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Fetal Thigh Circumference versus Fetal Abdominal Subcutaneous Tissue Thickness in Prediction of Fetal Weight in Term Pregnant Women

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Abstract

Background: Fetal weight estimation by ultrasound is an important factor in obstetrics; it is directly related to the gestational age which helps to plan the mode of delivery and labor management. **Objective:** to compare between fetal thigh circumference (TC) and abdominal subcutaneous tissue thickness (SCT) in estimating birthweight in term pregnant women. **Patients and Methods:** This prospective cohort study was conducted at outpatient clinic or emergency room, Obstetrics and Gynecology Department, Faculty of Medicine, Ain Shams University Maternity Hospitals from March 2022 until May 2023. During this study, 100 term pregnant females with gestational age 37 - 40 weeks attended El Demerdash Maternity Hospital and scheduled for delivery either at outpatient clinic or emergency room were enrolled, after consenting each of them. Basic fetal biometry was performed by an expert and professional medical personnel to ensure the accuracy of examination results. Fetal abdominal subcutaneous thickness and fetal thigh circumference were measured for assessment of gestational age and correlated with actual fetal body weight. In the current study, three formulas; Hadlock, Vintzileos' and SCT formula were correlated with actual fetal body weight after birth. **Results:** The present study revealed that TC formula is closer to the actual birth weight, followed by Hadlock formula, while the SCT formula is the furthest from it. **Conclusion:** To increase the accuracy of birth estimations, regular ultrasound examinations should include fetal thigh circumference measurement.

Keywords

Fetal Thigh Circumference, Fetal Abdominal Subcutaneous Thickness, Fetal

Weight, Term Pregnancy

1. Introduction

The fetal weight assessment by ultrasound is essential in obstetric practice to determine the labor mode, time, and management. It is an important to detect fetal growth abnormalities such as low birth weight and macrosomia; thus, it could help in decreasing the perinatal morbidity and mortality rates [1].

Many methods have been introduced to estimate the weight in utero, and many studies have evaluated their effectiveness to detect the most accurate method [2].

The most common methods are the clinical and ultrasound methods. The clinical method depends on the uterus height and the abdominal girth at the umbilical level. However, this method is not accurate in cases of polyhydramnios/oligo-hydramnios, increased maternal weight, fetal malpresentation, and multifetal conception [3].

It has been reported that the ultrasonographic method is more accurate than the clinical method.

Recently, fetal thigh circumference (TC) was introduced as another sonographic biometric parameter. TC could not only estimate the fetal birth weight, but it also can identify the soft tissue mass changes. It has been documented that adding fetal TC to other sonographic parameters showed a more accurate estimation of the fetal weight [4] [5].

Several studies have shown that sonographic measurements of fetal abdominal circumference and fetal abdominal subcutaneous tissue thickness are useful for predicting fetal macrosomia [6].

Measurement of fat in the abdominal wall is a simple technique with sensitivity for predicting low birth weight and macrosomia. Many studies have demonstrated that expected fetal weight (EFW) by the traditional techniques is not a reliable indicator of growth abnormalities such as macrosomia, consequently several other sono graphic measurements have been proposed [7].

Ultrasound has its limitations despite the use of more than 50 different formulae to estimate fetal weight as their performance is poor at the extremes of fetal weight. There has been emerging interest in studying fetal soft tissue measurements to improve the detection of growth abnormalities [8].

The aim of the study was to compare between fetal thigh circumference and abdominal subcutaneous tissue thickness in estimating birthweight in term pregnant women.

2. Patients and Methods

This prospective study was conducted on 100 pregnant women at outpatient clinic or emergency room, Obstetrics and Gynecology Department, Faculty of

Medicine, Ain Shams University Maternity Hospitals from March 2022 until May 2023.

The study included women with singleton pregnancy, gestational age between 37 - 40 weeks, gestational age confirmed retrospectively by recorded crown-rump length (CRL) before 12th weeks of gestation or last menstrual period and sonographically normal amniotic fluid index.

While patients with fetal congenital anomalies, intrauterine growth restriction (IUGR) and intrauterine fetal demise (IUFD) were excluded from the study.

A total of 100 patients were enrolled, after consenting each of them.

According to inclusion and exclusion criteria; patients were subjected to complete history taking of clinical importance including, Personal history, menstrual history, Obstetric history, contraceptive history, medical history, surgical history, family history and general examination. Measurement of symphysio fundal height was taken. Routine prelabour investigations as complete blood picture, liver and kidney function tests, coagulation profile "prothrombin time, partial thromboplastin time and international normalized ratio", viral hepatitis markers: hepatitis B and C viruses, blood group and Rh.

Antenatal ultrasound examination was done in Ain Shams University hospital by the same expert and professional sonographer. It included ultrasound measurements of biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), femur length (FL), thigh circumference (TC) and fetal abdominal subcutaneous thickness (SCT) that were taken using Samsung WS 80 Elite ultrasound machine using 3.9 MHZ transducer.

To measure the thigh circumference the long axis of the femur was imaged first, the transducer was then rotated 90 to obtain a cross sectional profile of the middle of the thigh at a position that the bone profile was as round as possible and the boundary of the thigh profile was well defined. Care was taken to take measurements in the same plane for all patients. Fetal weight was calculated using scientific calculator through Vintzileos' formula; $\text{Log10 (BW)} = 1.897 + (0.015 \times \text{AC}) + (0.057 \times \text{BPD}) + (0.054 \times \text{FL}) + (0.011 \times \text{TC})$. This formula was used in a study conducted in 2019 by Tahira *et al.* [3]

Fetal abdominal SCT was measured in the anterior one third of the abdominal circumference by placing the cursor at the outer and inner edges of echogenic subcutaneous fat lines. Care was taken to take measurements in the same plain for all patients.

The estimated fetal weight was calculated from the regression equation weight formula: $= 0.36 \times \text{SCT} + 1.284$. This formula was used in a study 2014 by Singh *et al.* [9]

Results from both formulas were compared with fetal weight obtained by Hadlock formula: $\log(10)\ \text{BW} = 1.335 - 0.0034\ [\text{AC}]\ [\text{FL}] + 0.0316\ (\text{BPD}) + 0.0457\ (\text{AC}) + 0.1623\ (\text{FL})$ and actual birthweight.

Primary outcome: To obtain an accurate expected fetal weight measurement using a single accurate parameter rather than multiple parameters.

Secondary outcome: To decrease the time consumed during ultrasound scan and to decrease the number of neonates admitted to an neonatal ICU due to low birth weight.

Sample size justification: For estimating the fetal weight using fetal thigh circumference; by using (PASS 11) (version 11.0.08) for sample size calculation, setting confidence level at 90%, margin of error ± 0.15, and after reviewing previous study results [3], showed that the coefficient of correlation between Vintzileos' method and the actual body weight of a newly born baby was (0.319); based on that a sample size of at least 100 pregnant females was sufficient to achieve study objective.

Data management and statistical analysis:

The data was collected, reviewed, coded and entered to excel sheet. Data was analysed using SPSS software. Descriptive statistics were done in terms of frequency and percentages for categorical variables. Mean (±SD) or median (interquartile range) was used for continuous variables. Statistical tests for comparing between groups including sensitivity, specificity, positive and negative likelihood ratios were used according to type of data. Differences were considered significant at a p-value less than or equal to 0.05.

Data were fed to the computer and analyzed using IBM SPSS software package version 20.0. (Armonk, NY: IBM Corp) Qualitative data were described using number and percent. Quantitative data were described using range (minimum and maximum), mean, standard deviation, median and interquartile range (IQR). Significance of the obtained results was judged at the 5% level.

Ethical considerations:

Before being enrolled into the study, the patient consented to participate after the nature, scope and possible consequences of the clinical study had been explained in a form understandable to her. All subjects participated voluntarily and their confidentiality was respected.

3. Results

Table 1 shows that the study was conducted on a wide age group ranging from 17 to 42 years, (mean age of 28.71 ± 6.88 years). It was mean of Maternal weight gain (kg) 10.04 ± 3.54, parity ranged 0 to 6 with median 1.50 (0.0 - 3.0) and Hb. 11.04 ± 1.50.

Table 1. Descriptive analysis of the studied cases according to demographic data of mother (n = 100).

	Min. - Max.	Mean ± SD.	Median (IQR)
Age (years)	17.0 - 42.0	28.71 ± 6.88	28.0 (22.0 - 35.0)
Maternal weight gain (kg)	0.0 - 20.0	10.04 ± 3.54	10.0 (8.0 - 12.0)
Parity	0.0 - 6.0	1.71 ± 1.49	1.50 (0.0 - 3.0)
Haemoglobin (HB)	0.70 - 13.40	11.04 ± 1.50	11.10 (10.4 - 11.8)

IQR: Inter Quartile Rang; SD: Standard Deviation.

Table 2 shows that there is no statistically significant correlation between age "years" with Hadlock, BW by TC and BW by SCT 1000, with p-value (p = 0.390, 0.237 and p = 0.815) respectively.

Also, there is no statistically significant correlation between maternal weight gain with Hadlock, BW by TC and BW by SCT 1000, with p-value (p = 0.265, 0.641 and p = 0.826) respectively.

Table 3 shows that 53 patients (53%) were males and 47 patients (47%) were females among gender of child.

Table 4 shows that the mean of BPD (cm) was 9.03 ± 0.39; AC (cm) was 32.82 ± 2.35; FL (cm) was 7.33 ± 0.35; TC (cm) was 16.55 ± 1.35 & SCT (mm) was 7.19 ± 1.71 among study group.

Table 5 shows that the mean of actual birth weight (g) was 2934.0 ± 475.8; EFW by TC formula was 3069.7 ± 492.5; EFW by SCT formula (×103) was 3871.3 ± 616.7 & EFW by Hadlock formula (gm) was 3135.6 ± 480.0 among study group.

Table 2. Correlation between age (years) and Maternal weight gain with Hadlock, BW by TC and BW by SCT 1000 among study group, using Pearson's correlation coefficient (r).

Patients Group	Age (years)		Maternal weight gain	
	r-value	p-value	r-value	p-value
Hadlock	0.087	0.390	−0.112	0.265
BW by TC	0.119	0.237	−0.047	0.641
BW by SCT 1000	0.024	0.815	0.022	0.826

Using: Pearson's correlation coefficient (r); p-value > 0.05 is insignificant; Thigh circumference.

Table 3. Distribution of the studied cases according to gender (n = 100).

	No.	%
Gender of child		
Male	53	53.0
Female	47	47.0

Table 4. Descriptive analysis of the studied cases according to different measurement (n = 100)

	Min. - Max.	Mean ± SD.	Median (IQR)
BPD (cm)	8.0 - 10.0	9.03 ± 0.39	9.10 (8.80 - 9.30)
AC (cm)	27.90 - 39.80	32.82 ± 2.35	32.50 (31.50 - 33.95)
FL (cm)	6.40 - 8.40	7.33 ± 0.35	7.30 (7.10 - 7.60)
TC (cm)	12.75 - 20.70	16.55 ± 1.35	16.75 (16.03 - 17.28)
SCT (mm)	4.60 - 13.70	7.19 ± 1.71	6.45 (6.0 - 8.0)

IQR: Inter quartile range; SD: Standard deviation; BPD: Biparietal diameter AC: Abdominal circumference; FL: Femur length TC: Thigh circumference; SCT: Subcutaneous tissue thickness.

Table 5. Descriptive analysis of the studied cases according to birth weight (n = 100).

	Min. - Max.	Mean ± SD.	Median (IQR)
Actual birth weight (g)	1950.0 - 4480.0	2934.0 ± 475.8	3000.0 (2562.5 - 3175.0)
EFW by TC formula	2016.0 - 4892.2	3069.7 ± 492.5	3010.8 (2821.8 - 3213.5)
EFW by SCT formula ($\times 10^3$)	2940.0 - 6216.0	3871.3 ± 616.7	3606.0 (3444.0 - 4164.0)
EFW by Hadlock formula (gm)	2200.0 - 4800.0	3135.6 ± 480.0	3075.5 (2843.0 - 3400.0)

IQR: Inter quartile range; SD: Standard deviation; EFW: Expected fetal weight; TC: Thigh circumference; SCT: Subcutaneous tissue thickness.

Table 6 shows statistically significant higher mean value of Hadlock formula than actual birth weight (g) with difference increase was 201.6 ± 415.7, with p-value ($p < 0.001$).

Also, statistically significant higher mean value of TC formula than actual birth weight (g) with difference increase was 135.6 ± 405.4, with p-value ($p = 0.001$).

As well as, highly statistically significant higher mean value of SCT formula ($\times 10^3$) than actual birth weight (g) with difference increase was 937.3 ± 626.5, with p-value ($p < 0.001$).

Thus, it is considered that TC formula is closer to the actual birth weight, followed by Hadlock formula, while the SCT formula furthest from actual birth weight.

Table 7 shows statistically significant moderate agreement between actual birth weight and TC formula, with (ICC coefficient 0.627 "0.475-0.739" & p-value < 0.001).

Also, statistically significant moderate agreement between actual birth weight and Hadlock formula, with (ICC coefficient 0.573 "0.359 - 0.717" & p-value < 0.001).

While, there was poor agreement between actual birth weight and SCT formula, with (ICC coefficient 0.145 "−0.080 - 0.381" & p-value < 0.001).

Thus, it is considered that TC formula is closer to the actual birth weight, followed by Hadlock formula, while the SCT formula farthest from actual birth weight.

Table 8 shows statistically significant lower mean value of TC formula than Hadlock formula with difference decrease was 65.92 ± 191.8, with p-value ($p = 0.001$).

Also, highly statistically significant higher mean value of SCT formula than Hadlock formula with difference increase was 735.7 ± 657.6, with p-value ($p < 0.001$).

Table 6. Comparison between Actual birth weight and each formula (n = 100).

	Actual	Hadlock formula	TC formula	SCT formula ($\times 10^3$)
Birth weight (g)				
Min. - Max.	1950.0 - 4480.0	2200.0 - 4800.0	2016.0 - 4892.2	2940.0 - 6216.0
Mean ± SD.	2934.0 ± 475.8	3135.6 ± 480.0	3069.7 ± 492.5	3871.3 ± 616.7
T		4.848*	3.346*	14.961*
P		<0.001*	0.001*	<0.001*
Differences		**↑201.6 ± 415.7**	**↑135.6 ± 405.4**	**↑937.3 ± 626.5**

SD: Standard deviation; t: Paired t-test: p: p value for comparing between Actual and each formula; TC: Thigh circumference; SCT: Subcutaneous tissue thickness. *: Statistically significant at p ≤ 0.05.

Table 7. Intra class correlation coefficient for birth weight (g) (n = 100).

Birth weight (g)	ICC coefficient	95% C.I	P	Level of agreement
Actual vs.				
Hadlock formula	0.573	0.359 - 0.717	<0.001*	Moderate
TC formula	0.627	0.475 - 0.739	<0.001*	Moderate
SCT formula ($\times 10^3$)	0.145	−0.080 - 0.381	<0.001*	Poor

ICC: Intra class Correlation coefficient VS: Versus; CI: Confidence interval; LL: Lower limit; UL: Upper Limit; *: Statistically significant at p ≤ 0.05.

Table 8. Comparison between Hadlock formula and each formula (n = 100).

	Hadlock formula	TC formula	SCT formula ($\times 10^3$)
Birth weight (g)			
Min. - Max.	2200.0 - 4800.0	2016.0 - 4892.2	2940.0 - 6216.0
Mean ± SD.	3135.6 ± 480.0	3069.7 ± 492.5	3871.3 ± 616.7
t		3.437*	11.188*
p		0.001*	<0.001*
Differences		**↓65.92 ± 191.8**	**↑735.7 ± 657.6**

SD: Standard deviation; t: Paired t-test: p: p value for comparing between Hadlock formula and each formula. *: Statistically significant at p ≤ 0.05.

Table 9 shows statistically significant excellent agreement between Hadlock formula and TC formula, with (ICC coefficient 0.915 "0.864 - 0.945" & p-value < 0.001).

While, there was poor agreement between Hadlock formula and SCT formula, with (ICC coefficient 0.155 "−0.066 - 0.369" & p-value 0.002).

Thus, it is considered that TC formula is closer to the Hadlock formula, followed by SCT formula.

Table 9. Intra class correlation coefficient for birth weight (g) (n = 100).

Birth weight (g)	ICC coefficient	95% C.I	P	Level of agreement
Hadlock formula vs.				
TC formula	0.915	0.864 - 0.945	<0.001*	Excellent
SCT formula ($\times 10^3$)	0.155	−0.066 - 0.369	0.002*	Poor

ICC: Intra class Correlation coefficient; CI: Confidence interval; LL: Lower limit; UL: Upper Limit. *: Statistically significant at $p \le 0.05$.

4. Discussion

It is crucial to reach an accurate estimation of fetal weight prenatal to avoid potential maternal and fetal complications such as macrosomia, preterm delivery, obstructed labor, unnecessary elective cesarean sections and avoidable neonatal ICU admissions.

Incorporating fetal thigh circumference and abdominal subcutaneous tissue thickness in prenatal fetal weight measurement is gaining importance and improving its accuracy because they reflect growth of both bone and soft tissue in contrast to other measurements, as femur length, that only evaluate bone tissue growth.

Results of the present study revealed that TC formula is closer to the actual birth weight, followed by Hadlock formula, while the SCT formula is farthest from it.

Several studies have been conducted to find the correlation between thigh circumference and birth weight. In 2022, Ali *et al.* [10] conducted a study to determine the accuracy of predicting prenatal weight using foetal thigh circumference. They enrolled 123 pregnant women and concluded that when used in conjunction with other fetal measures, the foetal thigh circumference may aid in the precise computation of fetal birth weight. This result is consistent with the results of the current study and agrees with it. The only different is that Ali *et al.* (10) did not compare the thigh circumference result to results produced by the subcutaneous tissue thickness formula, Hadlock formula.

In 2021, Mohamed *et al.* [11] evaluated the addition of fetal thigh circumference (TC) to other ultrasound parameters to predict fetal weight using Vintzileos formula and compared it to the standard hadlock formula that doesn't include fetal thigh circumference (TC). A total of 123 pregnant women were enrolled and also concluded that fetal TC improves estimation fetal birth weight when incorporated with other fetal parameters. They detected a significant positive correlation between different ultrasound parameters and actual weight and the highest correlation was observed between TC and actual fetal weight. Regarding both formulae, the correlation coefficient was higher in the Vintzileos formula than the Handlock formula (0.976 vs. 0.823). This result is also consistent with the result of the present study but yet again, didn't compare with the subcutaneous tissue thickness as a predictor for expected fetal weight.

In 2021, Ait-Allah *et al.* [12] evaluated of the accuracy of predicting birth weight by incorporating fetal thigh circumference in the formula of estimating birth weight using 2D-Ultrasound. This study was a prospective cohort study had been conducted on 228 pregnant women that concluded that the fetal thigh circumference measurement adding more accuracy, sensitivity, and specificity in estimation of intra-uterine fetal weight when incorporated with other fetal parameters. Correlation between Actual Birth Weight and each of EFW (using both Formulae) in included women revealed that there was more significant positive correlation between actual fetal birth weight and EFW using Vintzileos' formula. This result also agrees with the current study results, however, EFW using subcutaneous tissue formula was also not added in the comparison.

In 2019, Tahira *et al.* [3] correlated the fetal thigh circumference at 36 - 40 weeks ultrasonographically with birth weight. A cross sectional analytical study involving 236 patients was conducted. They concluded that Hadlock' formula is more accurate in predicting the actual birth weight than the Vintzileos' formula. However, due to its stronger correlation with birth weight thigh circumference (correlation between EFW by Vintzileos' formula and actual birth weight is 0.319 more significant than the correlation between EFW by Hadlock's formula and actual birth weight *i.e.* 0.300), it can be used as an alternative parameter to biparietal diameter for estimating the birth weight at or near term when biparietal diameter becomes difficult to measure because of fetal head position down to pelvic bone. Tahira *et al.* [3] conducted the study on a larger population number than or study (236 versus 100 respectively) and excluded diabetic and hypertensive females.

In 1995, Favre *et al.* [13] performed a prospective research on foetal weight estimate using TC as one of the criteria to investigate the possible utility of limb measurements. They verified that employing thigh circumference enhanced both the identification of macrosomic foetuses as well as the diagnosis of small for gestational age (SGA) foetuses. The present study also found increased accuracy of detected macrosomic fetuses and small for gestational age (SGA) fetuses by including thigh circumference. However, the current study included a small number of macrosomic and SGA fetuses so this result must be experimented more closely in further studies.

In 2005, Shripad and Varalaxmi [14] have discovered that measuring the foetal thigh circumference improves the accuracy of birth weight predictions in obstetric practice, particularly in newborns weighing less than 2.5 kg, with a 95 percent predictability. Again, this result agrees with the result of the present study with the difference that the current study didn't give particular attention to newborns weighting less than 2.5 kg.

The deposition of muscle and fat in the developing foetus may be easily examined with TC measures. Since it is less vulnerable to form changes, these criteria were selected over diameter measurements to determine birth weight estimates more accurately. The results of the present study are in line with those of Sanyal *et al.* [15], who found in 2012 that the combination of other common biometric indicators and the circumference of the foetus' thighs when used to calculate the foetus' weight by ultrasound increased predictability and may have the ability to identify intrauterine growth restriction.

The neonatal thigh circumference and sonographic estimations showed a strong correlation. It is further supported by a study conducted by Saqib *et al.* [16] in 2008 that used the Isobe' formula: EFW = 13 × (FL × CSAT) + 39 (gm), without the need for HC and utilised thigh measurements instead; femur length (FL) and cross sectional area of the thigh (CSAT). This could be helpful in routine clinical practice for determining foetal weight, especially when head measurements are not available. It would be the most practical approach since it would only need two thigh parameters and would calculate the foetal weight using a typical 2D ultrasound scan without the need for a close-up head measurement. In contrast, the current study included HC as one of the parameters to calculate EFW and didn't use the Isobe' formula.

By combining the AC and the fractional thigh volume, Lee *et al.* [17] who developed a model to estimate foetal weight. They showed that their method outperformed commonly used techniques based on standard ultrasound formulas. This study was different from the present study that it used a different US mode (3D instead of 2D) and compared with thigh volume and not thigh circumference. However, there are considerable limitations to the utility of this study in that: 1) 3D imaging techniques prevent clear visualisation of surface anatomical components, especially in cases of foetal malpresentation and malposition; 2) Not all facilities have 3D ultrasound technology; 3) Not many doctors and ultrasonographers are now proficient in 3D ultrasound.

Finally, incorporating foetal TC improves projection of foetal weight. TC aids in precisely determining foetal weight when combined with other prenatal traits. Since ultrasound can accurately replicate the true thigh circumference and there was a strong correlation between prenatal and postnatal thigh circumference estimations, using it in routine ultrasound is strongly advised to improve birth estimates.

Several studies have been conducted to find the correlation between subcutaneous tissue thickness and birth weight. In 2020, Oun *et al.* [7] correlated fetal abdominal subcutaneous tissue thickness (FASTT) measured by abdominal ultrasound at term and birth weight measured immediately after delivery and to obtain a cut-off value of FASTT to predict large and small for gestational age babies. A total of 200 pregnant women at term were enrolled and they concluded that FASTT is a good indicator of birth weight. There was a significant positive correlation between fetal anterior abdominal wall fat thickness and birth weight. It is a better parameter for LGA than SGA. Yet, it is less accurate than AC as an indicator of fetal macrosomia. This was also proven in a study conducted by Khalifa *et al.* [18]. The current study agrees with Oun *et al.* [7] and Khalifa *et al.* [18] in that there is a significant positive correlation between FASTT and actual birth weight. However, it was proven that FASTT is the least accurate method to predict expected fetal weight. They also didn't include fetal thigh circumference formula in their study.

In 2019, Yang *et al.* [19] evaluated SCTT to identify its significance in estimating fetal weight. In this retrospective observational study, 856 term pregnant women were recruited and they concluded that fetal SCTT positively correlated with actual birth weight but could suggest larger BW than EFW. This result completely agrees with the present study results. However, it differs in that it is a retrospective study with a different sample size and it doesn't compare with thigh circumference.

In 2014, Bhat *et al.* [20] also plotted birth weight against FASTT (scatter plot graph), and it showed a positive significant correlation between FASTT and birth weight obtained by Pearson's correlation coefficient ($r = 0.418$).

Similarly, in 2012, Grace *et al.* [21] demonstrated that FASTT may be useful in the assessment of fetal nutritional risk as they showed a significant correlation between subcutaneous tissue thickness, estimated fetal weight, and actual BW. However, this was studied upon a population of Philipino fetuses while the present study is conducted on Egyptian fetuses.

Regarding the statistically significant difference of FASTT in different birth weight categories, in 2015, Odthon *et al.* [22] showed similar results; they studied the correlation between FASTT and birth weight.

In comparison, the current study agrees with Bhat *et al.* [20], Grace *et al.* [21] and Odthon *et al.* [22] in that there is a significant correlation between FASTT and actual birth weight. However, when hadlock and vintzileos' formulae were included in the comparison; it was proven that FASTT is the least predictive among them.

Regarding the demographic data of the included subjects, the current study showed no correlation between ultrasound parameters and any of the maternal age, gravidity, and parity; however, a statistically significant correlation was noted with gestational age calculated by date. In 2014 and 2010 respectively, results of Chen *et al.* [23] and Farah *et al.* [24] are in agreement with the current study; both found that FASTT measurements increase as gestation advances.

In 2012, Valdecantos and Paguirigan-Kayaban [25] aimed to determine the correlation of fetal abdominal subcutaneous tissue thickness at term with other biometric measurements and neonatal outcome. FASTT significantly correlated with AC and actual birthweight. LGAs had significantly thicker FASTT than AGAs. Accuracy of FASTT in predicting a CS mode of delivery, with a cutoff of < 5.4 mm was low (47.5% sensitivity), while ability to predict NSD was high at 82.7%.

In 2004, Foromouzmehr *et al.* [26] showed a positive correlation between FASTT and a wide range of fetal weights. Immediate birth weight after delivery was correlated with FASTT measured within 11 days of delivery. The mean FASTT differed significantly between normal and macrosomic fetuses (6.6 mm vs 12 mm respectively; $p < 0.001$).

In 2008, Higgins *et al.* [27] showed that measurement of Anterior Abdominal

Wall (AAW) in macrosomic fetuses was significantly increased compared to those with a birth weight < 90^{th} percentile. A fetal AAW measurement of >5.6 mm measured at term or an AC > 90^{th} percentile for gestation should alert the obstetrician to the possibility of fetal macrosomia.

In another study by Bethune *et al.* [28] in 2003, showed that fetal fat layer or subcutaneous tissue thickness > 5 mm was more useful than abdominal circumference as a predictor of macrosomia in 90 pregnancies affected by gestational diabetes, but only took one measurment between 28 and 34 weeks.

The previous four studies evaluated the accuracy of FASTT in detecting small for gestational age babies and macrosomic babies. This was not the focus of the present study however the results are informative. However, they didn't compare with hadlock and vintzileous' formulae.

***The strength points of this study*:**

The strength points of this study are that it was prospective study design and having no patients who were lost during the study period.

It was the first study in literature to compare between fetal thigh circumference and abdominal subcutaneous tissue thickness along with hadlock formula to estimate birthweight in term pregnant women.

All clinical assessment, ultrasound measurements and evaluation of study outcomes were done by the same team.

***The limitations of the study*:**

This study was a hospital-based study, not being a multicentric study and did not represent a particular community.

Also, this study was conducted at third trimester that characterized by high probability of inaccurate ultrasound measurements.

5. Conclusion

The fetal thigh circumference may aid in the precise computation of fetal birth weight when used in conjunction with other fetal measures. To increase the accuracy of birth estimations, regular ultrasound examinations should include fetal thigh circumference measurement. On the other hand, fetal abdominal subcutaneous thickness had poor sensitivity and utility in assessment of accurate gestational age and fetal weight that might be due to current study was conducted at 3^{rd} trimester with high probability of inaccurate ultrasound measurements.

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Informed Consent

Informed consent was obtained from all individual participants included in the study.

Ethical Approval

All procedures performed in studies involving human participants were in accordance with ethical standards of the ethical committee of the department of obstetrics and Gynaecology faculty of medicine, Ain Shams University.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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