

Accuracy of Clinical and Ultrasound Estimation of Fetal Weight Compared with Actual Birth Weight in Term Pregnancies: A Prospective Cohort Study

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Abstract

Background

Accurate estimation of fetal weight is important for obstetric decision-making and identification of fetuses at risk of adverse perinatal outcomes. Although ultrasound-based estimation is widely used, clinical methods remain important in settings where access to ultrasound is limited. This study compared the accuracy of clinical and ultrasound-based fetal weight estimation with actual birth weight in term pregnancies and assessed the influence of maternal body mass index (BMI) on clinical estimation.

Methods

This prospective cohort study included 200 women with singleton term pregnancies between 37 and 41 + 6 weeks of gestation who were expected to deliver within 72 hours at Vardhman Mahavir Medical College and Safdarjung Hospital, New Delhi. Clinical estimated fetal weight (EFW) was calculated using Johnson's formula based on symphysis-fundal height and fetal head station. Ultrasound EFW was calculated using Hadlock's formula based on fetal biometric measurements. Both estimates were compared with actual birth weight (ABW). Correlation, mean differences, estimation accuracy within 10% of ABW, and agreement were assessed. The influence of maternal BMI on clinical estimation accuracy was also evaluated.

Results

The mean clinical EFW was 3060 ± 320 g, compared with 3180 ± 330 g by ultrasound and 3110 ± 350 g for ABW. Both clinical and ultrasound estimates were significantly correlated with ABW, with stronger correlation for ultrasound ($r = 0.89$, $p < 0.001$) than for clinical estimation ($r = 0.76$, $p < 0.001$). The proportion of estimates within 10% of ABW was higher with ultrasound than with clinical estimation (78.5% vs. 62.0%). Clinical estimation showed increasing underestimation with higher maternal BMI, with a mean difference from ABW of 30 ± 170 g in women with BMI < 25 kg/m², -60 ± 180 g in those with BMI 25–29.9 kg/m², and -130 ± 200 g in those with BMI ≥ 30 kg/m².

Conclusion

Ultrasound-based fetal weight estimation demonstrated greater correlation and accuracy with actual birth weight than clinical estimation in term pregnancies. Clinical estimation using Johnson's formula nevertheless provides a practical and accessible alternative where ultrasound is unavailable, particularly in resource-limited settings. Maternal BMI should be considered when interpreting clinically estimated fetal weight, as accuracy may decrease with increasing BMI.

INTRODUCTION

Accurate estimation of fetal weight is an important component of obstetric care, particularly at term, as it helps clinicians identify fetuses at risk of low birth weight, fetal growth restriction, and macrosomia and supports appropriate decisions regarding antenatal surveillance and delivery management [1, 2]. However, antenatal fetal weight estimation is inherently subject to measurement error, and differences between estimated fetal weight (EFW) and actual birth weight may affect clinical decision-making.

Clinical and ultrasonographic methods are the two commonly used approaches for estimating fetal weight. Clinical estimation is based primarily on abdominal examination, symphysis-fundal height (SFH), fetal presentation, and assessment of fetal station. Formulas such as Johnson's and Dare's provide a structured approach to translating these clinical measurements into an estimated fetal weight [2, 3]. Because clinical estimation requires minimal equipment and can be performed at the bedside, it remains particularly relevant in low-resource settings where access to ultrasonography may be limited.

Ultrasonography provides fetal weight estimates using biometric parameters including biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), and femur length (FL), which are incorporated into established equations such as the Hadlock formulas [4, 6]. A systematic review has demonstrated that ultrasound-estimated fetal weight generally has good correlation with actual birth weight, although the magnitude of error varies according to gestational age, fetal size, and other clinical factors [4]. Importantly, ultrasound estimation is also subject to technical and biological limitations and should therefore be interpreted as an estimate rather than a direct measurement of fetal weight.

Previous comparative studies have evaluated clinical and ultrasound methods against actual birth weight. Ugwu et al. reported that both clinical and ultrasound methods could provide useful estimates of fetal weight, although their accuracy varied across different fetal weight ranges [5]. Other studies have similarly compared Johnson's method with Hadlock-based ultrasound estimation and reported differences in agreement and estimation error between the two approaches [13, 14]. Studies from different populations have also demonstrated that the relative performance of clinical and ultrasound estimation may vary according to maternal and fetal characteristics [15, 17–21].

Maternal body habitus is an important factor that may influence clinical estimation. Increased maternal BMI, particularly obesity, can make abdominal palpation and accurate measurement of SFH more difficult because of increased subcutaneous tissue. This may reduce the ability to clinically identify fetal parts and may consequently increase estimation error [17, 18]. In contrast, ultrasound allows direct assessment of fetal biometric parameters and may be less affected by maternal body habitus, although ultrasound accuracy may also vary in certain maternal and fetal circumstances [10, 17, 22].

The clinical relevance of accurate fetal weight estimation is particularly important when suspected fetal growth restriction or excessive fetal growth may influence the timing or mode of delivery. Studies have shown that both clinical examination and ultrasound can have limitations in predicting actual birth weight, emphasizing the importance of understanding the degree of agreement and error associated

with each method [20–23]. In settings where ultrasound is not immediately available, a reasonably accurate clinical method could provide valuable information for initial assessment and referral decisions.

Despite the widespread use of both approaches, variation exists in their reported accuracy across populations and clinical settings. Furthermore, the influence of maternal BMI on clinical fetal weight estimation has not been uniformly characterized. Therefore, evaluating both methods within the same population and comparing them with actual birth weight may provide clinically useful information.

The present study aimed to compare clinical fetal weight estimation using Johnson's formula with ultrasound-based estimation using the Hadlock formula in term singleton pregnancies, using actual birth weight as the reference standard. The study also assessed the proportion of fetal weight estimates within 10% of actual birth weight and evaluated the influence of maternal BMI on the accuracy of clinical fetal weight estimation. The findings may help determine the practical role of clinical fetal weight estimation, particularly in settings where ultrasound facilities are limited or not immediately accessible.

MATERIALS AND METHODS

Study Design and Setting

This prospective observational cohort study was conducted in the Departments of Obstetrics and Gynaecology and Radiodiagnosis at Vardhman Mahavir Medical College and Safdarjung Hospital, New Delhi, India, over a period of 18 months. The study included term pregnant women admitted to the obstetric ward or labour room who were expected to deliver within 72 hours. The study was conducted after obtaining approval from the Institutional Ethics Committee of Vardhman Mahavir Medical College and Safdarjung Hospital (Approval No. IEC/VMMC/SJH/Thesis/06/2022/CC-150). Written informed consent was obtained from all eligible participants before enrolment.

Study Population

Women with singleton term pregnancies between 37 + 0 and 41 + 6 weeks of gestation, vertex presentation, and an expected delivery within 72 hours were considered eligible. Gestational age was determined from the available antenatal records and routine obstetric assessment.

Women in active labour, those with antepartum haemorrhage, fetuses with known congenital anomalies, haemodynamically unstable women, and women with uterine fibroids or other abdominal masses were excluded because these conditions could interfere with clinical assessment or fetal weight estimation.

Sample Size

The sample size was calculated based on findings reported by El Helali et al. [12], in which the proportion of fetal weight estimates with an error of $\leq 5\%$ was approximately 25% with clinical estimation and 48% with ultrasonographic estimation. Assuming a two-sided significance level of 5%, 99% statistical power, and the expected difference between the two proportions, the minimum required sample size was estimated to be 153 participants. To compensate for potential exclusions and improve the precision of the estimates, the final sample size was increased to 200 participants.

Clinical Estimation of Fetal Weight

Clinical fetal weight estimation was performed before delivery using symphysis-fundal height (SFH) measurement and fetal head station according to Johnson's method.

For SFH measurement, participants were asked to empty their bladder and were positioned supine with the legs flexed. The uterine fundus was identified using a two-handed fundal grip. A non-elastic measuring tape was used, with the zero mark placed at the upper border of the symphysis pubis and the tape extended along the longitudinal axis of the uterus to the uterine fundus. To minimize measurement bias, the numerical markings on the tape were concealed from the examiner during the initial measurement. The measurement was subsequently recorded in centimetres.

Fetal head station was assessed by vaginal examination with reference to the level of the ischial spines. The station was recorded as 0 when the presenting part was at the level of the ischial spines, with positive values indicating descent below the spines and negative values indicating that the presenting part remained above the spines.

Estimated fetal weight was then calculated using the Johnson formula:

$$\text{Estimated fetal weight (g)} = [\text{SFH (cm)} - n] \times 155$$

where n represents the correction factor according to the station of the fetal head, as specified in the original Johnson method used for the study.

Clinical fetal weight estimation was performed independently of the ultrasound assessment, and the clinical examiner was not provided with the ultrasound-derived fetal weight.

Ultrasound Estimation of Fetal Weight

Following clinical assessment, participants underwent obstetric ultrasonography in the Department of Radiodiagnosis using a Samsung SONOACE R7 ultrasound system. Ultrasound examinations were performed by trained radiologists according to a standardized fetal biometric protocol.

Fetal biometric measurements included biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), and femur length (FL). BPD and HC were measured in the standard trans-thalamic

plane. HC was obtained using an elliptical measurement along the outer margin of the fetal calvarium. AC was measured in the transverse abdominal plane at the level of the fetal stomach and the intrahepatic portion of the umbilical vein. FL was measured along the ossified diaphysis of the femur, excluding the epiphyses.

Ultrasound estimated fetal weight was calculated using the Hadlock 3 equation:

$$\text{Log}_{10} \text{ fetal weight (g)} = 1.326 - 0.00326 \times \text{AC} \times \text{FL} + 0.0107 \times \text{HC} + 0.0438 \times \text{AC} + 0.158 \times \text{FL}$$

The ultrasound-derived fetal weight was recorded before delivery and independently of the clinical fetal weight estimate. The radiologist was blinded to the clinical fetal weight estimate.

The interval between ultrasound examination and delivery was recorded for each participant to account for the potential change in fetal weight between estimation and birth.

Assessment of Actual Birth Weight

All participants were followed until delivery. Actual birth weight was measured immediately after birth using a calibrated standard neonatal weighing scale, with the newborn weighed according to institutional practice. Birth weight was recorded in grams and used as the reference standard for comparison with both clinical and ultrasound-derived fetal weight estimates.

For descriptive analysis, newborns were categorized according to birth weight as follows:

- Low birth weight: <2500 g
- Normal birth weight: 2500–4000 g
- Macrosomia: >4000 g

Study Outcomes

The primary outcome was the accuracy of clinical and ultrasound estimated fetal weight compared with actual birth weight.

Secondary outcomes included:

1. Correlation between clinical EFW and actual birth weight.
2. Correlation between ultrasound EFW and actual birth weight.
3. Mean absolute error and mean percentage error for each estimation method.
4. Proportion of fetal weight estimates within $\pm 10\%$ of actual birth weight.
5. Agreement between estimated fetal weight and actual birth weight using Bland–Altman analysis.
6. Influence of maternal BMI on the accuracy of clinical fetal weight estimation.

Accuracy within 10% of actual birth weight was calculated as the proportion of participants for whom the estimated fetal weight was within $\pm 10\%$ of the measured birth weight.

Assessment of Maternal BMI

Maternal height and weight were recorded during the study assessment, and BMI was calculated as weight in kilograms divided by height in metres squared.

Participants were categorized according to BMI into three groups:

- Normal BMI: $<25 \text{ kg/m}^2$
- Overweight: $25\text{--}29.9 \text{ kg/m}^2$
- Obese: $\geq 30 \text{ kg/m}^2$

Clinical fetal weight estimation accuracy was compared across these BMI categories to assess whether maternal body habitus influenced the performance of the clinical method.

Statistical Analysis

Data were entered into Microsoft Excel and analysed using IBM SPSS Statistics version 21.0. Continuous variables were summarized as mean $\pm$ standard deviation (SD) when normally distributed and as median with interquartile range when appropriate. Categorical variables were presented as frequencies and percentages.

The normality of continuous variables was assessed before statistical testing. Paired comparisons between estimated fetal weight and actual birth weight were performed using the paired t-test for normally distributed data and the Wilcoxon signed-rank test for non-normally distributed data.

Pearson's correlation coefficient was used to assess the correlation between estimated fetal weight and actual birth weight when the data met the assumptions for parametric analysis. Spearman's correlation was used when appropriate.

The absolute error was calculated as:

$$\text{Absolute error} = |\text{Estimated fetal weight} - \text{Actual birth weight}|$$

Percentage error was calculated as:

$$\text{Percentage error} = [(\text{Estimated fetal weight} - \text{Actual birth weight}) / \text{Actual birth weight}] \times 100$$

The proportion of estimates within $\pm 10\%$ of actual birth weight was calculated separately for clinical and ultrasound methods. Comparisons of categorical variables were performed using the Chi-square test or Fisher's exact test, as appropriate.

Agreement between estimated fetal weight and actual birth weight was assessed using Bland–Altman analysis. Separate analyses were performed for clinical EFW versus actual birth weight and ultrasound EFW versus actual birth weight, with calculation of mean bias and 95% limits of agreement.

Subgroup analysis was performed according to maternal BMI category to assess differences in clinical estimation error and accuracy. A two-sided p-value < 0.05 was considered statistically significant.

STUDY FLOWCHART

TERM PREGNANT WOMEN ADMITTED IN THE WARD /LABOUR ROOM WHO WERE EXPECTED TO DELIVER WITHIN NEXT 72 HOURS

ZH HISTORY AND EXAMINATION

SYMPHYSIS-FUNDAL HEIGHT MEASURED, STATION ASSESSED PER ABDOMEN AND PER VAGINUM AND WEIGHT CALCULATED USING JOHNSON'S FORMULA

ULTRASOUND FETAL WEIGHT ESTIMATED USING HADLOCK'S 3 FORMULA

PATIENT FOLLOWED UP TILL DELIVERY AND ACTUAL BIRTH WEIGHT MEASURED

COMPARED BOTH CLINICAL AND ULTRASOUND ESTIMATED FETAL WEIGHT WITH ACTUAL BIRTH WEIGHTTT CLINICAL AND ULTRASOUND ESTIMATED FETAL WEIGHT WITH ACTUAL BIRTH WEIGHT

RESULTS

Demographic and Clinical Characteristics

A total of 200 term pregnant women who fulfilled the eligibility criteria were included in the study. The demographic and clinical characteristics of the study participants are presented in Table 1.

The mean maternal age was 28.5 ± 4.3 years, and the mean gestational age at assessment was 39.2 ± 1.2 weeks. The mean maternal BMI was 25.3 ± 3.6 kg/m². Among the participants, 95 (47.5%) were primigravidas and 105 (52.5%) were multigravidas. Similarly, 95 (47.5%) women were nulliparous and 105 (52.5%) were parous.

Table 1
Demographic and Clinical Characteristics of the Study Participants

Characteristic	Value
Total participants, n	200
Maternal age, mean $\pm$ SD (years)	28.5 $\pm$ 4.3
Gravida, n (%)	
• Primigravida	95 (47.5)
• Multigravida	105 (52.5)
Parity, n (%)	
• Nulliparous	95 (47.5)
• Parous	105 (52.5)
Gestational age, mean $\pm$ SD (weeks)	39.2 $\pm$ 1.2
Maternal BMI, mean $\pm$ SD (kg/m ²)	25.3 $\pm$ 3.6

Comparison of Estimated Fetal Weight with Actual Birth Weight

The mean actual birth weight was 3110 $\pm$ 350 g. The mean fetal weight estimated by the clinical method using Johnson's formula was 3060 $\pm$ 320 g, whereas the mean ultrasound-estimated fetal weight using the Hadlock formula was 3180 $\pm$ 330 g.

The clinical method underestimated actual birth weight by a mean of 50 g, whereas ultrasound overestimated actual birth weight by a mean of 70 g. The mean difference between clinical EFW and actual birth weight was - 50 $\pm$ 180 g (p = 0.04), while the corresponding difference for ultrasound EFW was 70 $\pm$ 180 g (p = 0.03).

Table 2
Comparison of Clinical and Ultrasound Estimated Fetal Weight With Actual Birth Weight

Estimation method	Mean EFW $\pm$ SD (g)	Mean difference from ABW $\pm$ SD (g)	p-value
Clinical estimation (Johnson's formula)	3060 $\pm$ 320	-50 $\pm$ 180	0.04
Ultrasound estimation (Hadlock formula)	3180 $\pm$ 330	+ 70 $\pm$ 180	0.03
Actual birth weight	3110 $\pm$ 350	—	—

EFW: estimated fetal weight; ABW: actual birth weight. Paired statistical testing was used to compare estimated fetal weight with actual birth weight. A $p\text{-value} < 0.05$ was considered statistically significant.

Correlation Between Estimated and Actual Birth Weight

Both estimation methods demonstrated significant positive correlations with actual birth weight. The correlation was stronger for ultrasound estimation ($r = 0.89$, $p < 0.001$) than for clinical estimation ($r = 0.76$, $p < 0.001$).

Table 3 Correlation of Estimated Fetal Weight with Actual Birth Weight		
Estimation method	Correlation coefficient (r)	p-value
Clinical estimation	0.76	< 0.001
Ultrasound estimation	0.89	< 0.001

Accuracy Within $\pm 10\%$ of Actual Birth Weight

When accuracy was defined as an estimated fetal weight within $\pm 10\%$ of actual birth weight, ultrasound estimation demonstrated greater accuracy than clinical estimation. Ultrasound EFW was within $\pm 10\%$ of actual birth weight in 157 (78.5%) participants, compared with 124 (62.0%) participants using the clinical method.

Table 4 Accuracy of Clinical and Ultrasound Estimation Within $\pm 10\%$ of Actual Birth Weight		
Estimation method	Within $\pm 10\%$ of ABW, n (%)	Outside $\pm 10\%$ of ABW, n (%)
Clinical estimation	124 (62.0)	76 (38.0)
Ultrasound estimation	157 (78.5)	43 (21.5)

ABW: actual birth weight.

Bland–Altman Analysis

Bland–Altman analysis was performed to assess agreement between estimated fetal weight and actual birth weight. The analysis demonstrated variability in the differences between estimated and actual birth weight, with greater variability observed for clinical estimation than for ultrasound estimation.

The findings indicate that both methods showed some degree of estimation error; however, ultrasound demonstrated better overall correlation and accuracy with actual birth weight. Bland–Altman plots for clinical EFW versus ABW and ultrasound EFW versus ABW are presented in Fig. 1.

Influence of Maternal BMI on Clinical Fetal Weight Estimation

A subgroup analysis was performed to evaluate the influence of maternal BMI on clinical fetal weight estimation. As shown in Table 5, the mean difference between clinical EFW and actual birth weight became progressively more negative with increasing BMI.

Among women with BMI < 25 kg/m², the mean clinical EFW was 3140 ± 310 g, with a mean difference of 30 ± 170 g from actual birth weight. Among women with BMI 25–29.9 kg/m², the corresponding mean clinical EFW was 3060 ± 340 g, with a mean difference of – 60 ± 180 g. In women with BMI ≥ 30 kg/m², the mean clinical EFW was 2980 ± 350 g, with a mean difference of – 130 ± 200 g.

These findings suggest increasing underestimation of fetal weight by the clinical method with increasing maternal BMI.

Table 5
Influence of Maternal BMI on Clinical Fetal Weight Estimation

BMI category (kg/m ²)	Mean clinical EFW ± SD (g)	Mean difference from ABW ± SD (g)	p-value
< 25	3140 ± 310	+ 30 ± 170	0.02
25–29.9	3060 ± 340	–60 ± 180	0.04
≥ 30	2980 ± 350	–130 ± 200	0.03

EFW: estimated fetal weight; ABW: actual birth weight.

Overall Findings

Overall, both clinical and ultrasound methods demonstrated significant positive correlations with actual birth weight. Ultrasound estimation showed a stronger correlation with actual birth weight and a greater proportion of estimates within ± 10% of actual birth weight than clinical estimation. The accuracy of clinical fetal weight estimation decreased with increasing maternal BMI, with greater underestimation observed among women with BMI ≥ 30 kg/m².

DISCUSSION

Accurate estimation of fetal weight near term is an important component of obstetric care because it assists clinicians in anticipating fetal growth abnormalities, counselling women regarding delivery, and planning appropriate intrapartum and neonatal management. In the present prospective cohort of 200 term singleton pregnancies, both clinical estimation using Johnson’s formula and ultrasound estimation using the Hadlock formula showed significant positive correlations with actual birth weight. However, ultrasound demonstrated stronger correlation and better accuracy within ± 10% of actual birth weight than the clinical method.

In the present study, the mean actual birth weight was 3110 ± 350 g, compared with 3060 ± 320 g estimated clinically and 3180 ± 330 g estimated by ultrasound. The clinical method therefore showed a modest tendency toward underestimation, whereas ultrasound showed a modest tendency toward overestimation. The difference between estimated and actual birth weight was statistically significant for both methods. These findings are consistent with previous studies showing that both clinical examination and ultrasonography can provide useful estimates of fetal weight at term, although the magnitude and direction of estimation error vary between populations and clinical settings [1, 2].

The stronger correlation observed with ultrasound in the present study ($r = 0.89$) compared with clinical estimation ($r = 0.76$) is consistent with the established role of biometric ultrasound in antenatal fetal weight estimation. Ultrasound incorporates multiple fetal biometric parameters, including head and abdominal measurements and femur length, and mathematical algorithms such as the Hadlock formula provide an objective approach to estimating fetal weight [3, 4]. Nevertheless, ultrasound-derived fetal weight remains an estimate and can be affected by fetal position, maternal habitus, operator experience, gestational age, and the interval between examination and delivery [4, 5].

The finding that 78.5% of ultrasound estimates were within $\pm 10\%$ of actual birth weight, compared with 62.0% of clinical estimates, further supports the greater precision of ultrasound observed in this cohort. Previous comparative studies have similarly reported better agreement or accuracy with ultrasound than with clinical methods, although the reported differences are not uniform across studies [5–8]. Variations in study population, gestational age, operator expertise, ultrasound equipment, fetal size distribution, and the time interval between estimation and delivery may contribute to these differences.

Importantly, clinical estimation should not be regarded as obsolete despite the greater accuracy observed with ultrasound. Clinical methods remain relevant because they are inexpensive, rapid, and can be performed without specialized equipment. Johnson's formula uses symphysis–fundal height and fetal head station and can therefore provide a practical estimate when ultrasound is unavailable or access is delayed [2, 9]. This is particularly relevant in primary-care, rural, and resource-constrained settings where routine access to ultrasound may be limited. Clinical estimation may also serve as an initial assessment that can identify women who require further evaluation.

The results also have implications for the assessment of fetal growth abnormalities. Accurate identification of fetal growth restriction is important because affected fetuses have increased risks of adverse perinatal outcomes, including stillbirth and neonatal morbidity [10, 11]. Similarly, identification of suspected fetal macrosomia may influence counselling and delivery planning. Current international guidance emphasizes appropriate assessment of fetal growth and the use of ultrasound when clinically indicated, while recognizing that no antenatal estimation method provides perfect prediction of birth weight [12].

Maternal BMI appeared to influence the performance of the clinical method in this study. The mean difference between clinical EFW and actual birth weight changed from $+30 \pm 170$ g among women with $\text{BMI} < 25 \text{ kg/m}^2$ to -60 ± 180 g among those with $\text{BMI} 25\text{--}29.9 \text{ kg/m}^2$ and -130 ± 200 g among women

with BMI ≥ 30 kg/m². Thus, increasing BMI was associated with a progressively greater tendency toward underestimation by the clinical method. Previous studies have also suggested that maternal anthropometric characteristics can influence the accuracy of clinical fetal weight estimation [13, 14]. Increased maternal abdominal adiposity may make palpation of fetal parts and assessment of fundal height less precise, thereby contributing to estimation error.

However, the BMI findings should be interpreted cautiously. The p-values presented in the subgroup analysis represent comparisons between estimated and actual birth weight within each BMI category and do not, by themselves, establish a statistically significant difference in estimation error between BMI categories. A formal comparison of absolute error or percentage error across BMI groups would be required to demonstrate an independent effect of BMI on accuracy. Nevertheless, the progressive increase in underestimation observed in the present data provides a clinically relevant signal that warrants further investigation.

Previous studies have reported variable differences between clinical and ultrasound methods. Some investigations have found ultrasound to provide greater accuracy, whereas others have reported comparable performance between clinical and sonographic estimation, particularly when clinical examination is performed by experienced obstetricians [5–8, 15–18]. Such variation highlights the importance of considering local expertise, patient characteristics, equipment availability, and the clinical context rather than assuming that one estimation method will perform identically across all populations.

The present findings are also consistent with studies evaluating ultrasound estimation against actual birth weight at term. Although ultrasound generally provides better quantitative correlation, its performance is not uniformly accurate across all fetal weight ranges. Estimation errors may become clinically important at the extremes of fetal size, and systematic over- or underestimation can occur depending on the population and formula used [4, 6, 19]. Therefore, an ultrasound-derived fetal weight should be interpreted together with gestational age, growth trajectory, maternal and fetal clinical findings, and other relevant obstetric parameters.

The prospective design and inclusion of 200 term singleton pregnancies are important strengths of this study. Fetal weight estimation was performed before delivery and subsequently compared with the measured birth weight, allowing direct assessment of estimation performance. The study also evaluated both clinical and ultrasound methods within the same cohort, thereby reducing some of the differences that can arise when comparing results from separate populations.

Several limitations should be considered. First, the study was conducted at a single tertiary-care hospital, which may limit generalizability to other populations and healthcare settings. Second, ultrasound measurements may be influenced by operator-related variability, particularly when examinations are performed by more than one radiologist. Standardization of sonographic measurements and documentation of interobserver variability would strengthen future studies. Third, the study included only term singleton pregnancies and therefore the findings may not apply to preterm pregnancies, multiple gestations, or pregnancies complicated by significant fetal growth restriction. Fourth, although BMI

subgroup findings suggest increasing clinical underestimation with increasing maternal BMI, the present analysis does not establish an independent causal effect of BMI.

Future studies should include larger and more diverse populations, including women from rural and primary-care settings, and should evaluate fetal weight estimation across a broader range of gestational ages and birth weights. Standardized ultrasound protocols, assessment of interobserver variability, and analysis of absolute and percentage errors across BMI categories would provide additional information regarding method performance. Development and validation of simple digital or algorithm-based clinical tools may also help improve clinical fetal weight estimation where ultrasound access is limited.

Overall, the findings support ultrasound as the more accurate method for antenatal fetal weight estimation in this cohort, while also demonstrating that clinical estimation using Johnson's formula remains a useful and feasible alternative. The two approaches should therefore be considered complementary rather than mutually exclusive. In settings where ultrasound is readily available, it may provide a more precise estimate, particularly when accurate assessment is clinically important. Where ultrasound is unavailable or inaccessible, a standardized clinical method can continue to provide useful information for obstetric decision-making.

Conclusion

In this prospective cohort of term singleton pregnancies, both clinical and ultrasound methods showed significant correlation with actual birth weight. Ultrasound estimation using the Hadlock formula demonstrated stronger correlation and a higher proportion of estimates within $\pm 10\%$ of actual birth weight than Johnson's clinical method. Increasing maternal BMI was associated with greater underestimation by the clinical method in the observed subgroup analysis. Ultrasound should therefore be preferred when available, while clinical estimation remains a practical and valuable approach in resource-constrained settings.

Declarations

Ethics Approval and Consent to Participate

The study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Ethical approval was obtained from the Institutional Ethics Committee of Vardhman Mahavir Medical College and Safdarjung Hospital, New Delhi (IEC/VMMC/SJH/Thesis/06/2022/CC-150). Written informed consent was obtained from all participants before enrolment in the study.

Consent for Publication

Not applicable. No individually identifiable participant information or images are presented in this manuscript.

Competing Interests

The authors declare that they have no competing interests.

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Authors' Contributions

GRSP: Conceptualization, methodology, data collection, analysis, and manuscript drafting.

US: Supervision, clinical oversight, methodology, and critical revision.

YA: Ultrasound assessment, data interpretation, and critical revision.

ASL: Methodology, data analysis, interpretation, manuscript drafting, and critical revision.

SP: Data collection, management, statistical analysis, and manuscript revision.

All authors approved the final manuscript and agreed to be accountable for the work.

Availability of Data and Materials

The datasets generated and/or analysed during the current study are available from the corresponding author on reasonable request, subject to institutional and ethical restrictions.

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Figures

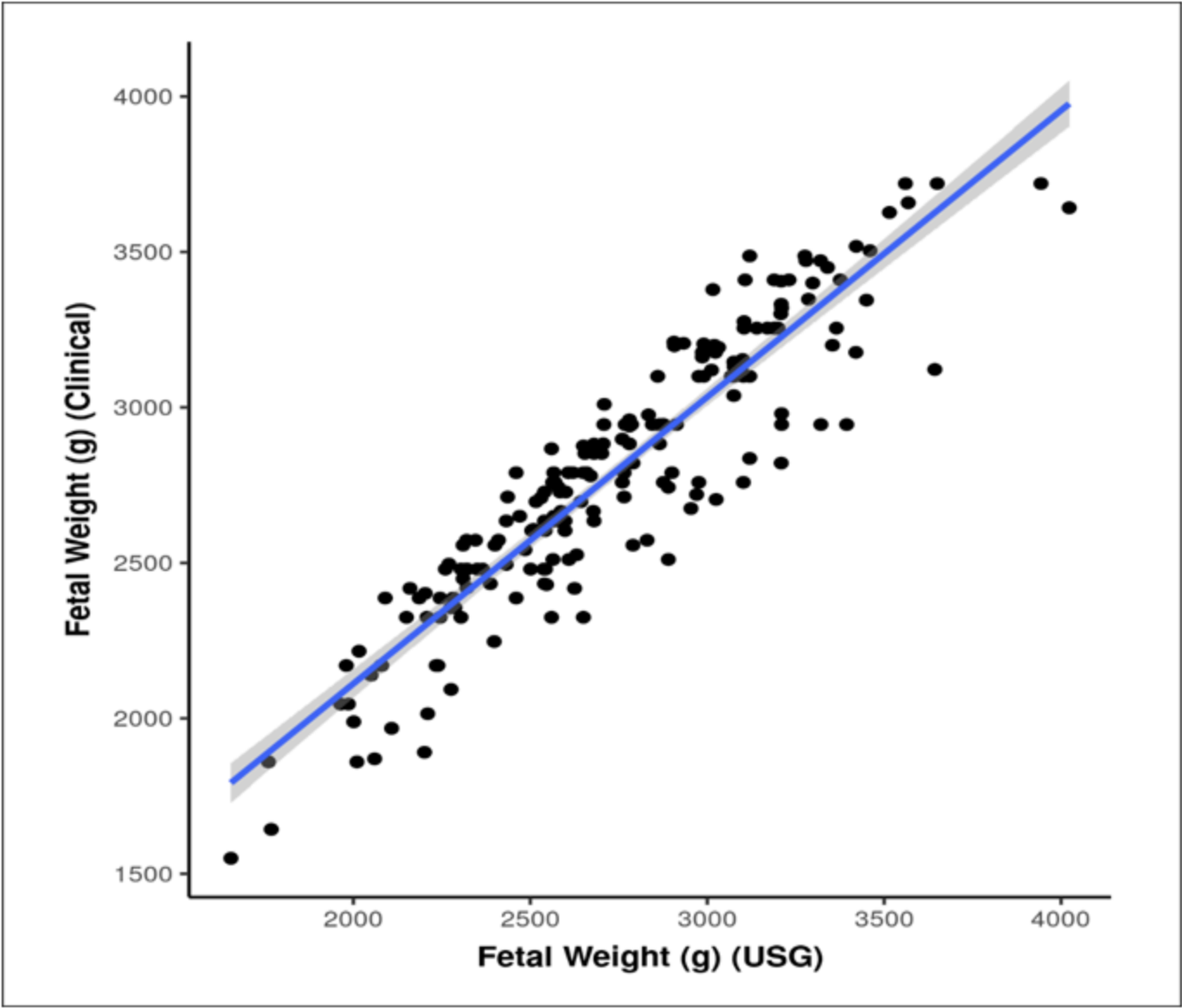


Figure 1

Bland–Altman plots for clinical EFW versus ABW and ultrasound EFW versus ABW

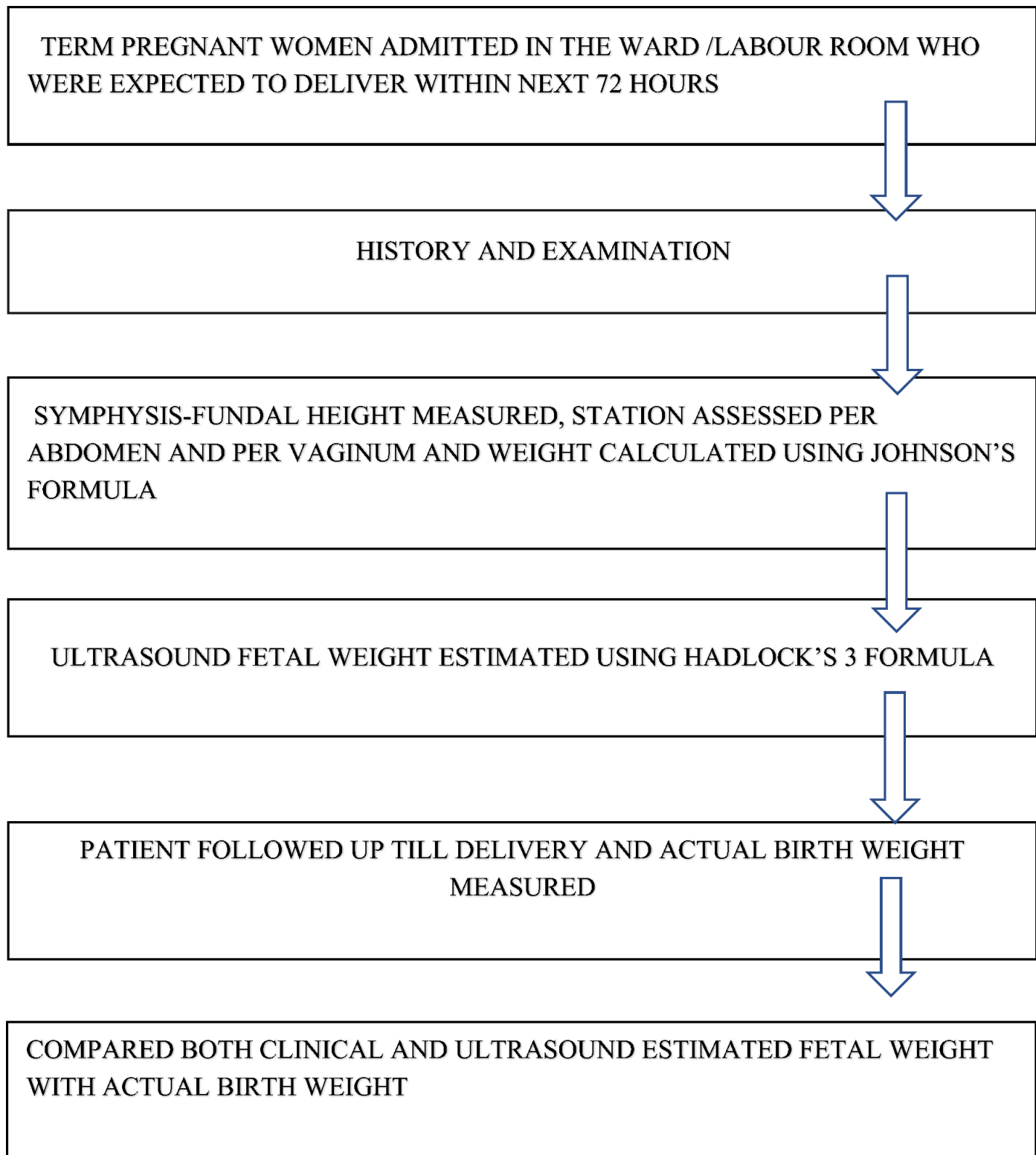


Figure 2

Unnumbered image in the Materials And Methods Section