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Original Research Article

Comparison of ultrasound scan fetal weight estimation and the combination of Dare and Johnson fetal weight estimation

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ABSTRACT

Background: Accurate estimation of fetal weight in pregnancy is key in decision making and determining when, where and how a delivery will occur, thereby contributing to the reduction of adverse pregnancy outcomes. Clinical and imaging methods have some degree of inaccuracy in estimating the fetal weight. This study aimed to evaluate the accuracy of fetal weight estimation by combination of the Dare and Johnson formulae compared with the Hadlock 2 ultrasound method in term pregnancies.

Methods: The study was a comparative cross-sectional study of 144 randomly selected pregnant women at the department of obstetrics and gynecology of the University of Port Harcourt Teaching Hospital from 1st June to 30th November, 2024. The degree of accuracy of fetal weight estimation using a combination of Dare and the Johnson formula and the Hadlock 2 ultrasound method was calculated using the mean absolute error, mean absolute percentage error, and the proportion of estimates within 10% of actual weight.

Results: The combination of the Dare and Johnson formulae overestimated fetal weight by 859.15±418.23 gm with a mean absolute percentage error of 25.13±15.18%. In comparison, the Hadlock 2 ultrasound scan method, underestimated the fetal weight by 163.01±253.19 gm with a lower mean absolute percentage error of 4.45±7.27%. The proportion of the combination of the Dare and the Johnson formulae, which is within 10% of the actual weight, was only 6.94%, while that of the Hadlock 2 ultrasound scan method had 76.39%.

Conclusions: The Hadlock 2 ultrasound scan method of fetal weight estimation has higher accuracy and should be preferred approach when available. However, in low-resource settings where ultrasound technology may not be available, the combination of the Dare and the Johnson formulae may be used, but with caution since it is less accurate.

Keywords: Dare formula, Estimated fetal weight, Hadlock ultrasound scan, Johnson formula

INTRODUCTION

The antepartum estimation of fetal weight influences newborn survival, and birth weight is a significant predictor of neonatal mortality.[1,2] The delivery of large babies is associated with an increased risk of caesarean delivery, injury to the genital tract, operative vaginal delivery, and post-partum haemorrhage.[3,4] Low birth weight neonates are at increased risk of respiratory distress syndrome, intraventricular haemorrhage, necrotising enterocolitis, electrolyte imbalance, hypothermia and neonatal mortality.[5-7] Therefore, accurate estimation of fetal weight in pregnancy is key in determining when, where and how a delivery will occur, to reduce the rate of adverse pregnancy outcomes.[8,9] Clinical methods, such as tactile assessment and clinical formulae and imaging methods, such as ultrasound scan and magnetic resonance imaging, are used to assess the fetal weight.[10,11] These methods all have some degree of inaccuracy because they use measurements of different parameters to estimate the actual fetal weight.[12,13]

The most common method of fetal weight estimation is the ultrasound scan method. This method is based on an algorithm from defined fetal measurements such as abdominal circumference (AC), femur length (FL), biparietal diameter (BPD) and head circumference (HC).[12,14] There are many published formulae for ultrasonographic estimation of fetal weight, such as Hadlock 1, Hadlock 2, Hadlock 3, Shephard, Campbell and Wilkins.[15,16] The use of an ultrasound scan for estimating fetal weight may be limited by maternal obesity, oligohydramnios, and anterior placentation.[15,17] In low-resource settings, there is an unavailability of the ultrasound machine, a poor power supply, the machine is expensive to maintain, and a lack of trained personnel to operate the machine.

Clinical methods of fetal weight estimation involve measurements of physical maternal parameters and the use of a formula to calculate the estimated fetal weight. They are suitable in a low-resource setting because they are readily available, cheap, and easy to perform.[18,19] Some studies have even reported a comparable level of accuracy between clinical methods and imaging modalities.[11,13] Examples of clinical methods are the Johnson formula and the Dare formula. In the Johnson formula, the fetal weight in gm = (FH (cm) – n) × 155: FH = fundal height and n=12 if the vertex is above the ischial spine or 11 if the vertex is below the ischial spine. If a patient's weight is more than 91 kg, 1 cm is subtracted from the Fundal Height.[20] In the Dare formula, SFH × AG = fetal weight in grams, where SFH is symphysio-fundal height, and AG is abdominal girth at the level of the umbilicus in cm, and the result was expressed in grams.[21] Other examples of clinical formulas are Johnson and Tosach, Poulous and Langstadt, Dawn formula, Ojwang formula, Bothner formula, and Kongnyuy-Mbu formula.[22-27]

This study aimed to evaluate the accuracy of fetal weight estimation by a combination of the Dare and Johnson methods compared with the Hadlock 2 ultrasound method in term pregnancies. There is limited data on a comparison between a combination of two clinical methods (Dare's and Johnson's) and a sonographic (Hadlock 2) method on the same patient. The Dare method and the Johnson method of fetal weight estimation are objective, reproducible, easy to teach, and beneficial in low-resource settings where ultrasound scan machines and manpower may be scarce.[28,29]

METHODS

The study was a comparative cross-sectional study of 144 randomly selected pregnant women at the department of obstetrics and gynecology of the University of Port Harcourt Teaching Hospital from 1st June to 30th November, 2024. The study included women with singleton pregnancy, cephalic presentation, longitudinal lie, intact membranes, a known last menstrual period or an early dating scan on or before 14 weeks gestation and at term pregnancy. Term pregnancy was defined as a pregnancy between 37+0 weeks and 41+6 weeks. Women with malpresentation, polyhydramnios, oligohydramnios, gross congenital anomaly on scan, uterine fibroids, pelvic or intra-abdominal masses, antepartum hemorrhage, intrauterine fetal death, advanced first stage of labour or second stage of labour were excluded.

The interval between the clinical and ultrasound fetal weight estimation and delivery was 72 hours. The women were asked to empty their urinary bladders before their symphysio-fundal height and abdominal girth were measured. A flexible, non-elastic metric tape was used to measure the abdominal girth and symphysio-fundal height, and each measurement was rounded to the nearest centimetre. The measurements of the abdominal girth and symphysio-fundal height were performed with the patient lying supine in anatomical position. The symphysio-fundal height was measured in the midline from the highest point on the uterine fundus to the upper border of the symphysis pubis. The abdominal girth was measured at the level of the umbilicus. Each measurement was taken twice to minimise errors. The fetus was considered to be engaged if the fetal head was at two-fifths or one-fifth palpable per abdomen, equating to fetal station 0 or +1. The measurements were imputed into the Dare formula and the Johnson formula and used to estimate fetal weight in grams. The newborn babies were weighed within 30 minutes of birth using a standard Waymaster analogue scale corrected for zero error, and the actual birth weight was recorded to the nearest 0.1 gm.

The ultrasound machine was used the WED-2018 Fully Digital Ultrasonic Diagnostic System (version V2.0, 2022-10). It is a two-dimensional real-time system with an abdominal sector 3.75 MHz transducer. Each participant emptied their urinary bladder and laid flat on their back, with their head slightly raised on a comfortable pillow and legs extended. The BPD was taken from the trans axial sonogram of the fetal head at the level of the paired thalami and cavum septum pellucidum, measuring from the outer edge of the cranium nearest to the transducer to the inner edge of the cranium. The AC was measured on a plane perpendicular to the fetal spine, which intersects only a small portion of the umbilical vein. The FL was assessed by measuring the length of the diaphysis of the fetal femur beginning from the greater trochanter to the femoral condyles. The estimated fetal weight was calculated automatically by the ultrasound machine using the Hadlock 2 reference table.

Data on infants' actual birth weight, ultrasound estimates, Dare's estimates, Johnson's estimates, and maternal information were analysed using the Statistical Product and Services Solutions for Windows® version 21. Descriptive statistics were presented with means and standard deviations. The level of significance was when the p-value was ≤0.05, with a 95% confidence interval. The accuracy of fetal weight estimation was calculated using the mean absolute error (MAE = estimated fetal weight - actual fetal weight), the mean absolute percentage

error (MAPE = error in estimate/actual weight ×100), and the proportion of estimates within 10% of actual weight (10% AW = total occurrences within -10% to +10% range in a list of 144 ×100).

RESULTS

Descriptive statistics of the study participants

Table 1 provides an overview of the age, parity, gestational age at delivery, weight, height and Body mass index (BMI) of the study population. The mean maternal age of the participants was 31.59±4.81 years. This age distribution suggests the sample is representative of the contemporary obstetric population in our environment. The mean parity in this study was 1.76±1.28, and the mean gestational age was 38.61±1.19 weeks. The mean maternal weight and height were 86.43±14.85 kg and 1.64±0.08 m, respectively. The average admission BMI was 31.85±4.68 kg/m^2), suggesting that a significant proportion of the study participants were overweight or obese.

Table 1: Descriptive statistics of the study participants.

Variables	Mean	SD
Maternal age (years)	31.59	4.81
Parity	1.76	1.28
Gestational age (weeks)	38.61	1.19
Maternal weight (kg)	86.43	14.85
Maternal height (m)	1.64	0.08
Admission BMI (kg/m^2)	31.85	4.68

Fetal weight estimates and actual birth weight

The mean actual birth weight was 3612.50±375.07 gm. The Dare formula of fetal weight estimation gave a higher mean estimate of 4501.07±393.97 gm. The Johnson formula also gave a higher mean estimate of 4420.70±171.90 gm. The Dare and Johnson formula combined gave a mean value of 4471.65±251.13 gm, which was higher than the Hadlock 2 ultrasound mean estimate of 3449.49±401.96 gm (Table 2).

Table 2: Clinical fetal weight estimates and actual birth weight.

Variables	Mean	SD
Dare Estimate (gm)	4501.07	393.97
Johnson Estimate (gm)	4420.70	171.90
Combination of the Dare and Johnson formula (gm)	4471.65	251.13
Hadlock 2 ultrasound estimate (gm)	3449.49	401.96
actual birth weight (gm)	3612.50	375.07

Comparison of the accuracy of the combination of the Dare and the Johnson formulae and the Hadlock 2 ultrasound scan method in estimating fetal weight

The MAE of the combination of the Dare and the Johnson formulae was 859.15±418.23 gm, representing a substantial average difference from the actual weights. The Hadlock 2 ultrasound scan method had an MAE of 163.01±253.19 gm, indicating that the ultrasound estimates were approximately 163 gm lower than the actual birth weights. The mean absolute percentage error of the combination of the Dare and the Johnson formulae was 25.13±15.18%. The Mean absolute percentage error for the Hadlock 2 ultrasound scan method was 4.45±7.27%. The proportion of the combination of the Dare and the Johnson formula, which is within 10% of the actual weight, was only 6.94%, while the Hadlock 2 ultrasound scan method had 76.39% of its estimates within 10% of the actual weight (Table 3).

Table 3: The mean accuracy of the various methods of fetal weight estimation.

	MAE (gm)	MAPE (%)	Proportion of estimates within 10% of actual weight (%)
Combination of Dare and Johnson formula (gm)	859.15±418.23	25.13±15.18	6.94
Mean Hadlock 2 ultrasound scan method (gm)	163.01±253.19	4.45±7.27	76.39

MAE = Mean Absolute Error; MAPE = Mean Absolute Percentage Error.

Table 4: A comparison of the accuracy of fetal weight estimations made by the combination of the Dare and the Johnson formula and the Hadlock 2 ultrasound scan method.

	Dare's and Johnson's estimates combined±SD	Hadlock 2 ultrasound estimate (±SD)	Mean/proportional difference	t-test/Chi-square	P value
Mean estimate (gm)	4471.65±251.13	3449.49±401.96	1022.16	25.88α	0.001*
MAE (gm)	859.15±418.23	163.01±253.19	696.14	25.09α	0.001*
MAPE (%)	25.13±15.18	4.45±7.27	20.68	21.09α	0.001*
Proportion of estimates within 10% of actual weight (%)	6.94	76.39	69.45	60.82μ	0.001*

*Statistically Significant (p≤0.05); α=Student t-test; μ = Chi-Square test.

Table 4 compares the accuracy of fetal weight estimations made by the combination of the Dare and the Johnson formulae and the Hadlock 2 ultrasound scan method. There was a statistically significant difference in the mean estimates, MAE, MAPE, and the proportion of estimates within 10% of the actual weight between the combination of the Dare and the Johnson formulae and the Hadlock 2 ultrasound scan method.

DISCUSSION

This study compared the combination of the Dare and the Johnson formulae with the Hadlock 2 ultrasound method in estimating fetal weight in a cohort of term pregnancies. Findings reveal a significant difference in the accuracy of estimating the fetal weight of the various methods. The combination of the Dare and the Johnson formulae overestimated the fetal weight, while the Hadlock 2 ultrasound method provided more accurate estimates that are slightly lower than actual birth weights.

The combination of the Dare and the Johnson formulae of fetal weight estimation gave a mean of 4471.65±251.13 gm, which is higher compared to the mean actual birth weight of 3612.50±375.07 gm. This overestimation is further quantified by the MAE of 859.15±418.23 gm, representing a substantial average difference between the estimated and actual birth weights. The Hadlock 2 ultrasound method gave a mean estimate of 3449.49±401.96 gm, which is lower than the mean actual birth weight. This underestimation is reflected in the Hadlock 2 ultrasound method MAE of 163.01±253.19 gm, indicating that, on average, the ultrasound estimates were approximately 163 grams lower than the actual birth weights.

The lower accuracy of this combined clinical method is further expressed by the MAPE of 25.13±15.18%. This indicates that, on average, the estimates deviated from the actual birth weight by about a quarter of its value, which is a considerable margin of error in clinical practice. The Hadlock 2 ultrasound method had a smaller MAPE of 4.45±7.27%, indicating that its estimates were only approximately 4.45% lower than the actual birth weights. A similar study of 100 pregnant women in south-western Nigeria also reported an overestimation of fetal weight with clinical methods and an underestimation of fetal weight with sonographic methods.[30]

The precision of the combination of the Dare and the Johnson formulae of fetal weight estimation is also called into question, as evidenced by the fact that only 6.94% of the estimates fell within 10% of the actual birth weight. This means that the vast majority of estimates (93.06%) were more than 10% off from the actual weight, suggesting poor reliability for individual cases. The Hadlock 2 ultrasound scan method of fetal weight estimation had 76.39% of estimates within 10% of actual birth weight, significantly outperforming the combination of the Dare and the Johnson formulae of fetal weight estimation. This finding is similar to a report by Mgbafulu et al who noted that the combination of the Dare and the Johnson formulae of fetal weight estimation had only 21.7% of estimates within 10% of the actual birth weight, while the sonographic method had 68.2% of estimates within 10% of the actual birth weight.[28] Ezeugo et al and Patil et al have similar findings and recommended the use of ultrasound scan in predicting actual birth weights.[8,31] The accuracy of the ultrasound scan can be attributed to its reliance on objective measurements like BPD and AC, making it a better option for accurate fetal weight estimation, especially in high-risk pregnancies.

CONCLUSION

The Hadlock 2 ultrasound method provides more reliable estimates, making it the preferred approach for fetal weight assessment when available. However, in low-resource settings where ultrasound technology may not be available, the combination of the Dare and the Johnson formulae may be used, but with caution since it is less accurate.

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