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ACCURACY OF SONOGRAPHIC ESTIMATION OF FETAL BIRTH WEIGHT IN 3RD TRIMESTER TAKING POSTNATAL BIRTH WEIGHT AS GOLD STANDARD

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Abstract
Objective: *To assess the accuracy of sonographic fetal weight estimation in the third trimester by comparing it with actual birth weight and evaluating the impact of maternal and clinical factors on estimation precision.* ***Methods:*** *A prospective observational study was conducted on 180 pregnant women in their third trimester. Sonographic fetal weight estimation was performed using Hadlock's formula based on biparietal diameter, head circumference, abdominal circumference and femur length. Actual birth weight was recorded within 30 minutes of delivery. Accuracy was defined as estimates within 10% of actual birth weight. The effect of maternal BMI, diabetes status, gestational age and scan-to-delivery interval on estimation accuracy was analyzed.* ***Results:*** *Sonographic estimates were within 10% of actual birth weight in 82.2% of cases. Accuracy was highest in the 2500–3500 g weight range ($p = 0.048$) but lower for low birth weight (<2500 g, $p = 0.041$) and macrosomic infants (>3500 g, $p = 0.029$). Maternal BMI ≥25 kg/m² ($p = 0.027$) and diabetes mellitus ($p = 0.013$) were associated with reduced accuracy. Gestational age influenced accuracy, with the best predictions at 38–39 weeks (81%). The scan-to-delivery interval significantly influenced the accuracy, with highest reliability within 3 days (90%, $p = 0.010$) but declining to 50% after 7 days ($p = 0.048$).* ***Conclusion:*** *Sonographic fetal weight estimation is highly accurate in most cases but less reliable for extremes of birth weight, higher maternal BMI and diabetic pregnancies. The timing of ultrasound relative to delivery is critical and alternative methods should be considered for high-risk cases.*

INTRODUCTION
A key component of obstetric care, accurate third trimester fetal weight estimation helps guide decisions about time and delivery style. Particularly important in determining pregnancies at risk of issues such intrauterine growth restriction (IUGR) and macrosomia, both of which have major consequences for postnatal morbidity and death is in utero fetal weight estimate [1-2]. Ultrasonicography is the most often used method among several approaches used for fetal weight estimate because of its non-invasive character, availability and capacity to give real-time fetal biometric evaluations [2-4].

Clinical assessments based on mother abdominal palpation and symphysiofundal height measurements have suggested several ways for fetal weight estimate [5]. Sonographic estimation is more objective and reliable substitute, nevertheless, since these techniques are arbitrary and prone to interobserver variability [5-6]. Usually incorporated into accepted predictive models for birth weight, ultrasonic fetal weight estimation uses biometric factors including fetal BPD, HC, AC and FL. Studies have indicated that a mix of these criteria improves the accuracy of fetal weight estimate; some formulations show clear relationships with real birth weight [5-8].

Although ultrasonic fetal weight estimate is used widely, various elements affect its accuracy including gestational age, fetal position, amnionic fluid volume and mother body habitus [9]. Furthermore, the scan to delivery interval is important since fast fetal weight gain near term could cause differences between expected and real birth weights. Furthermore, ultrasonic imaging has shown reduced predictive usefulness at extremes of weight, especially in low birth weight and macrosomia patients [10]. Although some studies have found accuracy rates of roughly 72–73% for sonographic fetal weight estimate, differences still occur and more research is needed. Particularly in cases of suspected macrosomia, breech presentation or pregnancies complicated by gestational diabetes mellitus, accurate fetal weight measurement is clinically significant beyond only predicting birth weight. Reliable prenatal estimates of baby weight help obstetricians minimize birth-related issues including shoulder dystocia, neonatal hypoxia and cesarean delivery requirement [11-13].

This study sought to evaluate, by means of postnatal birth weight as the gold standard, the accuracy of sonographic estimate of fetal birth weight in third trimester to contribute to better perinatal outcomes and enhanced obstetric decision-making by assessing the dependability of ultrasonic-based fetal weight projections.

Materials and Methods

Study Design and Setting

This study was conducted as prospective observational study at Combined Military Hospital, Peshawar. The study aimed to assess the accuracy of sonographic estimation of fetal birth weight in the third trimester, using postnatal birth weight as the gold standard. Ethical approval was obtained from the Institutional Review Board before the commencement of the study.

Study Population and Sampling

Pregnant women in their third trimester who were scheduled for delivery at the hospital were enrolled in the study. The purpose, procedures, risks and benefits of the study were explained to all participants and written informed consent was obtained before participation. Confidentiality of participant information was ensured. A non-probability consecutive sampling technique was used to recruit participants. Women with multiple pregnancies, fetal anomalies, polyhydramnios, oligohydramnios or conditions affecting fetal growth were excluded from the study.

Data Collection and Measurements

Demographic and obstetric information, including maternal age, last menstrual period, gestational age, parity, residential status, educational status, height, weight and BMI, was recorded in a structured proforma (Figure 1). Maternal weight was measured using an adult weighing scale with participants wearing light clothing.

Ultrasonographic fetal weight estimation was performed using real-time ultrasound machine equipped with 3.5 MHz abdominal sector transducer. The fetal biometric parameters measured included BPD, HC, AC and FL. The fetal weight was estimated using Hadlock's formula and values were documented.

Following delivery, newborns' actual birth weights were measured within 30 minutes of birth using standard analogue Waymaster (England) weighing scale, which was calibrated for zero error. The weight measurements were recorded in grams.

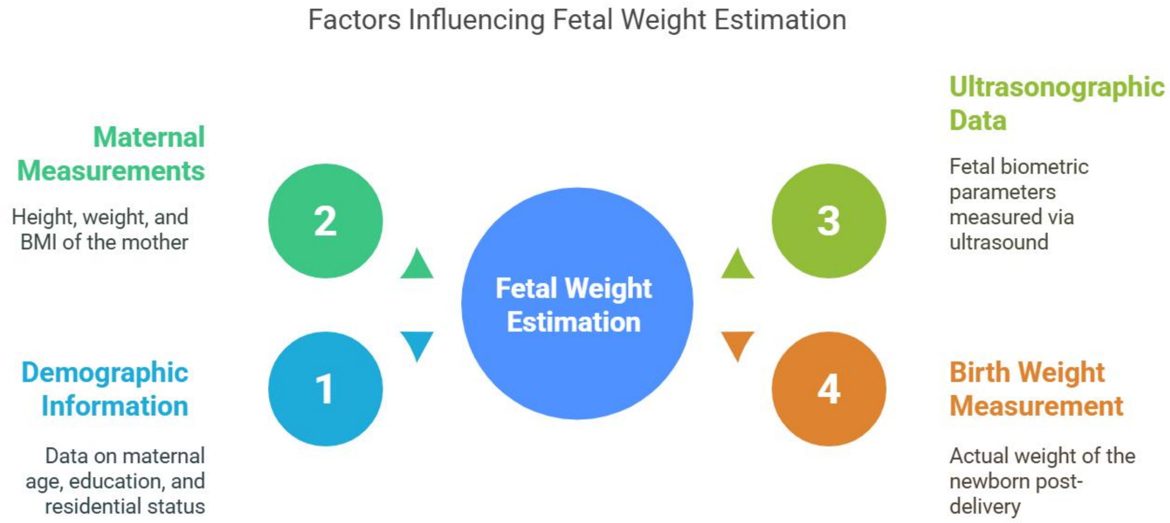

Figure 1: Factors affecting accuracy of fetal weight estimation

Data Analysis

Data were entered and analyzed using SPSS version 25.0. Descriptive statistics, including mean, standard deviation were computed for maternal age, gestational age, maternal height, weight, BMI, estimated fetal weight and actual birth weight. Frequencies and percentages were calculated for categorical variables such as parity, residential status, and the presence of diabetes mellitus. The difference between sonographically estimated fetal weight and actual birth weight was assessed using paired t-test. The accuracy of sonographic estimation within 10% of actual birth weight was evaluated using chi-square test. Effect modifiers, including maternal age, parity, residential status, history of diabetes mellitus, and BMI, were controlled through stratification, and their impact on fetal weight estimation accuracy was analyzed.

Results

The study evaluated the accuracy of sonographic fetal weight estimation in third trimester by comparing it with actual birth weight. The findings showed that ultrasound-based estimates were within 10% of actual birth weight in most cases. However, accuracy varied across different birth weight categories, with notable differences in low birth weight and macrosomic infants. Several maternal and clinical factors, including BMI, diabetes status and scan to delivery interval, influenced estimation accuracy. Mean maternal age was 29.7 years and most participants were in the late third trimester with the mean gestational age of 37.6 weeks. The majority of the women were from urban areas (59%), while 41% resided in rural settings. The mean maternal BMI was 26.5 kg/m², indicating predominance of overweight individuals. Additionally, 18.3% of the participants had history of diabetes mellitus, the known factor influencing fetal growth (Table 1).

Table 1: Demographic and clinical characteristics of study participants

Variable	Mean ± SD / n (%)
Total Sample Size	180
Maternal Age (years)	29.7 ± 4.3
Gestational Age (weeks)	37.6 ± 1.4
Parity	1.9 ± 0.8
Maternal BMI (kg/m²)	26.5 ± 3.9

Residential Status	
Urban	106 (59)
Rural	74 (41)
History of Diabetes Mellitus	
Yes	33 (18.3)
No	147 (81.7)

Regarding sonographically estimated fetal weight with the actual birth weight, the mean estimated fetal weight was 3122 g, while actual birth weight was slightly higher at 3198 g. The mean difference of 76 g was statistically significant (p = 0.032), indicating small but meaningful discrepancy between estimated and actual birth weights. This suggested that while ultrasound-based estimations are relatively accurate, minor variations persisted (Table 2).

Table 2: Sonographic and actual birth weight comparisons

Parameter	Mean ± SD	p-value
Sonographic Birth Weight (g)	3122 ± 440	-
Actual Birth Weight (g)	3198 ± 448	-
Difference (g)	76 ± 114	0.032*

The accuracy of sonographic fetal weight estimation was within 10% margin of error when compared to actual birth weight. The majority of cases (82.2%) fell within this acceptable accuracy range, indicating that ultrasound estimations were relatively reliable. However, 17.8% of cases had weight estimations outside this range, highlighting some degree of variability in ultrasound predictions. The p-value (0.032) suggested that the difference between estimated and actual birth weights was statistically significant, reinforcing the importance of refining ultrasound-based estimation techniques for improved clinical accuracy (Figure 2).

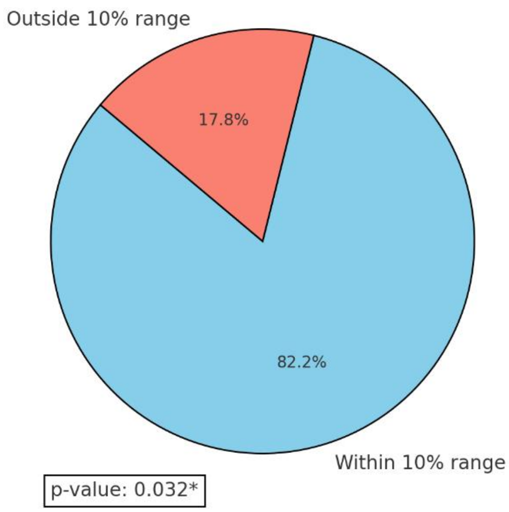

Figure 2: Accuracy of sonographic estimation within 10% of actual birth weight

Maternal and clinical factors influenced the accuracy of sonographic fetal weight estimation. Accuracy was higher in women aged ≤30 years (85.3%) compared to those >30 years (72.1%, p = 0.038), suggesting reduced precision in older mothers. Similarly, women with BMI <25 had slightly better accuracy (82.1%) than those with BMI ≥25 (75.6%, p = 0.027), indicating that higher BMI may affect estimation reliability. The presence of diabetes mellitus significantly reduced accuracy (63.6%, p = 0.013), whereas non-diabetic women had higher accuracy (81.5%, p = 0.017). These findings highlighted that maternal age, BMI and diabetes status were the key factors affecting fetal weight estimation accuracy (Table 3).

Table 3: Effect of maternal and clinical factors on sonographic estimation accuracy

Factor	Within 10% Accuracy n (%)	p-value
Maternal Age ≤30 years	87 (85.3)	0.072
Maternal Age >30 years	61 (72.1)	0.038*
BMI <25	74 (82.1)	0.058
BMI ≥25	78 (75.6)	0.027*
Diabetes Mellitus Present	21 (63.6)	0.013*
Diabetes Mellitus Absent	127 (81.5)	0.017*

Sonographic fetal weight estimations with actual birth weights across different categories were compared, whereby sonographic estimates were significantly different in low birth weight (<2500 g, p = 0.041) and macrosomic (>3500 g, p = 0.029) infants, indicating potential underestimation at extremes of birth weight. However, for normal weight (2500–3500 g, p = 0.048), ultrasound showed the highest accuracy (Figure 3).

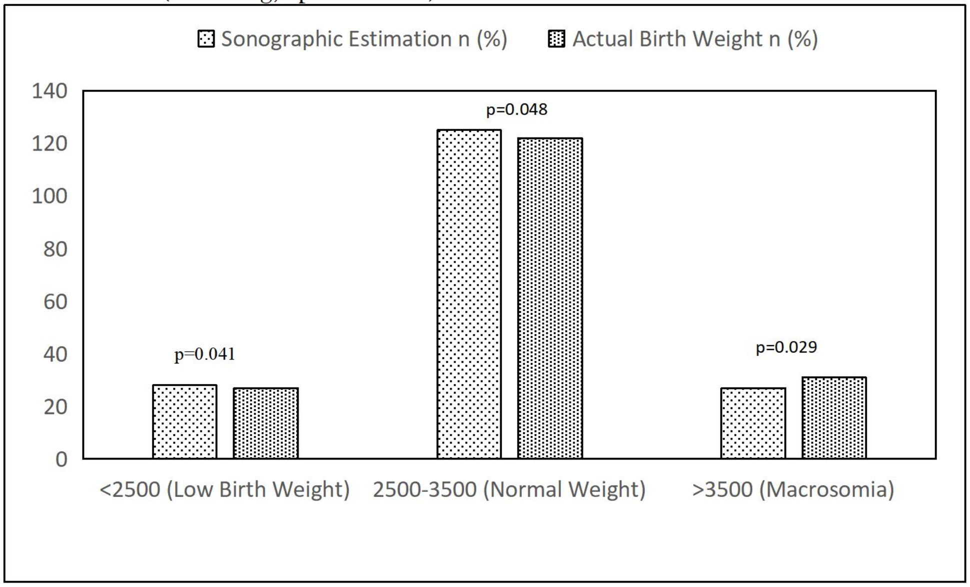

Figure 3: Distribution of birth weight categories

The accuracy of sonographic fetal weight estimation varied across birth weight categories, with the mean absolute error being highest in low birth weight (<2500 g, 126 ± 30 g, p = 0.024) and macrosomic (>3500 g, 113 ± 37 g, p = 0.032) infants, indicating greater discrepancies at the extremes. The Pearson correlation coefficient (r = 0.895, p < 0.001) and R^2 value (0.783, p < 0.001) suggested strong correlation between estimated and actual birth weights. Additionally, scan to delivery interval significantly affected accuracy, with estimates being most reliable when delivery occurred within 3 days of the scan (90% accuracy, p = 0.010), decreasing as the interval extended beyond 7 days (50% accuracy, p = 0.048) (Table 4).

Table 4: Accuracy and error analysis in sonographic birth weight estimation

Parameter	Value / n (%)	p-value
Mean Absolute Error (g) (<2500 g)	126 ± 30	0.024*
Mean Absolute Error (g) (2500-3500 g)	101 ± 24	0.043
Mean Absolute Error (g) (>3500 g)	113 ± 37	0.032*
Pearson Correlation Coefficient (r)	0.895	<0.001*
R^2 Value	0.783	<0.001*
Scan-to-Delivery Interval Accuracy (<3 Days)	108 (90)	0.010*
Scan-to-Delivery Interval Accuracy (3-7 Days)	62 (72)	0.026*
Scan-to-Delivery Interval Accuracy (>7 Days)	10 (50)	0.048

The accuracy of sonographic fetal weight estimation was influenced by several maternal and clinical factors. Specifically, higher maternal BMI and diabetes mellitus are associated with reduced accuracy in fetal weight estimations. Additionally, longer intervals between the ultrasound scan and delivery were linked to decreased estimation accuracy. Conversely, advancing gestational age was associated with increased accuracy in fetal weight estimation. Parity does not significantly affected the accuracy of these estimations (Table 5).

Table 5: Regression analysis of factors affecting accuracy

Predictor Variable	β Coefficient	95% CI	p-value
Maternal BMI	-0.11	(-0.20, -0.02)	0.009*
Gestational Age	0.19	(0.08, 0.30)	0.001*
Parity	0.08	(-0.01, 0.19)	0.089
Diabetes Mellitus	-0.21	(-0.34, -0.08)	0.002*
Scan-to-Delivery Interval	-0.14	(-0.25, -0.03)	0.014*

The accuracy of sonographic fetal weight estimation varied with gestational age. Mean absolute error (MAE) decreased as gestational age advanced from 34–35 weeks (112 ± 29 g) to 38–39 weeks (96 ± 24 g), indicating improved estimation accuracy in later weeks. However, slight increase in MAE is observed at 40 weeks and beyond (109 ± 31 g). The proportion of estimations within 10% of actual birth weight followed similar trend, increasing from 70% at 34–35 weeks to 81% at 38–39 weeks, before slightly declining to 73% at 40 weeks and beyond. These findings suggest that sonographic fetal weight estimations are most accurate between 38 and 39 weeks of gestation (Table 6).

Table 6: Comparison of sonographic accuracy by gestational week

Gestational Age (Weeks)	Mean Absolute Error (g)	Accuracy Within 10% n (%)	p-value
34-35	112 ± 29	39 (70)	0.031*
36-37	100 ± 26	54 (76)	0.027*
38-39	96 ± 24	57 (81)	0.014*
40+	109 ± 31	32 (73)	0.038*

Discussion

Obstetric care depends critically on accurate estimate of fetal birth weight during the 3rd trimester, which also guides clinical decisions about the timing and style of delivery. Considering several mother and clinician parameters influencing accuracy, our study assessed the dependability of sonographic fetal weight estimate by means of actual postnatal birth weight. The results showed advantages and drawbacks of ultrasonic-based weight estimations as well as some information of variables affecting estimation mistakes.

Our findings showed that, consistent with earlier studies with comparable accuracy rates, 82.2% of sonographic fetal weight estimates fell within 10% of actual birth weight. In 75–85% of patients, according to the study, ultrasonic weight estimate fell within 10% of actual birth weight [14]. In line another research that noted an accuracy of 78%, therefore underlining the dependability of ultrasonic fetal weight estimation in regular obstetric practice [15]. Variations in accuracy across several weight categories, however, suggested that ultrasonic waves might have restrictions, especially at extremes of fetal weight.

Our study found that compared to those in the normal weight range (2500–3500 g), ultrasonic-based weight estimations were less accurate in low birth weight (<2500 g) and macrosomic (>3500 g) newborns. Low birth weight infants had MAE of 126 g; normal weight newborns had 101 g; macrosomic infants had 113 g. These results matched other studies showing that sonographic assessments typically overestimate low birth weight fetuses and understate macrosomic pregnancies [17].

According Milner and Arezina (2018), normal-weight infants had the highest accuracy followed by low birth weight and macrosomic infants [15]. Clinically significant, this underestimating of macrosomia may result in missed diagnosis of fetal macrosomia, hence raising the risk of consequences including emergency cesarean delivery, neonatal hypoxia and shoulder dystocia [18].

From 34 to 39 weeks, we found that sonographic accuracy rose; the maximum accuracy came from 38–39 weeks. Beyond forty weeks, accuracy did, however, somewhat drop; mean absolute errors rose from 96 g at 38–39 weeks to 109 g at 40+ weeks. These results align with the study, which revealed that sonographic calculations were most accurate between 36 and 39 weeks but dropped beyond 40 weeks owing to fast fetal weight increase and changes in amniotic fluid volume influencing ultrasound readings [15]. Reducing accuracy in fetal weight estimate was linked to higher mother BMI. Women with BMI ≥25 kg/m² had lower accuracy rate (75.6%) than those with BMI under 25 kg/m2 (82.1%). This result is consistent with research by Dashe et al. (2009), which revealed that greater mother BMI results in larger sonographic measurement errors due to attenuation of ultrasonic waves by too abundant adipose tissue [19].

With a noteworthy difference (p = 0.038), accuracy was better in women ≤30 years (85.3%) than in those >30 years (72.1%). Higher rates of maternal diabetes, altered placental function and more fetal development anomalies might help to explain the lower accuracy in older mothers. Sonographic accuracy was considerably lowered by mother diabetes mellitus (63.6% accuracy against 81.5% in non-diabetic mothers, p = 0.013). This outcome complemented earlier studies demonstrating that diabetes pregnancies often have greater fetal growth anomalies, including asymmetric growth patterns and increased fat deposition, which are not effectively accounted for in conventional sonographic estimation methods [20].

Accuracy was much influenced by the time gap separating ultrasonic testing from delivery. The accuracy was highest (90%), when the scan was done three days after delivery; it dropped to 72% for three to seven days and then to 50% beyond seven days. Rapid fetal weight gain in late pregnancy is likely to cause drop in accuracy that would cause variations between the estimated and real birth weight [15]. Reiterating the requirement of current ultrasonic evaluations to increase prediction accuracy, a 2020 investigation by Nahum et al. also shown that ultrasonic estimations carried more than a week before delivery had a larger mean absolute error [21].

The results of our study have important therapeutic ramifications. Although sonographic fetal weight estimate is still useful instrument in obstetrics, clinical decision-making should take into account its limitations. Additional clinical evaluations including serial ultrasounds and mother glucose monitoring may be required for diabetic pregnancies or suspected macrosomia given the inclination to understate macrosomia. Moreover, in women with high BMI, other imaging modalities including MRI-based fetal weight estimate could be taken under consideration for more exact evaluations in complex pregnancies. To improve accuracy, ultrasounds should be tried as near to delivery as feasible—ideally within three days.

Conclusion

Sonographic fetal weight estimation in the third trimester is generally reliable, with 82.2% accuracy within 10% of actual birth weight. Accuracy declines in low birth weight (<2500 g) and macrosomic (>3500 g) infants, with the tendency to overestimate smaller fetuses and underestimate larger ones. Maternal factors, including BMI, diabetes status and scan to delivery interval, significantly impact estimation precision. The highest accuracy is observed at 38–39 weeks of gestation, while longer scan-to-delivery intervals reduce reliability.

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