RESEARCH PAPER

A comparative study of clinical methods and ultrasound for prediction of fetal birth weight at term gestation

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ABSTRACT
Introduction: Accurate antenatal estimation of fetal birth weight at term remains fundamental to optimal obstetric management. While ultrasonography represents the reference standard, limited availability in resource-constrained settings necessitates the continued use of simple clinical methods. This study compared the accuracy of clinical formulas and ultrasonography for predicting fetal birth weight at term. Methods: This prospective, cross-sectional study was conducted over a six-month period at a tertiary care hospital in Chennai. Sixty-three women with singleton, cephalic pregnancies between 37 and 41 weeks of gestation were included. Estimated fetal weight was calculated within 48 hours prior to delivery using Johnson's formula, Dare's formula, and ultrasonography based on the Hadlock formula. Actual birth weight measured immediately after delivery served as the reference standard. Accuracy was assessed using mean percentage error, proportion within ±10% of actual birth weight, Pearson's correlation coefficient, and Bland-Altman analysis. Results: The mean actual birth weight was 2940 ± 450 g. Ultrasonography demonstrated the highest accuracy (mean percentage error −3.8%, 81% within ±10%, r = 0.89). Johnson's formula showed moderate accuracy (6.4%, 71.4%, r = 0.82), while Dare's formula was less accurate (10.7%, 63.5%, r = 0.78). Conclusion: Ultrasonography using the Hadlock formula remains the most accurate method for fetal weight estimation at term. Johnson's formula may serve as a reasonable alternative where ultrasound is unavailable...

Keywords: Fetal Weight Estimation; Birth Weight; Ultrasonography, Prenatal; Symphysis-Fundal Height; Fetal Growth.
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INTRODUCTION

Accurate estimation of fetal birth weight near term represents a critical component of obstetric decision-making, directly influencing intrapartum management and neonatal outcomes. Birth weight serves as a stronger predictor of perinatal survival and early life morbidity than gestational age alone [1]. Low birth weight infants face substantially increased risks of perinatal mortality, intrapartum hypoxia, neonatal metabolic complications, impaired growth, and long-term neurodevelopmental and cardiometabolic sequelae [2]. More than 20 million infants are born with low birth weight annually worldwide, with the highest burden concentrated in low- and middle-income countries [2].

Fetal macrosomia is associated with increased maternal and neonatal complications, including shoulder dystocia, birth trauma, postpartum hemorrhage, and higher rates of operative vaginal delivery and caesarean section [3]. Both extremes of fetal weight pose significant clinical challenges, particularly during labour, where inaccurate assessment may result in delayed or inappropriate interventions. Reliable antenatal estimation of fetal birth weight is therefore crucial for identifying at-risk fetuses and guiding timely obstetric management.

Birth weight has been demonstrated to be a robust and readily measurable indicator of neonatal survival and adverse pregnancy outcomes, particularly in low- and middle-income countries where accurate assessment of gestational age is frequently limited. Epidemiological evidence indicates that low birth weight contributes substantially to perinatal morbidity and mortality, with public health importance potentially exceeding that of gestational age alone in such settings [4]. Antenatal estimation of fetal weight enables the identification of at-risk fetuses and facilitates the implementation of

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appropriate interventions, such as enhanced intrapartum surveillance or planned cesarean delivery.

Fetal weight can be estimated antenatally using clinical or imaging-based methods. Ultrasonography, particularly formulas incorporating multiple fetal biometric parameters, including biparietal diameter, abdominal circumference, head circumference, and femur length, is widely regarded as the reference standard for fetal weight estimation. The Hadlock formulas have been validated in prospective studies and systematic reviews, demonstrating accuracy of approximately 70-85% within ±10% of actual birth weight, although clinically relevant random measurement errors persist [5,6]. However, the availability of ultrasonography remains limited in many peripheral and resource-constrained settings, necessitating continued reliance on simple clinical methods.

In settings where access to ultrasonography is limited, clinical methods continue to serve an important role in antenatal care. Johnson's formula, based on symphysis-fundal height measurement, and clinical methods incorporating symphysis-fundal height and abdominal girth are commonly employed because they require minimal equipment and can be readily applied in routine clinical practice. Studies conducted in resource-limited settings have demonstrated reasonable correlation between these clinical estimates and actual birth weight, supporting their utility as alternative methods for fetal weight estimation [7,8]. However, reported accuracy varies across populations, and regional data from South India remain limited. This study was therefore undertaken to compare the accuracy of Johnson's formula, Dare's formula, and ultrasonographic estimation using the Hadlock formula against actual birth weight in term pregnancies.

METHODS

Study Design and Setting

This prospective cross-sectional study was conducted in the Department of Obstetrics and Gynaecology at Sree Balaji Medical College and Hospital, Chennai, a tertiary care teaching hospital serving urban and peri-urban populations. The study was carried out over a six-month period.

Study Population

The study population consisted of antenatal women admitted for delivery with singleton pregnancies at term.

Inclusion Criteria

Pregnant women aged 18 years and above with singleton pregnancies between 37 and 41 completed weeks of gestation, confirmed by early ultrasonography or reliable last menstrual period, who were admitted for spontaneous labour, induction of labour, or elective caesarean section and who provided written informed consent were included in the study.

Exclusion Criteria

Women with multiple gestations, known fetal congenital anomalies, intrauterine fetal demise, abnormal amniotic fluid volume (oligohydramnios or polyhydramnios), placenta previa, eclampsia, uterine fibroids or pelvic masses interfering with abdominal assessment, and maternal weight exceeding 90 kg were excluded. Pregnancies complicated by early or late diagnosed intrauterine growth restriction were also excluded to minimise confounding.

Sample Size and Sampling Technique

Based on previous studies reporting an accuracy of approximately 70% for ultrasonographic fetal weight estimation within ±10% of actual birth weight, the sample size was calculated using a single proportion formula assuming an expected accuracy of $p = 0.70$, 10% absolute precision, and 95% confidence level. The minimum required sample size was 63. Participants were recruited using consecutive purposive sampling, wherein all eligible participants meeting the inclusion criteria during the study period were enrolled consecutively, thereby achieving the required sample size.

Estimation of Fetal Weight

The estimated fetal weight was calculated within 48 hours prior to delivery using two clinical formulas and ultrasonography.

Clinical estimation was performed using Johnson’s formula and Dare’s formula. Symphysis-fundal height was measured in centimetres using a non-elastic measuring tape with the woman in the supine position and an empty bladder. Abdominal girth was measured at the level of the umbilicus. Johnson’s formula was applied by subtracting the fetal station and multiplying by a constant, while Dare’s formula involved multiplication of symphysis-fundal height and abdominal girth.

Ultrasonographic estimation was performed by a single experienced radiologist using a calibrated ultrasound machine. Biparietal diameter, head circumference, abdominal circumference, and femur length were measured, and fetal weight was calculated using the Hadlock formula.

Measurement of Actual Birth Weight

Actual birth weight was recorded within 30 minutes of delivery using a calibrated digital weighing scale and was considered the reference standard for comparison.

Outcome Measures and Statistical Analysis

The primary outcome was the accuracy of each fetal weight estimation method compared to the actual birth weight. Accuracy was assessed using mean percentage error, proportion of estimates within ±10% of actual birth weight, and Pearson's correlation coefficient. Agreement between estimated fetal weight and actual birth weight was assessed using Bland-Altman analysis to evaluate systematic bias and limits of agreement [9,10]. Data were entered in Microsoft Excel and analyzed using SPSS software version 25. A p-value less than 0.05 was considered statistically significant.

Ethical Considerations

The study was approved by the Institutional Ethics Committee of Sree Balaji Medical College and Hospital (Ref: SBMC/IEC/2023/045). Written informed consent was obtained from all participants before enrolment, and confidentiality of participant data was strictly maintained throughout the study.

RESULTS

Among the 70 eligible women for the study, 63 completed it, and seven were excluded due to preterm delivery.

Table 1 presents the baseline maternal and neonatal characteristics of the study population. The mean maternal age was 27.4 ± 4.2 years, with a mean gestational age at delivery of 38.6 ± 1.1 weeks. The mean body mass index was 26.8 ± 3.5 kg/m². Primigravidae comprised 60.3% of the study population, while 39.7% were multigravidae. The mean actual birth weight was 2940 ± 450 grams.

Table 1. Maternal and neonatal characteristics of participants (N=63)

Variable	Mean ± SD / n (%)
Maternal age (years)	27.4 ± 4.2
Gestational age (weeks)	38.6 ± 1.1
BMI (kg/m²)	26.8 ± 3.5
Primigravida	38 (60.3%)
Multigravida	25 (39.7%)
Actual birth weight (g)	2940 ± 450

Table 2 demonstrates the comparative accuracy of the three fetal weight estimation methods. Ultrasonography using the Hadlock formula exhibited the lowest mean percentage error (MPE) at −3.8% and achieved the highest proportion of estimates within ±10% of actual birth weight (81.0%). The correlation with actual birth weight was strongest for ultrasonography ($r = 0.89$, $p < 0.001$). Johnson's formula demonstrated a mean percentage error of 6.4%, with 71.4% of estimates falling within ±10% of actual birth weight and a correlation coefficient of 0.82 ($p < 0.001$). Dare's formula showed the lowest accuracy among the three methods, with a mean percentage error of 10.7%, only 63.5% of estimates within ±10% of actual weight, and a correlation coefficient of 0.78 ($p < 0.001$). All three methods demonstrated statistically significant correlations with actual birth weight.

Table 2. Accuracy of fetal weight estimation methods

Method	MPE (%)	Within ±10% n (%)	Pearson's r	p-value
Hadlock (USG)	−3.8	51 (81.0)	0.89	<0.001
Johnson's formula	6.4	45 (71.4)	0.82	<0.001
Dare's formula	10.7	40 (63.5)	0.78	<0.001

Figure 1 depicts the proportion of estimated fetal weights falling within ±10% of the actual birth weight for ultrasonographic and clinical estimation methods. Figure 2 illustrates the mean percentage error of fetal weight estimation methods in comparison with actual birth weight.

Fig.1 Proportion of fetal weight estimates within ±10% of actual birth weight

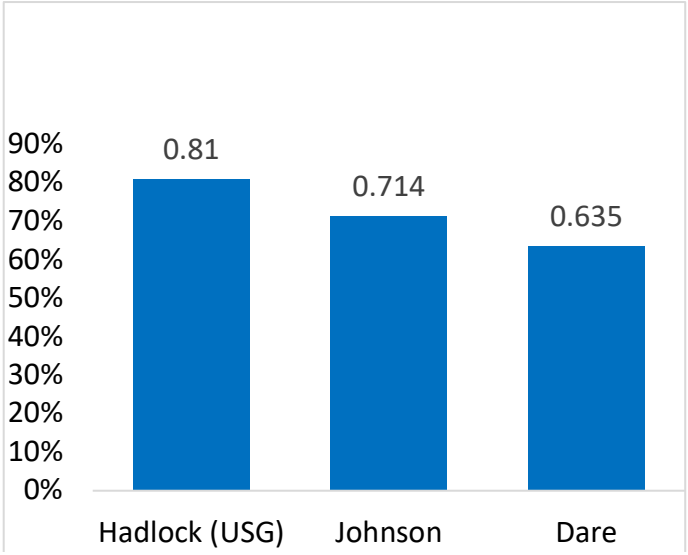
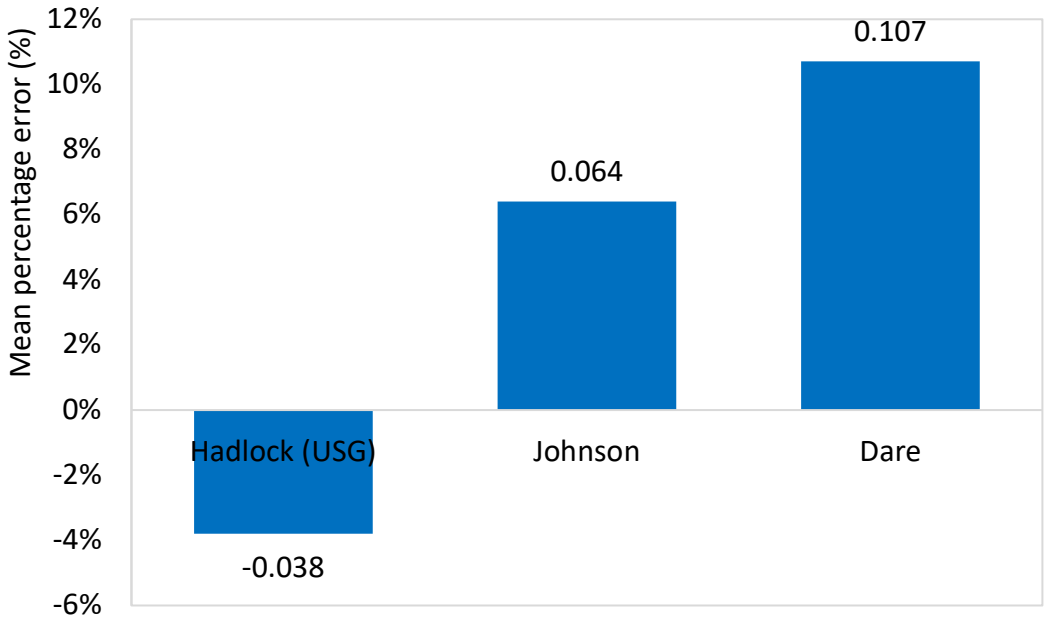


Fig 2. Mean percentage error of fetal weight estimation methods compared with actual birth weight.



Footnote: Negative values indicate underestimation and positive values indicate overestimation.

Table 3 presents the Bland-Altman analysis results for agreement between estimated and actual birth weight. Ultrasonography demonstrated the smallest mean bias at −112 grams with the narrowest limits of agreement, ranging from −320 to +280 grams. Johnson's formula showed a positive bias of +188 grams with wider limits of agreement (−450 to +660 grams). Dare's formula exhibited the largest bias at +315 grams and the widest limits of agreement (−600 to +880 grams). These findings indicate that ultrasonography demonstrated superior agreement with actual birth weight compared to the clinical methods.

Table 3. Bland–Altman agreement with actual birth weight

Method	Mean bias (g)	95% limits of agreement (g)
Hadlock (USG)	−112	−320 to +280
Johnson's formula	+188	−450 to +660
Dare's formula	+315	−600 to +880

DISCUSSION

In the present study, ultrasonographic estimation of fetal weight using the Hadlock formula demonstrated the highest accuracy and strongest agreement with actual birth weight. This finding is consistent with the original prospective validation by Hadlock et al., which demonstrated that fetal weight estimates derived from multiple biometric parameters—particularly abdominal circumference, head circumference, and femur length—exhibited relatively low systematic error and reduced random variability when measurements were performed in proximity to delivery [5]. Systematic reviews of ultrasound-based fetal weight estimation have confirmed that commonly employed Hadlock models achieve acceptable accuracy in term pregnancies, with the majority of estimates falling within ±10% of actual birth weight, although clinically relevant random errors persist [6]. Similar observations have been reported in comparative clinical studies evaluating ultrasound-based fetal weight estimation against birth weight, where ultrasonography demonstrated superior correlation and narrower limits of agreement compared with clinical methods [9]. The narrow limits of agreement observed on Bland-Altman analysis in the current study further support the reliability of ultrasonography in term pregnancies. Comparable findings demonstrating favorable correlation and acceptable accuracy between ultrasonographic fetal weight estimation and actual birth weight have been reported in comparative studies from low- and middle-income countries as well as South India, where ultrasonography consistently demonstrated lower percentage error when compared with clinical methods such as Johnson's and Dare's formulas [11,12].

Findings from a large Indian comparative study have demonstrated that ultrasonographic fetal weight estimation using the Hadlock formula achieves a higher proportion of estimates within ±10% of actual birth weight when compared with commonly employed clinical methods, although clinical formulas continue to demonstrate acceptable correlation in term pregnancies [13].

Among the clinical methods evaluated in this study, Johnson's formula demonstrated superior accuracy and lower mean percentage error compared to methods incorporating both symphysis-fundal height and abdominal girth. This observation is consistent with previous studies demonstrating that symphysis-fundal height-based formulas provide reasonably reliable estimates of fetal weight in uncomplicated term pregnancies, with acceptable

correlation and error margins when applied in proximity to delivery [14,15]. Indian studies evaluating clinical fetal weight estimation have similarly reported acceptable correlation between symphysis-fundal height-based formulas and actual birth weight in uncomplicated term pregnancies [8].

In contrast, clinical methods incorporating abdominal girth measurements have been reported to exhibit wider variability in agreement with actual birth weight. Studies evaluating Dare-derived and other abdominal girth-based clinical approaches have demonstrated that, although these methods show positive correlation with actual birth weight, they are associated with greater prediction error and variability when compared with ultrasonographic estimates, particularly at the extremes of birth weight [14,15]. This increased variability may be attributable to difficulties in standardizing abdominal girth measurements, which are influenced by maternal habitus and soft tissue thickness, thereby affecting the precision of fetal weight estimation.

Although ultrasonography remains the preferred method, its limited availability in resource-constrained settings underscores the continued relevance of clinical formulas. Johnson's formula, in particular, offers a practical alternative when ultrasound facilities are unavailable, especially in peripheral healthcare settings. Previous studies have demonstrated that the accuracy of both clinical and ultrasonographic methods may vary across populations, emphasizing the importance of region-specific validation [16]. Indian validation studies have demonstrated that clinical estimation using the product of symphysio-fundal height and abdominal circumference shows favorable correlation with actual birth weight and may serve as a useful screening tool in low-resource settings where access to ultrasonography is limited [8].

The present study has several limitations. The single-center design and modest sample size may restrict generalizability to other populations. The exclusion of women with extreme obesity and abnormal amniotic fluid volumes may limit applicability to high-risk obstetric populations. Previous studies have emphasized that both clinical and ultrasonographic estimates of fetal weight are subject to inherent measurement errors, and that high correlation does not necessarily indicate close agreement with actual birth weight, emphasizing the importance of population-specific validation of estimation methods [16]. Nevertheless, this study provides region-specific data supporting the rational use of clinical and ultrasonographic methods for fetal weight estimation at term in South Indian populations.

CONCLUSION

Ultrasonography using the Hadlock formula remains the most accurate method for estimating fetal birth weight at term gestation. Among clinical methods, Johnson's formula demonstrated acceptable agreement with actual birth weight and may serve as a reasonable alternative in settings where ultrasound facilities are not readily available. Dare's formula demonstrated lower accuracy and should be employed with appropriate caution in clinical practice..

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