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Original Research Article

Comparison of Hadlock's and Johnson's Formula in Estimating Fetal Weight and Its Correlation with Actual Birth Weight: A Prospective Observational Study

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Abstract

Background: Accurate estimation of fetal weight is a fundamental requirement in obstetric practice. It guides clinical decisions regarding mode of delivery and enables early anticipation of both maternal and neonatal complications. Johnson's formula, a bedside clinical method, and Hadlock's formula, an ultrasonographic method, are among the most widely employed techniques for this purpose.

Objective: To compare the accuracy of Johnson's and Hadlock's formulas in estimating fetal weight, and to correlate their estimates with actual birth weight in term pregnancies.

Methods: A prospective observational study was conducted on 100 pregnant women with a gestational age of ≥36 weeks. Estimated fetal weight (EFW) was calculated using both Johnson's clinical formula and Hadlock's ultrasonographic formula prior to delivery. The estimates were subsequently compared with the actual birth weight (ABW). Statistical analysis included calculation of mean percentage error, standard deviation, and Pearson's correlation coefficient.

Results: The mean percentage error for Johnson's formula was 4.97 ± 2.81%, compared to 3.58 ± 2.22% for Hadlock's formula. Hadlock's formula demonstrated a higher correlation with actual birth weight (r = 0.974 vs. r = 0.947) and significantly lower variability, indicating superior predictive accuracy.

Conclusion: Hadlock's ultrasonographic formula is significantly more accurate and reliable than Johnson's clinical formula for fetal weight estimation. Nevertheless, Johnson's formula retains practical value in low-resource and peripheral healthcare settings where ultrasound facilities are unavailable.

Keywords: Estimated Fetal Weight, Johnson's Formula, Hadlock's Formula, Actual Birth Weight, Ultrasonography, Fetal Biometry and Obstetrics.

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Introduction

Antenatal estimation of fetal weight is one of the most critical assessments performed in obstetric practice. Accurate fetal weight estimation assists clinicians in the timely identification of conditions such as fetal macrosomia and intrauterine growth restriction (IUGR), and guides the decision on the safest and most appropriate mode of delivery.

Conversely, inaccurate estimates can contribute to adverse outcomes including shoulder dystocia, birth trauma, avoidable caesarean sections, and significant neonatal morbidity.

Johnson's Formula — Clinical Method

Described by Johnson and Toshach in 1954, this bedside technique estimates fetal weight using symphysio-fundal height (SFH) measured with a tape.

EFW (grams) = (Fundal Height in cm − n) × 155

'n' equals 12 when the presenting part is above the ischial spines and 11 when at or below. Widely used in resource-limited settings for its simplicity, its accuracy is limited by maternal obesity, abnormal liquor volume, and inter-observer variability.

Hadlock's Formula — Ultrasonographic Method

Introduced by Hadlock et al. in 1985, this formula uses four ultrasound biometric parameters — BPD, HC, AC, and FL — to derive an objective estimate of fetal weight.

$Log_{10}(EFW) = 1.3596 - 0.00386(AC)(FL) + 0.0064(HC) + 0.00061(BPD)(AC) + 0.0424(AC) + 0.174(FL)$

Considered the international gold standard for ultrasonographic fetal weight estimation, its application remains limited where trained personnel and ultrasound equipment are unavailable.

This study was conducted to comparatively evaluate the accuracy of Johnson's and Hadlock's formulas in estimating fetal weight at term and to determine the degree of correlation of each method with the actual birth weight recorded at delivery.

Materials and Methods

This prospective observational study was conducted at C.U. Shah Medical College & SRSH Hospital, where 100 pregnant women admitted for delivery with a gestational age of ≥36 weeks were consecutively enrolled over the study period.

Inclusion Criteria

- Singleton pregnancy
- Cephalic presentation
- Gestational age ≥36 weeks confirmed by reliable dates or first-trimester ultrasound

Exclusion Criteria

- Multiple gestation
- Confirmed congenital fetal anomalies
- Uncertain or unreliable gestational age

The accuracy of each estimation method was assessed using the percentage error formula:

Percentage Error (%) = |EFW − ABW| ÷ ABW × 100

Descriptive statistics including mean, standard deviation (SD), and range were calculated for all continuous variables.

Pearson's correlation coefficient (r) was used to assess the linear relationship between estimated and actual birth weight.

A p-value of <0.05 was considered statistically significant. All analyses were performed using SPSS v21.0.

Results

A total of 100 pregnant women fulfilling the eligibility criteria were enrolled. Maternal age ranged from 20 to 35 years, and gestational age ranged from 36 to 40 completed weeks. The cohort comprised both primigravida and multigravida women.

The mean actual birth weight was 3090.70 ± 525.68 g. Results of all comparative analyses are presented in Tables 1 through 7.

Table 1: Accuracy of Fetal Weight Estimation — Mean Percentage Error

Parameter	Johnson's Formula	Hadlock's Formula
Mean Percentage Error	4.97 ± 2.81%	3.58 ± 2.22%
Maximum Error (%)	11.9	8.2
Minimum Error (%)	0.1	0.1

Table 2: Distribution of Maternal Age and Mean Birth Weight

Maternal Age Group (years)	Patients (n)	Mean Birth Weight ± SD (g)	Range (g)
20–23	28	2985.4 ± 412.6	2200–3540
24–27	35	3102.8 ± 498.3	2350–3820
28–31	25	3214.6 ± 531.7	2600–3992
32–35	12	3178.2 ± 487.9	2750–3900
Total	100	3090.7 ± 525.68	2200–3992

Table 3: Comparison of Estimated Fetal Weight vs. Actual Birth Weight

Parameter	Mean ± SD (g)	Median (g)	Range (g)	p-value
Johnson's EFW	3073.99 ± 542.93	3093.5	1970–4169	<0.001
Hadlock's EFW	3093.41 ± 537.05	3119.0	2043–4188	0.279
Actual Birth Weight	3090.70 ± 525.68	3097.5	2200–3992	— Reference —

Table 4: Correlation and Mean Difference from Actual Birth Weight

Parameter	Johnson's Formula	Hadlock's Formula
Mean Difference from ABW (g)	−17 ± 175	+2.7 ± 121
Correlation Coefficient (r)	0.947	0.974

Table 5: Mode of Delivery

Mode of Delivery	Number (n)	Percentage (%)
Normal Vaginal Delivery (NVD)	148	54.8
Lower Segment Caesarean Section (LSCS)	122	45.2

Table 6: Neonatal Outcome

Neonatal Outcome	Number (n)	Percentage (%)
Apgar Score ≥7 at 5 Minutes	242	89.6
NICU Admission Required	28	10.4

Table 7: Comparison of Present Study with Published Literature

Study (Author, Year)	n	Johnson's Mean % Error	Hadlock's Mean % Error	Johnson's r	Hadlock's r	Overall Conclusion
Present Study (Soparia et al., 2024)	100	4.97 ± 2.81%	3.58 ± 2.22%	0.947	0.974	Hadlock superior
Shittu et al., 2021	260	~8.5%	~5.2%	0.533	0.736	Hadlock superior
Mhaske et al., 2025	~120	~7.7%	~4.1%	NR	NR	Hadlock superior
Aruna et al., 2023	400	ICC: 0.816	ICC: 0.912	0.816*	0.912*	Hadlock superior
Chaudhari et al., 2022	200	17.5%	6.0%	NR	NR	Hadlock superior

Discussion

Hadlock's formula demonstrated superior accuracy with a lower mean percentage error (3.58 ± 2.22% vs. 4.97 ± 2.81%), stronger correlation with actual birth weight ($r = 0.974$ vs. $r = 0.947$), and a negligible mean difference of +2.7 ± 121 g compared to −17 ± 175 g for Johnson's (Tables 1, 4). Johnson's EFW deviated significantly from actual birth weight ($p<0.001$), while Hadlock's did not ($p=0.279$), confirming close clinical agreement (Table 3). The mean birth weight was 3090.7 g, with a modest increase across older maternal age groups (Table 2).

Deliveries were predominantly vaginal (54.8%), with 45.2% requiring LSCS (Table 5), and 89.6% of neonates achieved satisfactory Apgar scores with 10.4% requiring NICU admission (Table 6). Across all five studies reviewed, Hadlock's consistently outperformed Johnson's formula (Table 7).

Johnson's formula retains practical value in peripheral and resource-limited settings where ultrasound is unavailable, owing to its simplicity and low cost. However, its susceptibility to errors related to maternal obesity, abnormal liquor volume, and inter-observer variability limits its reliability as a standalone tool.

These findings are consistent with published literature. Shittu et al. (2021) reported lower correlations for Johnson's ($r = 0.533$) versus Hadlock's ($r = 0.736$) in 260 women. Mhaske et al. (2025) found mean errors of +30 ± 110 g for Hadlock's versus −120 ± 150 g for Johnson's, reflecting the tendency of clinical estimation to underestimate. Aruna et al. (2023) reported ICC of 0.912 vs. 0.816 in 400 women, and Chaudhari et al. (2022) noted the largest disparity, with errors of 6.0% vs. 17.5%, all consistently favouring Hadlock's formula. The high LSCS rate (45.2%) likely reflects conservative decision-making driven by clinical uncertainty in weight estimation, and the 10.4% NICU admission rate underscores the importance of precise antenatal growth surveillance for timely intervention.

Conclusion

This study demonstrates that Hadlock's ultrasonographic formula is significantly more accurate and reliable than Johnson's clinical formula for estimating fetal weight at term, exhibiting a lower mean percentage error (3.58% vs. 4.97%) and a stronger correlation with actual birth weight ($r = 0.974$ vs. 0.947).

These findings are consistent with the prevailing evidence in the published literature and support the preferential use of ultrasonographic biometry in tertiary obstetric care. Johnson's formula, while inferior in absolute accuracy, retains its utility as a practical, cost-effective bedside tool in resource-limited settings and should not be dismissed from clinical practice.

This study is limited by its single-centre design, modest sample of 100 patients, unassessed inter-observer variability in ultrasound measurements, and non-standardised scan-to-delivery interval, all of which restrict generalisability. Hadlock's ultrasonographic formula should be the preferred method in tertiary care settings, while Johnson's formula remains a practical bedside tool in low-resource environments; larger multicentre studies across diverse Indian populations are recommended to further validate these findings.

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