highlighting that gestational timing and biological modifiers may shape observed associations [7]. In metabolic disease, a meta-analysis found no overall difference in UA-PI between diabetic and non-diabetic pregnancies, despite higher uterine artery PI later in gestation—highlighting that placental and uterine circulations can be differentially affected [10].

Taken together, our data support that increasing maternal BMI is associated with higher UA-PI at 28–40 weeks, which may reflect augmented feto-placental vascular resistance. In practice, BMI could help contextualize UA-PI readings and inform frequency of surveillance and counseling on gestational weight management.

CONCLUSION

Among antenatal women at 28–40 weeks, UA-PI increased across BMI categories and correlated positively with BMI on regression, while parity showed no association. These findings suggest that higher maternal adiposity is linked with higher feto-placental vascular resistance late in pregnancy and support the clinical value of considering BMI when interpreting umbilical artery Doppler. Larger, longitudinal studies with outcome assessment are warranted to define prognostic thresholds and guide surveillance protocols.

Strengths and limitations

Strengths include standardized Doppler acquisition within a single department and adequate numbers across BMI strata. Limitations include cross-sectional design (no temporal change), single-center setting, and absence of outcome analyses; residual confounding (e.g., diet, physical activity) cannot be excluded.

SOURCES OF FUNDING

None

CONFLICT OF INTEREST

None

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