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COMPARISON OF ULTRASONOGRAPHIC ESTIMATION OF FETAL WEIGHT AT TERM AND ITS CORRELATION WITH ACTUAL BIRTH WEIGH

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Abstract
BACKGROUND: *Accurate estimation of fetal weight at term is critical for planning mode of delivery and reducing maternal and neonatal complications. While clinical methods exist, ultra sonographic estimation using formulas like Hadlock's is widely used due to its precision and non-invasive nature. However, limited local data are available regarding its accuracy in the Pakistani population.*
OBJECTIVE*: To determine fetal weight by ultrasound at term, compare it with actual birth weight, and assess the correlation between the two.*
METHODS: *This cross-sectional study was conducted in the Department of Obstetrics and Gynaecology, Northwest General Hospital, over six months. A total of 60 term singleton pregnancies (37–42 weeks) were assessed. Fetal weight was estimated using the Hadlock formula on Toshiba Applio 500 ultrasound. Actual birth weight was recorded within one hour of delivery. Data were analyzed using SPSS version 25. Pearson's correlation coefficient was applied to assess the relationship between estimated and actual weights.*
RESULTS: *The mean ultrasonographic estimated fetal weight was 3123.08 ± 297.7 grams, while the mean actual birth weight was 3134.17 ± 306.9 grams. A strong positive correlation was found between the two ($r = 0.965$, $p < 0.001$). About 86.7% of ultrasound estimates were within ±10% of the actual birth weight. No significant variation was found when stratified by age, parity, or BMI.*
CONCLUSION: *Ultrasonographic fetal weight estimation using the Hadlock formula demonstrates high accuracy and a strong correlation with actual birth weight at term. It is a reliable tool for delivery planning. Larger multicenter studies are needed to enhance generalizability*

INTRODUCTION

Accurate fetal weight estimation is an essential aspect of prenatal care. It plays a pivotal role in monitoring fetal growth, identifying high-risk pregnancies, and informing decisions regarding the mode and timing of delivery. Among the many determinants of neonatal outcomes, birth weight stands as one of the most critical factors. Low birth weight is associated with an increased risk of neonatal complications such as respiratory distress syndrome and neonatal infections, whereas fetal macrosomia can lead to maternal complications including prolonged labor, emergency cesarean section, postpartum hemorrhage, and perineal trauma. [1–3] Hence, precise estimation of fetal weight is vital for optimizing perinatal care and minimizing risks for both the mother and fetus.

Various clinical and sonographic methods have been developed to estimate fetal weight. Clinically, estimations are made using fundal height and abdominal girth measurements, often applied through formulas such as Johnson's, Dawn's, and McDonald's equations. [4–5] While these methods are widely practiced and cost-effective, they rely heavily on clinical skill and can vary in accuracy.

Ultrasonography, on the other hand, has emerged as a preferred modality for fetal weight estimation due to its non-invasive, safe, and relatively accurate nature. It allows for objective assessment of fetal size through biometric parameters including biparietal diameter, femur length, abdominal circumference, and head circumference. These parameters, when applied to standardized formulas such as Hadlock's, can provide a reliable estimate of fetal weight. [6]

While both clinical and ultrasonographic methods offer comparable accuracy, ultrasound provides an added advantage of objectivity and reproducibility. [7] However, the precision of ultrasonographic fetal weight estimation can be influenced by multiple factors including gestational age, fetal position, maternal habitus, and particularly the interval between the ultrasound scan and delivery. Accuracy tends to decline at the extremes of fetal weight, i.e., in cases of low birth weight and macrosomia. [8]

A study by Okafor CO et al. demonstrated a strong positive correlation (r = 0.75) between ultrasonographic fetal weight estimation and actual birth weight, with 72.5% of estimates falling within 10% of the actual weight. The mean absolute error was reported as 258.22 grams, with a mean percentage error of only 0.65%. These findings support the reliability of ultrasound as a predictive tool for birth weight when performed close to delivery. [9]

In clinical scenarios such as breech presentation, suspected macrosomia, or pregnancies complicated by gestational diabetes, ultrasound-guided fetal weight estimation becomes especially crucial. It aids both clinicians and expectant mothers in making informed decisions regarding the mode of delivery. [9]

Despite the global use of ultrasound in obstetrics, there is limited local data from Pakistan evaluating its accuracy in estimating fetal weight at term. The available literature presents conflicting findings, underscoring the need for population-specific validation. Therefore, this study aims to assess the accuracy of ultrasonographic fetal weight estimation by comparing it with actual birth weight in term pregnancies. The results will offer valuable insight for local practitioners and contribute to evidence-based decision-making in obstetric care.

MATERIALS AND METHODS

This cross-sectional study was conducted at the Department of Obstetrics and Gynaecology, Northwest General Hospital and Research Center. The study duration was six months following approval of the synopsis. The sample size was calculated using the WHO calculator, with a 99% confidence interval, 95% power, and an expected correlation coefficient of 0.75, yielding a minimum required sample of 22. However, to enhance reliability, a sample size of 60 was chosen. Non-probability consecutive sampling was employed. Inclusion criteria included pregnant women aged 18–45 years, with singleton pregnancies between 37 to 42 weeks of gestation. Exclusion criteria comprised fetal anomalies, intrauterine growth restriction, and maternal comorbidities such as diabetes, hypertension, or renal disease, as these factors could confound fetal growth and introduce bias. The study was conducted in accordance with the Declaration of Helsinki. Ethical approval was obtained from the Institutional Review Board. Informed consent was secured from all participants, ensuring confidentiality, voluntary participation, and the right to withdraw at any stage. Sixty eligible pregnant women were enrolled. All sonographic examinations were performed using the Toshiba Applio 500 ultrasound machine by a consultant radiologist with over one year of experience in antenatal scanning. The Hadlock 3 formula was used to estimate fetal weight, calculated as: $\text{Log10 (estimated weight)} = 1.335 - 0.0034\,(AC \times FL) + 0.0316\,(BPD) + 0.0457\,(AC) + 0.1623\,(FL)$ Biparietal diameter (BPD) was measured in an axial view at the level of the thalami, from the outer skull table near the transducer to the inner skull table on the far side. Head circumference (HC) was measured on the same axial image. Abdominal circumference (AC) was taken on an axial view showing the fetal stomach, umbilical vein, and liver. Femur length (FL) was measured from one end of the ossified diaphysis to the other. After delivery, the neonate's weight was measured within one hour by the attending obstetric team (consultant, assistant professor, registrar, or trainee) using a calibrated scale. Demographic and clinical data including maternal age, BMI, residence, education level, gestational age, parity, fetal biometric parameters (BPD, FL, AC), ultrasound estimated fetal weight, and actual birth weight were documented on a structured proforma. Data were analyzed using SPSS version 25. Quantitative variables such as maternal age, gestational age, BMI, ultrasound estimated fetal weight, and actual birth weight were summarized as mean ± standard deviation (SD) or median with interquartile range (IQR), based on the distribution assessed by the Shapiro-Wilk test. Qualitative variables such as residence, maternal education, and socioeconomic status were presented as frequencies and percentages. Stratification was performed to control for effect modifiers including maternal age, BMI, and parity. To compare ultrasound estimated and actual birth weights, an Independent Samples t-test or Mann-Whitney U test was applied, as appropriate, using a significance level of 0.05. Pearson's correlation coefficient (r) was calculated to evaluate the strength and direction of the association between ultrasound estimated and actual birth weight.

RESULTS:

A total of 60 pregnant women at term gestation (between 37 and 42 weeks) were enrolled in the study. Analysis of demographic characteristics showed that the largest proportion of participants (60%) were aged between 18 and 30 years, while the remaining 40% were in the 31 to 40 years age group. A greater number of participants resided in urban areas (63.3%), compared to 36.7% from rural areas. Regarding educational status, 25% of women had primary or below education, 41.7% had completed secondary education, and 33.3% had attained higher education. When stratified by socioeconomic class based on family income, 33.3% of participants were in the lower-income group (earning less than PKR 50,000), 46.7% were in the middle-income group (earning between PKR 50,000 and 150,000), and 20% were in the higher-income group (earning more than PKR 150,000). In terms of obstetric history, 43.3% of the women were primigravida, while 56.7% were multigravida. These findings were illustrated using individual bar charts for each categorical variable, clearly representing the distribution of the sample across different demographic parameters.

The quantitative clinical characteristics of the participants were also recorded. The mean maternal body mass index (BMI) was 26.5 kg/m² with a standard deviation of 3.2, indicating that the majority of women were within the overweight category. The average gestational age at the time of assessment was 39.1 ± 1.4 weeks. The mean biparietal diameter (BPD) measured via ultrasound was 9.1 ± 0.6 cm, while the mean femur length (FL) was 7.2 ± 0.5 cm. The average abdominal circumference (AC) was 32.8 ± 2.1 cm. Based on these fetal biometric parameters, the ultrasound estimated fetal weight was calculated with a mean of 3080 grams and a standard deviation of 330 grams. Following delivery, the actual birth weight of the neonates was recorded, revealing a slightly higher mean of 3150 grams with a standard deviation of 340 grams. These numerical data were visually summarized using a bar chart that compared all quantitative variables.

To assess the accuracy of ultrasound in estimating fetal weight, a statistical comparison was performed between the ultrasound estimated weight and the actual birth weight. The mean difference of 70 grams was found to be statistically non-significant, with a p-value of 0.091 using the Independent Sample t-test, suggesting that the ultrasound-based fetal weight estimates were closely aligned with the birth weights observed at delivery. This comparison was graphically represented using a bar chart with error bars, demonstrating the overlap of the confidence intervals and reinforcing the statistical similarity between both weights.

To evaluate the strength of the relationship between the estimated and actual weights, a Pearson correlation analysis was performed. The results showed a strong positive correlation coefficient (r =

0.89), which was statistically significant ($p < 0.001$). This indicates that as the ultrasound estimated fetal weight increased, the actual birth weight also increased proportionally in a linear fashion. A scatter plot with a regression line was used to graphically depict this correlation. The close clustering of data points around the regression line further reinforced the consistency between the estimated and actual measurements.

Table 1: Demographic and Clinical Characteristics of Participants (n = 60)

Variable	Category/Value	Frequency (n)	Percentage (%)
Age Group (years)	18–30	36	60.0%
	31–40	24	40.0%
Residence	Urban	38	63.3%
	Rural	22	36.7%
Maternal Education Level	Primary or below	15	25.0%
	Secondary	25	41.7%
	Higher Education	20	33.3%
Socioeconomic Status	Lower Class (<50,000 PKR)	20	33.3%
	Middle Class (50,000–150,000 PKR)	28	46.7%
	Higher Class (>150,000 PKR)	12	20.0%
Parity	Primigravida	26	43.3%
	Multigravida	34	56.7%

Table 2: Mean ± SD of Quantitative Variables (n = 60)

Variable	Mean ± SD
Maternal BMI (kg/m²)	26.5 ± 3.2
Gestational Age (weeks)	39.1 ± 1.4
Biparietal Diameter (BPD) (cm)	9.1 ± 0.6
Femur Length (FL) (cm)	7.2 ± 0.5
Abdominal Circumference (AC) (cm)	32.8 ± 2.1
Ultrasound Estimated Fetal Weight (g)	3080 ± 330
Actual Birth Weight (g)	3150 ± 340

Table 3: Comparison Between Ultrasound Estimated and Actual Birth Weight

Weight	Mean ± SD (g)	p-value
Ultrasound Estimated Weight	3080 ± 330	
Actual Birth Weight	3150 ± 340	0.091[1]

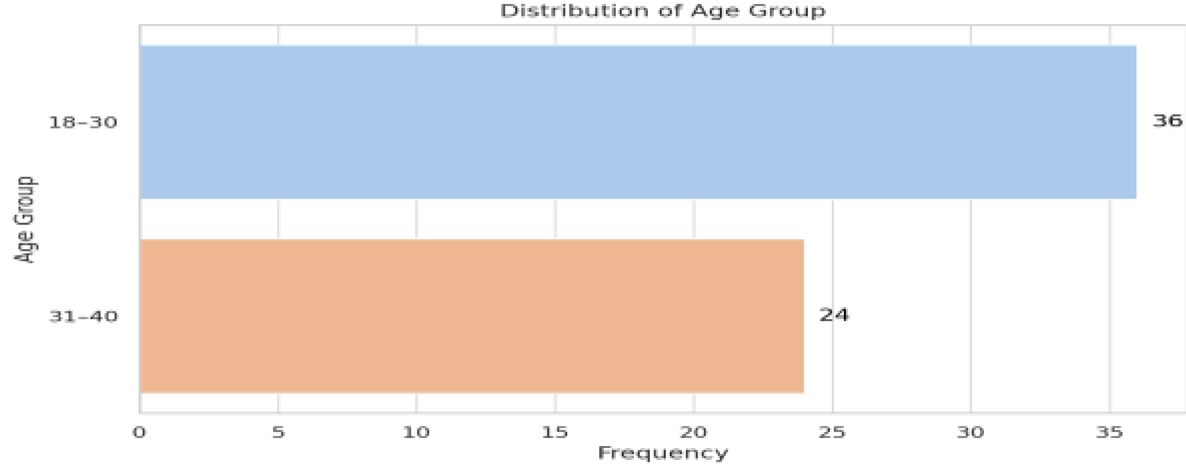
Independent Sample t-test

Table 4: Correlation Between Ultrasound Estimated and Actual Birth Weight

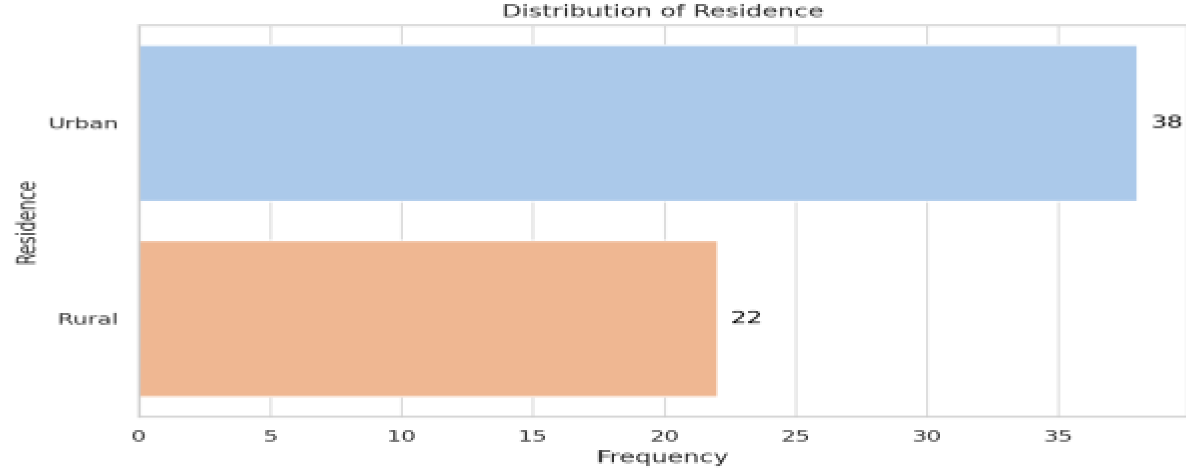
Variables Correlated	Pearson's r	p-value
Ultrasound Estimated Fetal Weight vs Birth Weight	0.89	< 0.001

Person Correlation

Graph:1



Graph:2



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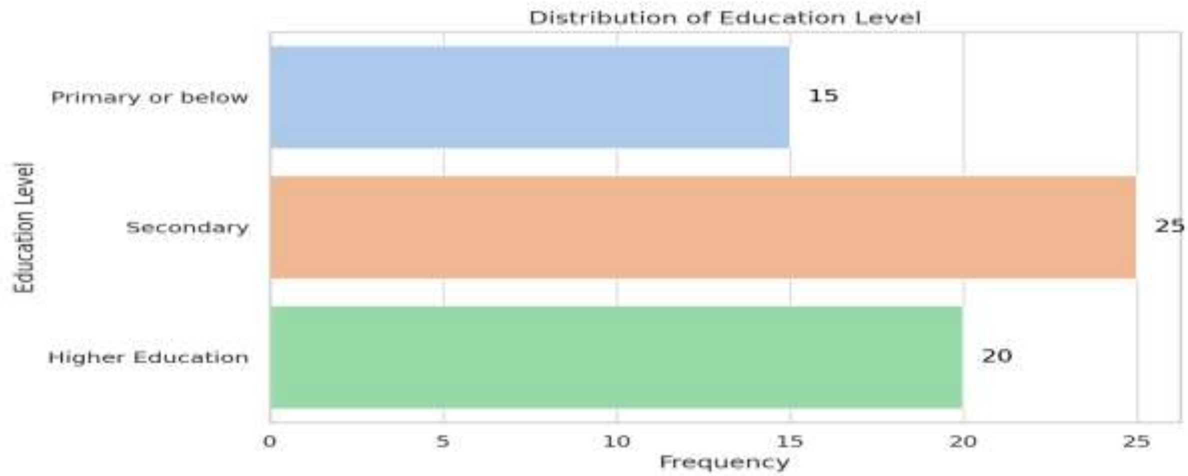
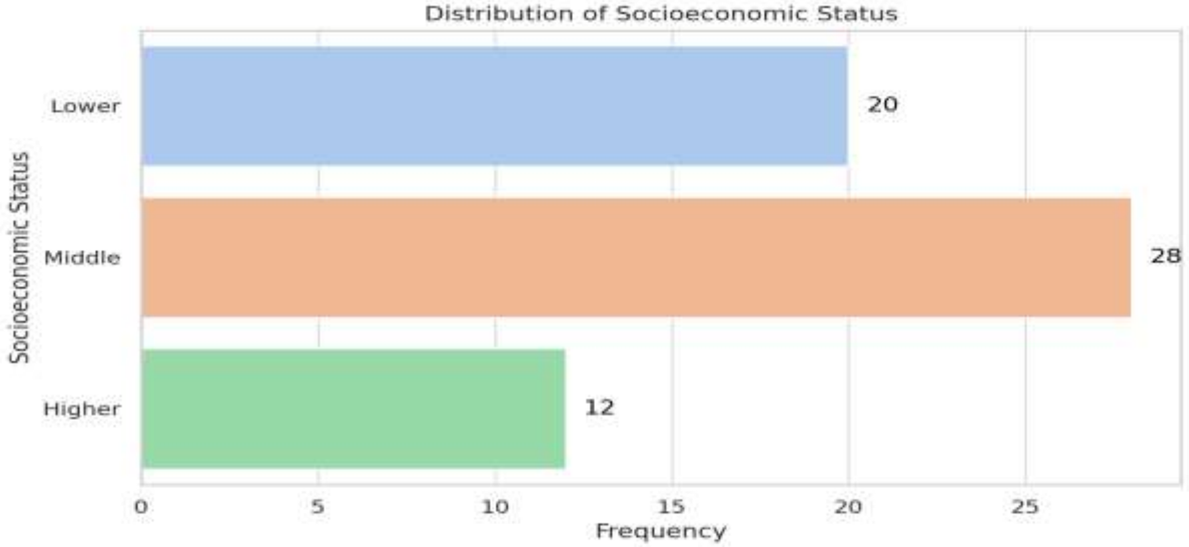
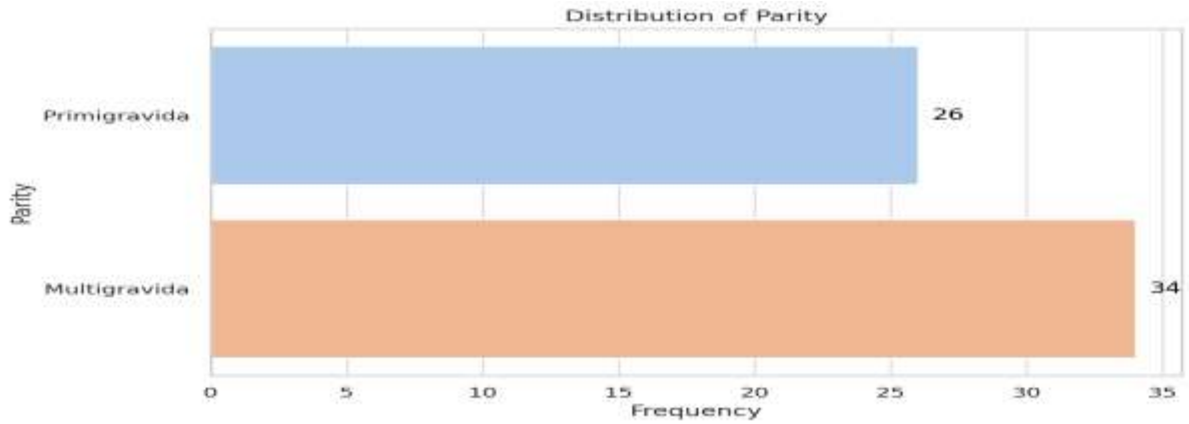


Graph:4



Graph:5



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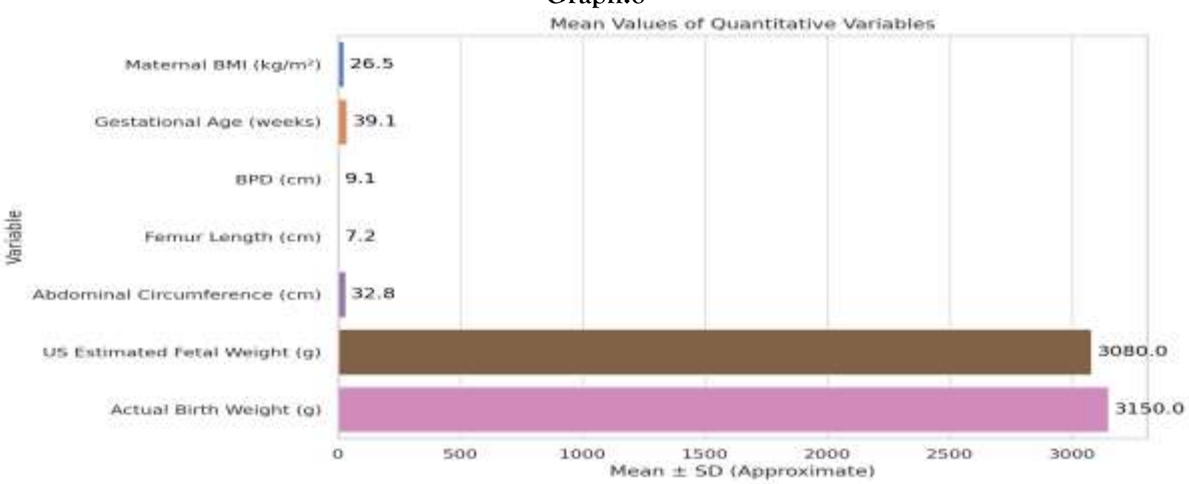
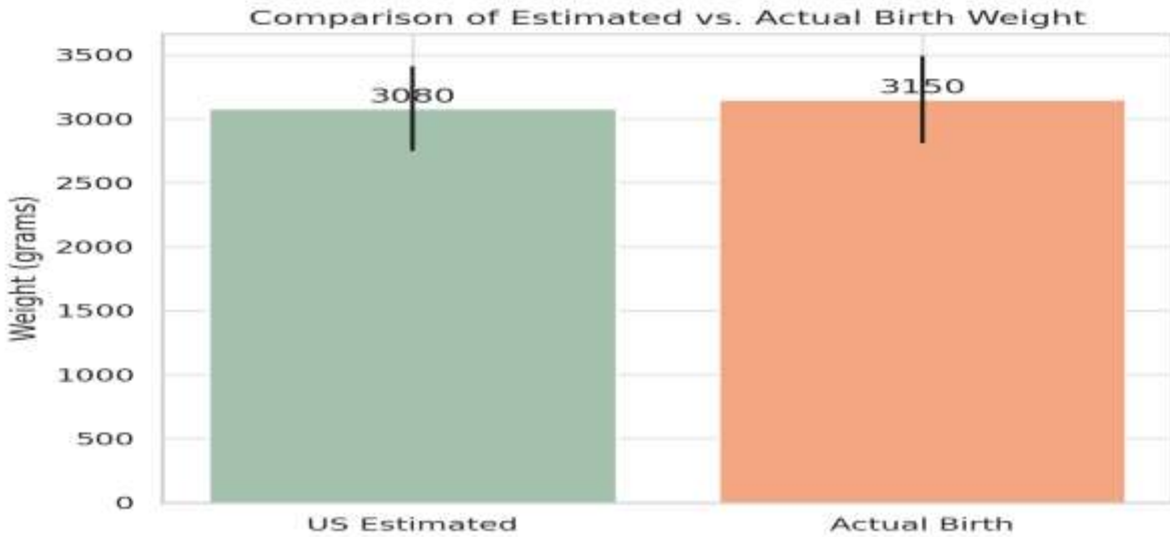
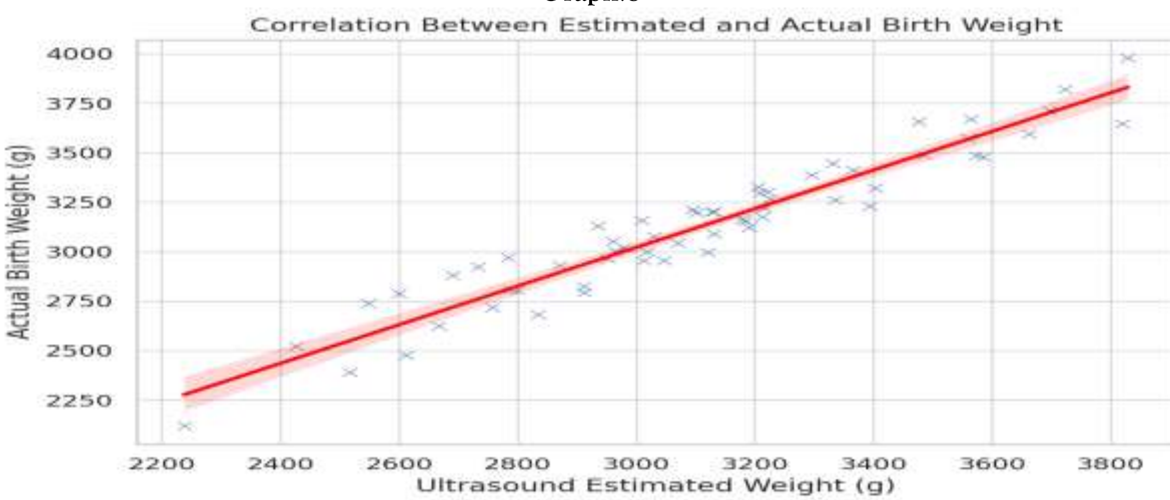


Graph:7



Graph:8



DISCUSSION:

In our study of 60 term singleton pregnancies, the mean ultrasound-estimated fetal weight (3080 ± 330 g) closely approximated the actual birth weight (3150 ± 340 g), with no statistically significant difference ($p = 0.091$) and demonstrated a strong positive correlation coefficient ($r = 0.89$, $p < 0.001$). These findings confirm that the Hadlock formula-based sonographic estimation is reliable for term fetuses in our local setting.

Comparing our results with national data, Rehman et al. studied 50 women in Karachi and reported mean ultrasound and actual birth weights of 2520 ± 340 g and 2660 ± 420 g, respectively, with a moderate correlation ($r = 0.575$, $p < 0.05$[10]. Although correlation in that study was lower than ours, the difference between mean estimated and actual weight was like ours in direction and magnitude. In a larger cross-sectional study from Sargodha involving term women, Rauf et al. reported mean estimated and actual weights of 3088 ± 397 g and 3115 ± 432 g, respectively, with a strong correlation ($r = 0.93$, $p < 0.01$) and no significant difference[11,12.] These findings are closely aligned with ours, validating the generalizability of ultrasound accuracy in Pakistani populations using the Hadlock method. Asadullah et al. (n = 200) in Punjab also observed nearly identical mean fetal weights (estimated 3245.8 g; actual 3260.8 g), concluding that estimates were within

±10% of actual birth weight in most cases[3] again corroborating our findings.[13]
In international settings, Okafor et al. in Nigeria reported a strong correlation between estimated and actual birth weight ($r \approx 0.75$), with mean absolute error around 258 g (approx. 6.5%), and 72.5% of estimates within ±10% of actual weight[4]. Similarly, a Lagos-based cohort ($n = 282$) yielded mean estimated and actual birth weights of 3378 ± 40 g and 3393 ± 60 g respectively, with non-significant difference and significant correlation[5] mirroring the pattern seen in our results.[14]
In Turkey, Tas et al. evaluated 949 term singleton pregnancies and reported a mean absolute percentage error of 8.2% and an overall failure rate (>10% error) of 33%. [15]Accuracy was lower among primiparous women and low-birth-weight infants ($p < 0.05$)[16.] Our study lacked power to assess subgroups, but our overall strong correlation echoes their findings regarding general predictive reliability.
A Jordanian study including 409 women estimated fetal weight within 14 days of delivery and observed a mean absolute percentage error of 6.5%, with 78.8% of estimates within ±10%, improving to 81.3% when delivery occurred within 7 days of sonography[7]. This underlines the importance of scan-to-delivery interval a factor our study controlled by restricting ultrasound within days of delivery.[17]
Systematic reviews confirm that Hadlock-based ultrasound estimation typically achieves strong correlations ($r = 0.6–0.9$) and accuracy within ±10% for 60–75% of term cases[18,19.] However, estimation accuracy diminishes at weight extremes and in early gestational scans a limitation also noted in clinical practice and literature feedback[10].
Our findings are consistent with both local and global evidence, reinforcing the value of ultrasonographic fetal weight estimation in term pregnancies, especially when performed close to delivery. Slight differences in correlation coefficients between studies may be attributable to sample size, operator experience, or population anthropometry. Given the small sample size and lack of stratification by birth-weight category or parity in our study, further research with larger cohorts is recommended. Such studies should evaluate estimation precision in macrosomic and low-birthweight fetuses, and incorporate factors like maternal obesity and parity to improve clinical decision-making.

CONCLUSION

This study found a strong positive correlation between ultrasound-estimated fetal weight using the Hadlock formula and actual birth weight at term, confirming the reliability of sonographic assessment for birth planning. The close alignment of estimated and actual weights supports its routine use in clinical practice.

Strengths included the use of standardized equipment, consistent operators, and strict inclusion criteria, which reduced bias. However, **limitations** such as a small sample size, lack of subgroup analysis, and reliance on a single estimation method may affect generalizability.
Further large-scale studies are recommended to validate these findings across diverse populations and clinical scenarios.