European Journal of Obstetrics and Gynecology 319 (2026) 114976

Contents lists available at ScienceDirect

European Journal of Obstetrics & Gynecology and Reproductive Biology

journal homepage: www.journals.elsevier.com/european-journal-of-obstetrics-and-gynecology-and-reproductive-biology

Full length article

# Umbilical cord diameter and cross-sectional area in association with gestational age among women with uncomplicated pregnancies in north-central Nigeria: a cross-sectional study

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ARTICLE INFO

*Keywords:*
Gestational age
Umbilical cord diameter
Cross-sectional area
Ultrasonography

ABSTRACT

*Aim and objectives:* To assess gestational age using the umbilical cord diameter (UCD) and cross-sectional area (CSA).

*Methodology:* This was a cross-sectional study among 300 women with no adverse medical history and uncomplicated pregnancies between the 14th and 40th completed weeks of pregnancy. The commonly used foetal parameters for gestational age (GA) estimation: Biparietal Diameter, Head and Abdominal Circumference and Femur Length were measured using standard protocols.

UCD and CSA were measured in a plane adjacent to cord insertion into the foetal abdomen within 1 cm. UCD was measured in long axis from outer-to-outer border of the umbilical cord using the electronic calipers. The cross-sectional area was obtained in transverse axis using the ellipse measurement and area was calculated automatically by the ultrasound machine in-built software. Measurements were taken twice for each parameter, and the average value was recorded for each participant to reduce intra-observer error.

*Result:* The mean UCD and CSA were 16.12 ± 4.28 mm and 2.08 ± 0.87 $cm^2$ respectively. UCD and CSA were observed to increase steadily with GA up to the 33rd week of gestation, decline and then remain stable from the 38th and 39th week gestation respectively until the end of pregnancy. Significant correlations ($p = 0.001$) between umbilical cord diameter and cross-sectional area with estimated foetal weight (EFW), GA and other foetal parameters for GA estimation was observed.

A regression analysis model between UCD, CSA and GA showed 95% confidence interval (CI). GA by LMP (weeks) = 1.528 (UCD) + 2.646, 7.544 (CSA) + 11.540. GA by US (weeks) = 1.542 (UCD) + 2.653, 7.618 (CSA) + 11.619.

*Conclusion:* UCD and CSA measurement is a reliable method for prediction of GA and has a strong linear relationship with commonly used foetal parameters.

## Introduction

The precise knowledge of gestational age (GA) is an important determinant of both prenatal care and outcome of pregnancy [1]. Gestational age refers to the length of pregnancy, usually expressed in weeks and days [2]. Gestation lasts for about 40 weeks (280 days) and is defined as the number of weeks between the first day of onset of a woman's last menstrual period (LMP) and the day of delivery [3,4]. Gestational age can also be estimated by clinical examination and ultrasonography (US) [2,5].

GA estimation based on LMP is often inaccurate as many women are often unsure of the date of onset of their LMP [2]. It has been estimated that 10% to 45% of women cannot relate the LMP with certainty and 18% with 'certain' dates have significant differences between menstrual

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https://doi.org/10.1016/j.ejogrb.2026.114976
Received 25 November 2025; Received in revised form 18 January 2026; Accepted 24 January 2026
Available online 27 January 2026
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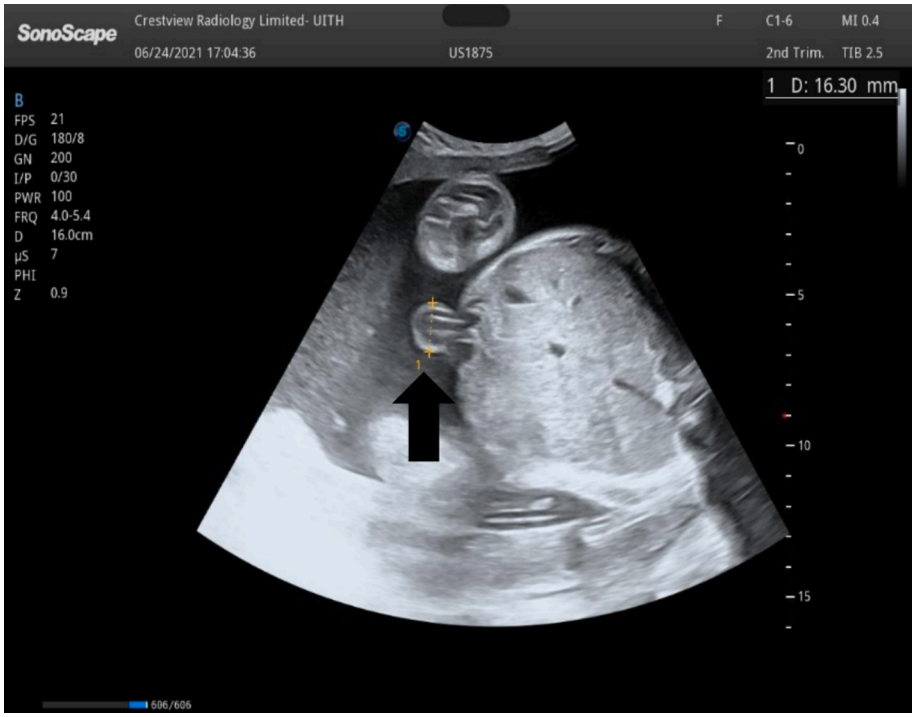



**Fig. 1.** Umbilical cord sonogram in longitudinal plane showing the measurement of UCD (Arrow).

and ultrasonographic dating [2,4]. This is as a result of poor recall, irregular cycles (oligomenorrhoea, metrorrhagia), bleeding in first trimester of pregnancy, pregnancy following use of oral contraceptives or intrauterine devices, and during postpartum period [4,6].

Estimation of GA using US is done by measuring foetal parameters such as biparietal diameter (BPD), femur length (FL), head circumference (HC), and abdominal circumference (AC) [1,2,4,7]. Differences in techniques of measurement, interobserver error, advanced pregnancy and pregnancy complicated by foetal structural and growth abnormalities tend to diminish the accuracy of GA determined by US measurement of these foetal parameters [8,9].

The accuracy of foetal parameters as gestational age scheduler can increase or decline as GA advances [1]. The accuracy of BPD is ±10 to 11 days in the second trimester and ±21 days in the third trimester [10]. Similarly, the accuracy of FL is ±7 days in the second trimester, and ±16 days in the third trimester [4,8,9]. However from 20 weeks of gestation, it is more reliable to use the mean values of BPD, FL, HC and AC because the use of a single parameter becomes relatively unreliable [8,9].

The drawbacks in the above listed foetal parameters, therefore suggest the need of another parameter such as umbilical cord diameter (UCD) and cross-sectional area (CSA) for supplementing GA estimation [8].

Umbilical Cord (UC) is an intra-amniotic tube-like structure through which the foetus is connected to the placenta [11]. It is covered by the amniotic membrane and includes two umbilical arteries and one umbilical vein that is surrounded by a homogeneous substance called Wharton's jelly which gives the umbilical cord elasticity and strength, preventing tearing or refraction of the vessels [12,13].

The purpose of this study was to measure UCD and CSA using ultrasonography and correlate the measurements with the GA of their foetuses calculated from LMP.

## Material and methods

### *Study design*

This cross-sectional study was carried out in the Department of Radiology of the university of Ilorin teaching hospital, Ilorin, Nigeria, over a period of 6 months. Approval of the Ethics Research Committee was obtained before commencement of the study (Approval number: ERC PAN/2021/12/0217).

Study population

The required sample size was estimated using the Taro Yamane formula [14]. Purposive sampling method [15] was used to select a sample of 300 eligible pregnant women from the population of antenatal attendee at the antenatal clinic of the Hospital. An informed written consent was obtained from each participant. Study participants were consenting pregnant women above 18 years with uncomplicated singleton pregnancies between 14- and 40-weeks GA, estimated from patient's LMP, intact membranes, and normal amniotic fluid index. Women with multiple pregnancy, diabetes mellitus, hypertension of any aetiology, foetal umbilical or placental anomalies detected during scanning, oligohydramnios or anhydramnios, intrauterine growth retardation, and unsure of LMP were excluded from the study.

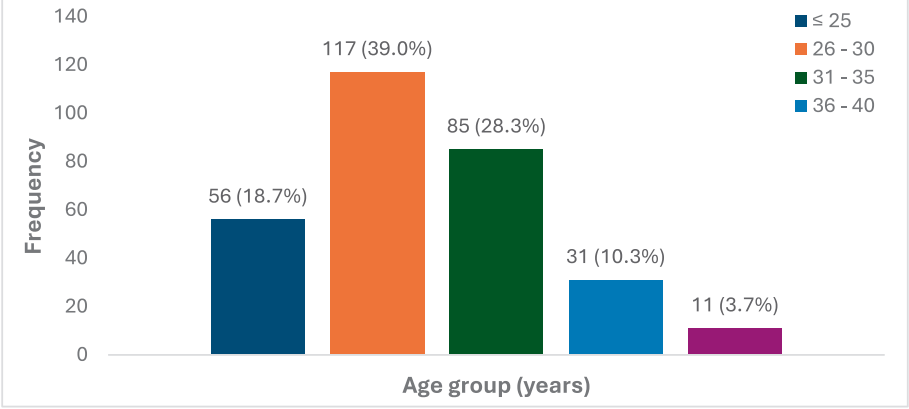
Data collection

Trans-abdominal ultrasound examinations were done real-time using Sonoscape *S*30 machine with a high resolution 3.5 MHz convex probe. All measurements were taken by the first author to eliminate inter-observer error on frozen images with the on-screen electronic calliper of the ultrasound unit. The commonly measured foetal parameters for GA estimation such as BPD, HC, AC and FL were measured using the standard landmark protocols.

Ultrasound estimation of GA was obtained using the algorithm of the ultrasound machine based on the formula proposed by Hadlock et al. [16] Images of the umbilical cord used for measurements were captured when the outer edges of the umbilical cord were outlined in a longitudinal plane as well as in the transverse plane. The sonographic cross-sectional area and the greatest diameter of the umbilical cord were measured in a plane adjacent to the umbilical cord insertion to foetal



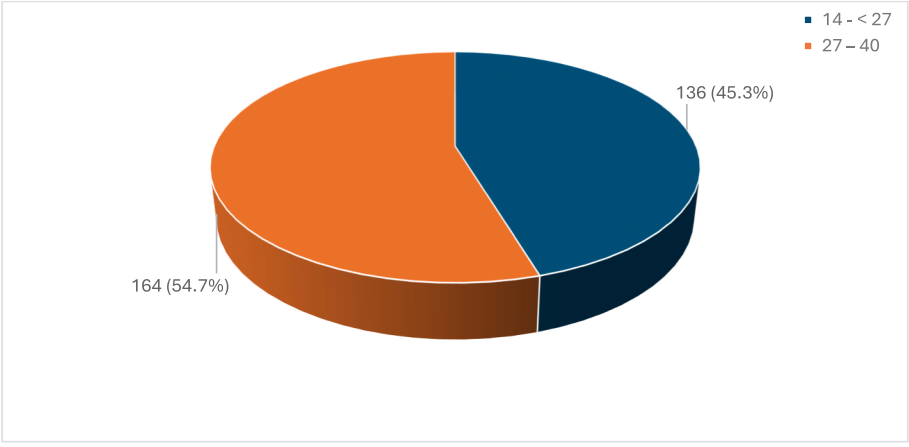

**Fig. 2.** Umbilical cord sonogram in transverse plane showing the measurement of CSA (Arrowhead).




Mean ± SD: 30.09 ± 5.05; Range: 20 – 46

**Fig. 3.** Age distribution of the participants. Mean ± SD: 30.09 ± 7.44; Range: 20–46.

abdomen within the maximum distance of 1 cm as described by Afroze et al. [11] and Raio et al. [17]. Measurement of the umbilical cord diameter was performed in long axis view of the umbilical cord by placing the electronic calipers from outer to outer border [1,17,18]




Mean ± SD: 27.27 ± 7.44; Range: 14.0 – 40.0

**Fig. 4.** Gestational age distribution of the study participants in trimester. Mean ± SD: 27.27 ± 7.44; Range: 14.0–40.0.

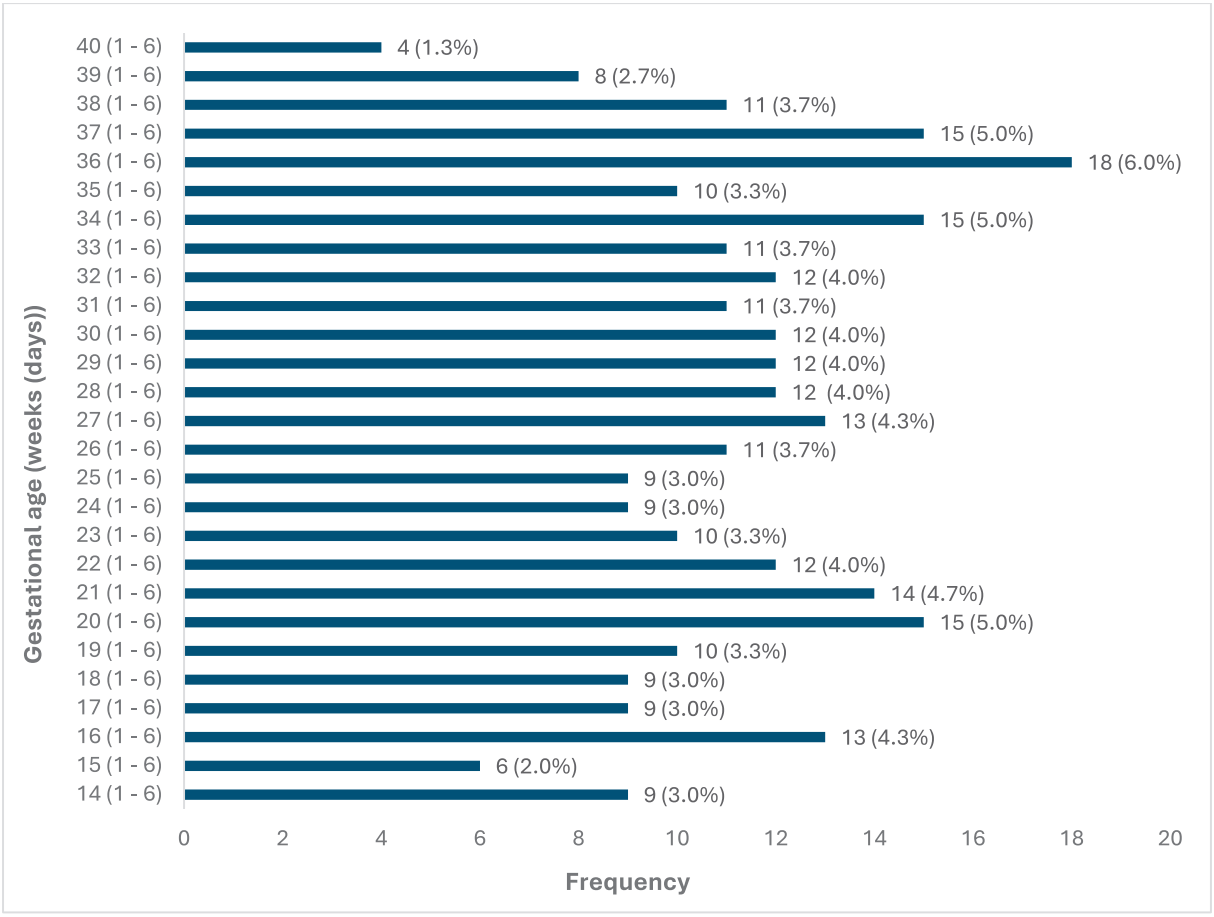



**Fig. 5.** Gestational age of the study participants in weeks.

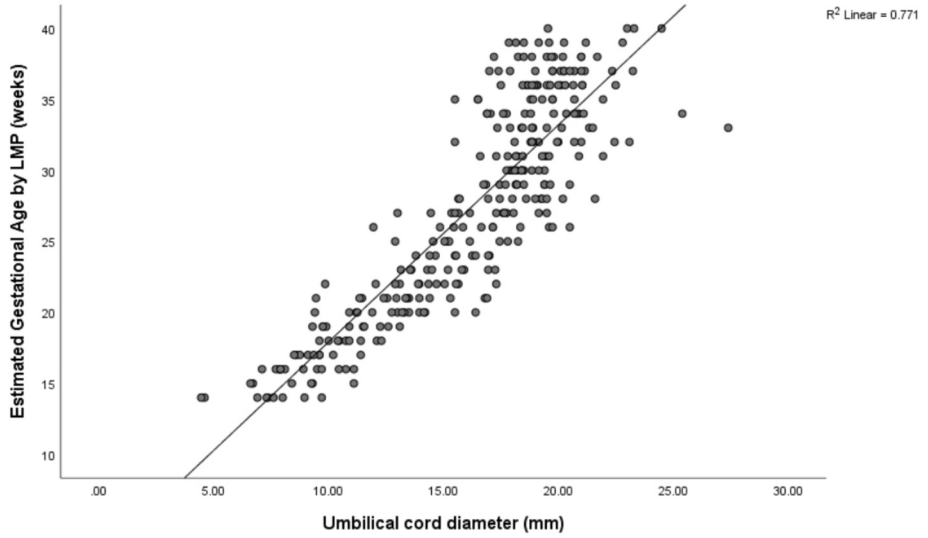



**Fig. 6.** Scatter plot showing the relationship between Estimated Gestational Age (by LMP) and Umbilical cord diameter. The plot shows a positive correlation between Estimated Gestational Age (by LMP) and Umbilical cord diameter implying an increase in gestational age as the cord diameter increases.

(Fig. 1).

The cross-sectional area of the umbilical cord was obtained in transverse axis, encircled circumferentially using the ellipse measurement function of the machine followed by automatic calculation of the area by the software of the ultrasound machine [9,17,19] (Fig. 2).

Measurements were taken twice for each parameter, and the average value was recorded for each participant to reduce intra-observer error.

Statistical analysis

This was performed with SPSS version 26.0 released 2018 (IBM SPSS Statistics, Armonk NY). Data obtained were analysed and presented using tables and charts.

The correlation between umbilical cord diameter, cross-sectional

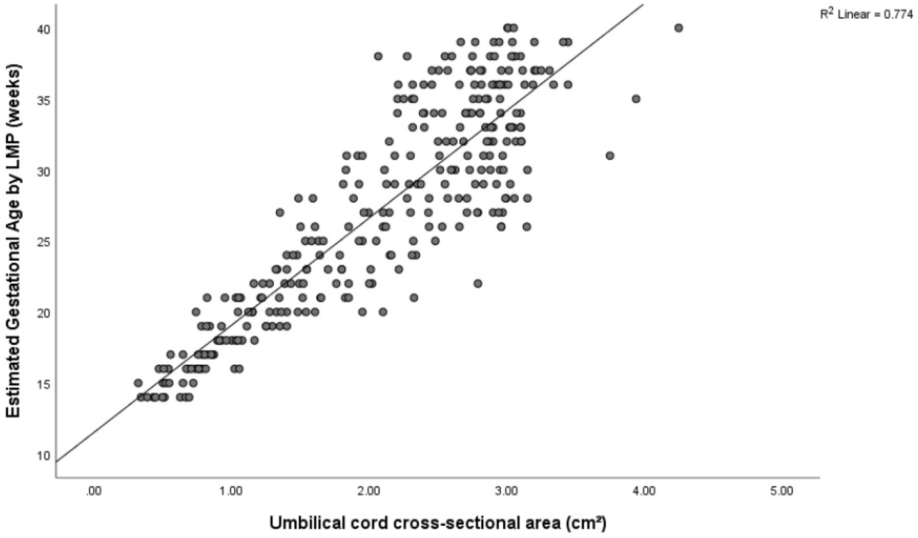



**Fig. 7.** Scatter plot showing the relationship between Estimated Gestational Age (by LMP) and Umbilical cord cross-sectional area. The plot shows a positive correlation between Estimated Gestational Age (by LMP) and Umbilical cord cross-sectional area implying an increase gestational age as the cross-sectional area increases.

area and gestational age as well as commonly used foetal parameters were determined using Spearman's correlation coefficient. The estimation of foetal gestational age from umbilical cord diameter and cross-sectional area was determined with linear regression analysis.

Level of statistical significance was set at $p < 0.05$ at confidence interval of 95% for all inferential statistics.

## Results

Three hundred pregnant women with singleton pregnancy who met the inclusion criteria were recruited in the study. Their demographic characteristics are shown in Figs. 3–5.

The UCD and CSA ranged from 4.45 to 27.40 mm and 0.32 to 4.25 $cm^2$ respectively for GAs between 14 and 40 weeks with a mean ± SD of umbilical cord diameter 16.12 ± 4.28 mm and 2.08 ± 0.87 $cm^2$ for cross-sectional area. Histogram showing this distribution is available in the Supplementary file.

Figs. 6 and 7 represents a linear regression graph showing the relationship and correlation (r and p) values between umbilical cord diameter, cross-sectional area and gestational age by LMP (p = 0.001). A very strong correlation was observed between UCD, CSA and GA by LMP (r = 0.771 and 0.774 for UCD and CSA respectively).

Nomograms were generated for the umbilical cord diameter and cross-sectional area as well as the 5th, 10th, 50th, 90th and 95th percentiles for each gestational age. The mean umbilical cord diameter and cross-section area increased steadily with gestational age (Tables 1 and 2).

Table 3 shows a regression analysis model between umbilical cord diameter, cross-sectional area and gestational age measured by LMP and US. This model 95% CI clearly depicts the explained variation in dependent variables. The results can be predicted by the following equations:

$$\text{GA by LMP (weeks)} = 1.528\,(\text{UCD}) + 2.646,\ 7.544\,(\text{CSA}) + 11.540$$

$$\text{GA by US (weeks)} = 1.542\,(\text{UCD}) + 2.653,\ 7.618\,(\text{CSA}) + 11.619$$

The above-mentioned equation shows that gestational age estimated by LMP or US can be related with umbilical cord diameter and cross-sectional area. Both significantly predict gestational age just like other foetal parameters.

Table 4 show that umbilical cord diameter, cross-sectional area and other foetal parameters as well as EFW increases with GA as pregnancy advanced.

Table 5 show significant correlation (p = 0.001) between umbilical cord diameter and cross-sectional area with EFW and other foetal parameters for gestational age estimation. Spearman's correlation coefficient, r includes; BPD (r = 0.874); HC (r = 0.861); AC (r = 0.879); FL(r = 0.874); EFW (r = 0.877) and BPD (r = 0.852); HC (r = 0.852), and AC (r = 0.865); FL (r = 0.861); EFW (r = 0.865) for umbilical cord diameter and cross-sectional area respectively. Linear regression graphs for these correlations are available in the Supplementary files.

## Discussion

Gestational age is one of the most important features of a pregnancy. Foetal growth assessment, either clinically or by ultrasound evaluation relies on accurate estimation of gestational age [7].

Ultrasound assessment of foetal growth in obstetrics is very important because it is cheap, readily available and does not use ionising radiation. It allows a more direct means of assessing foetal structures and development. Measurements of a variety of foetal parameters including the UCD and CSA have been devised to establish gestational age.

The mean maternal age in this study was 30.09 ± 5.05 years. This was similar to that of studies by Raio et al. [17], Rostamzadeh et al. [20], Togni et al. [21] and Abd Al- fadel et al. [9] in which the mean maternal age was 28.3 ± 4.6, 27 ± 5.5, 28 ± 6 and 28.24 ± 5.5 years respectively.

This however differs from the mean age reported by Afroze et al[11] on 437 pregnant women in India and Begum et al. [22] on 230 pregnant women in Bangladesh which were 25.08 ± 3.5 and 24.3 ± 4.7 years respectively. The difference is probably due to geographical location and variation in sample size used in these studies.

The mean GA of the participants in this study was 27.27 ± 7.44 weeks. This is comparable to the findings of Khalid et al. [1] who reported a mean gestational age of 27.58 ± 6.1 weeks. This similarity is probably due to the similar inclusion criteria adopted in both studies. However, the findings differ from those of other researchers who reported higher mean GA: 34.42 ± 2.5 weeks (Afroze et al.) [11], 32.1 ± 4.5 weeks (Begum et al.) [22] and 33.7 ± 5.8 weeks (Rostamzadeh et al.) [20].

In this study, the mean UCD was 16.12 ± 4.28 mm. This finding is slightly higher than those reported from previous studies in which the mean UCD were 14.5 ± 7.2 mm, 13.1 ± 1.7 mm and 13.7 ± 3.48 mm by Eze et al. [8], Ugwuja [23], and Khalid et al. [1] respectively. However,

**Table 1**
Nomogram of umbilical cord diameter according to gestational age.

| Gestational age (week (day)) | N (300) | Umbilical cord diameter (mm) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Mean ± SD | 5 | 10 | 50 | 90 | 95 |
| 14 (1–6) | 9 | 7.21 ± 1.75 | 4.45 | 4.45 | 7.35 | 7.35 | 7.35 |
| 15 (1–6) | 6 | 8.56 ± 1.72 | 6.60 | 6.60 | 8.82 | 8.82 | 8.82 |
| 16 (1–6) | 13 | 8.83 ± 1.32 | 7.10 | 7.34 | 8.10 | 10.96 | 10.96 |
| 17 (1–6) | 9 | 9.46 ± 0.91 | 8.50 | 8.50 | 9.35 | 9.35 | 9.35 |
| 18 (1–6) | 9 | 10.88 ± 0.91 | 9.60 | 9.60 | 10.75 | 10.75 | 10.75 |
| 19 (1–6) | 10 | 11.06 ± 1.35 | 9.30 | 9.35 | 11.20 | 13.05 | 13.05 |
| 20 (1–6) | 15 | 12.97 ± 1.83 | 9.40 | 10.30 | 13.20 | 15.86 | 15.86 |
| 21 (1–6) | 14 | 13.41 ± 2.04 | 9.45 | 10.40 | 13.38 | 16.85 | 16.85 |
| 22 (1–6) | 12 | 14.03 ± 1.93 | 9.85 | 10.51 | 14.15 | 16.81 | 16.81 |
| 23 (1–6) | 10 | 15.02 ± 1.44 | 13.15 | 13.19 | 14.85 | 17.22 | 17.22 |
| 24 (1–6) | 9 | 15.61 ± 1.14 | 13.80 | 13.80 | 15.55 | 15.55 | 15.55 |
| 25 (1–6) | 9 | 15.84 ± 1.74 | 12.90 | 12.90 | 15.25 | 15.25 | 15.25 |
| 26 (1–6) | 11 | 17.02 ± 2.50 | 11.95 | 12.53 | 17.15 | 20.35 | 20.35 |
| 27 (1–6) | 13 | 16.70 ± 1.88 | 13.00 | 13.58 | 17.30 | 19.36 | 19.36 |
| 28 (1–6) | 12 | 18.43 ± 1.77 | 15.65 | 15.67 | 18.80 | 21.18 | 21.18 |
| 29 (1–6) | 12 | 18.40 ± 1.15 | 16.75 | 16.78 | 18.20 | 20.25 | 20.25 |
| 30 (1–6) | 12 | 18.42 ± 0.50 | 17.75 | 17.79 | 18.40 | 19.33 | 19.33 |
| 31 (1–6) | 11 | 18.88 ± 1.57 | 16.60 | 16.74 | 18.45 | 21.74 | 21.74 |
| 32 (1–6) | 12 | 19.71 ± 2.01 | 15.50 | 16.28 | 19.55 | 22.91 | 22.91 |
| 33 (1–6) | 11 | 19.98 ± 2.79 | 17.35 | 17.46 | 18.90 | 26.22 | 26.22 |
| 34 (1–6) | 15 | 19.35 ± 2.30 | 16.90 | 16.90 | 18.80 | 22.82 | 22.82 |
| 35 (1–6) | 10 | 18.76 ± 2.03 | 15.50 | 15.60 | 19.10 | 21.83 | 21.83 |
| 36 (1–6) | 18 | 19.64 ± 1.18 | 17.50 | 18.36 | 19.55 | 21.20 | 21.20 |
| 37 (1–6) | 15 | 20.02 ± 1.70 | 17.00 | 17.24 | 20.25 | 22.71 | 22.71 |
| 38 (1–6) | 11 | 19.61 ± 1.35 | 17.20 | 17.41 | 19.70 | 21.56 | 21.56 |
| 39 (1–6) | 8 | 19.69 ± 1.68 | 17.85 | 17.85 | 19.38 | 19.38 | 19.38 |
| 40 (1–6) | 4 | 22.59 ± 2.13 | 19.55 | 19.55 | 23.15 | 23.15 | 23.15 |

**Table 2**
Nomogram of umbilical cord cross-sectional area according to gestational age.

| Gestational age (weeks (days)) | N (300) | Umbilical cord cross-sectional area ($cm^2$) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Mean ± SD | 5 | 10 | 50 | 90 | 95 |
| 14 (1–6) | 9 | 0.51 ± 0.13 | 0.34 | 0.34 | 0.50 | 0.50 | 0.50 |
| 15 (1–6) | 6 | 0.54 ± 0.14 | 0.32 | 0.32 | 0.53 | 0.53 | 0.53 |
| 16 (1–6) | 13 | 0.73 ± 0.17 | 0.47 | 0.48 | 0.74 | 1.04 | 1.04 |
| 17 (1–6) | 9 | 0.77 ± 0.11 | 0.55 | 0.55 | 0.80 | 0.80 | 0.80 |
| 18 (1–6) | 9 | 1.00 ± 0.09 | 0.90 | 0.90 | 1.00 | 1.00 | 1.00 |
| 19 (1–6) | 10 | 1.10 ± 0.24 | 0.78 | 0.78 | 1.18 | 1.40 | 1.40 |
| 20 (1–6) | 15 | 1.36 ± 0.35 | 0.74 | 0.92 | 1.33 | 2.01 | 2.01 |
| 21 (1–6) | 14 | 1.39 ± 0.43 | 0.82 | 0.89 | 1.28 | 2.09 | 2.09 |
| 22 (1–6) | 12 | 1.66 ± 0.46 | 1.16 | 1.18 | 1.51 | 2.56 | 2.56 |
| 23 (1–6) | 10 | 1.67 ± 0.30 | 1.32 | 1.32 | 1.62 | 2.19 | 2.19 |
| 24 (1–6) | 9 | 1.86 ± 0.39 | 1.40 | 1.40 | 1.79 | 1.79 | 1.79 |
| 25 (1–6) | 9 | 1.90 ± 0.34 | 1.54 | 1.54 | 1.92 | 1.92 | 1.92 |
| 26 (1–6) | 11 | 2.35 ± 0.56 | 1.50 | 1.52 | 2.44 | 3.11 | 3.11 |
| 27 (1–6) | 13 | 2.41 ± 0.49 | 1.35 | 1.59 | 2.43 | 2.96 | 2.96 |
| 28 (1–6) | 12 | 2.48 ± 0.57 | 1.49 | 1.52 | 2.61 | 3.12 | 3.12 |
| 29 (1–6) | 12 | 2.43 ± 0.39 | 1.81 | 1.84 | 2.36 | 3.00 | 3.00 |
| 30 (1–6) | 12 | 2.65 ± 0.37 | 1.83 | 1.91 | 2.68 | 3.10 | 3.10 |
| 31 (1–6) | 11 | 2.53 ± 0.57 | 1.84 | 1.85 | 2.51 | 3.59 | 3.59 |
| 32 (1–6) | 12 | 2.78 ± 0.29 | 2.15 | 2.25 | 2.86 | 3.11 | 3.11 |
| 33 (1–6) | 11 | 2.85 ± 0.27 | 2.32 | 2.33 | 2.90 | 3.10 | 3.10 |
| 34 (1–6) | 15 | 2.69 ± 0.25 | 2.21 | 2.32 | 2.72 | 3.08 | 3.08 |
| 35 (1–6) | 10 | 2.72 ± 0.52 | 2.21 | 2.21 | 2.78 | 3.84 | 3.84 |
| 36 (1–6) | 18 | 2.85 ± 0.34 | 2.21 | 2.30 | 2.92 | 3.35 | 3.35 |
| 37 (1–6) | 15 | 2.90 ± 0.28 | 2.46 | 2.49 | 2.82 | 3.27 | 3.27 |
| 38 (1–6) | 11 | 2.75 ± 0.34 | 2.07 | 2.11 | 2.88 | 3.09 | 3.09 |
| 39 (1–6) | 8 | 3.05 ± 0.28 | 2.67 | 2.67 | 2.99 | 2.99 | 2.99 |
| 40 (1–6) | 4 | 3.33 ± 0.61 | 3.01 | 3.01 | 3.03 | 3.03 | 3.03 |

the mean UCD observed in the present study is significantly higher than 11.63 ± 3.5 mm reported by Sarwa et al. [24]. The observed differences may be attributable to differences in study population.

Weissman et al. [25] and Raio et al. [17] observed that UCD increased progressively with the GA up to 32 weeks, after which it declines and then reaches a plateau. This present study similarly demonstrates a direct relationship between GA and UCD with the mean UCD increasing steadily with GA up to the 33rd week of gestation, declines thereafter and then remains stable from the 38th week gestation until the end of pregnancy.

The mean CSA of 2.08 ± 0.87 $cm^2$ is similar to the mean CSA of 2.01 ± 1.35 $cm^2$ reported in a previous study in Enugu, Nigeria [8]. This result is only slightly different from the mean CSA of 1.91 $cm^2$ reported in a previous study among Iranian subjects [19]. However, this value appeared significantly different from 1.58 ± 4.0 $cm^2$ reported by Ugwuja [23].

This study also observed a steady increase in the mean umbilical cord CSA with GA up to the 33rd week of gestation, followed by a decline from the 34th week and stabilization from the 39th week onwards. These findings are consistent with those reported by Afroze et al. [11], Raio et al. [17], Togni et al. [21] and by Ghezzi et al. [26] with an increase in the mean umbilical cord CSA up to 34th week gestation followed by a decline. Barbieri et al. [27] and Rostamzadeh et al. [20] also observed a linear increase in the umbilical cord CSA up to 32nd and 30th weeks of gestation respectively.

These variations in the mean umbilical cord sizes may suggest racial or environmental differences in the development of the umbilical cord. It could also be due to difference in the study populations, inclusion

**Table 3**
Estimating foetal gestational age using umbilical cord diameter and cross-sectional area (Linear regression analysis).

| Variable | B | t | *p* value | 95.0% CI for B | |
|---|---|---|---|---|---|
| | | | | Lower Bound | Upper Bound |
| **GESTATIONAL AGE BY LMP** | | | | | |
| **Diameter** | 1.528 | 31.667 | 0.001 | 1.433 | 1.622 |
| ***Constant*** | *2.646* | | | | |
| **Area** | 7.544 | 31.988 | 0.001 | 7.080 | 8.008 |
| ***Constant*** | *11.540* | | | | |
| **GESTATIONAL AGE BY US** | | | | | |
| **Diameter** | 1.542 | 33.318 | 0.001 | 1.451 | 1.633 |
| ***Constant*** | *2.653* | | | | |
| **Area** | 7.618 | 33.790 | 0.001 | 7.175 | 8.062 |
| ***Constant*** | *11.619* | | | | |

**B: Unstandardized Coefficient of Linear Regression;**
**95% CI: 95% Confidence Interval.**
EGA by LMP (weeks) = 1.528 (diameter) + 2.646 EGA by LMP (weeks) = 7.544 (area) + 11.540.
EGA by US (weeks) = 1.542 (diameter) + 2.653 EGA by US (weeks) = 7.618 (area) + 11.619.

criteria and inter-observer bias in the measurements of the UCD and CSA.

Both UCD and CSA were observed to increase progressively with GA as pregnancy advanced from the 14th to the 40th week of gestation. Both showed significant positive correlation with GA and these findings are in line with those of previous studies in our locality which showed similar positive correlation [8,23,28].

Togni et al. [21], observed a significant correlation between umbilical cord cross-sectional area and other foetal anthropometric measurements like BPD, HC, AC, and FL. Raio et al. [17] described a reference curve for the cross-sectional area of the umbilical cord and its vessels by viewing the cord through a cross-section, a correlation was found between the cross-sectional area of the umbilical cord and foetal anthropometric parameters. In this study, the same technique was applied and similar correlations (p = <0.001) between umbilical cord diameter, cross-sectional area and all the foetal anthropometric measurements were observed.

All the parameters increased with gestational age with a positive correlation. Various studies done in Enugu, Cross river, Bangladesh and Pakistan have also shown a strong positive correlation between these parameters and umbilical cord diameter and cross-sectional diameter and area [8,22,24,28].

This study has established reference values for UCD and CSA across different GA, including the 5th, 10th, 50th, 90th and 95th percentiles in the study population. In addition, a regression analysis model was developed which demonstrated that GA estimated by LMP or US correlates significantly with both UCD and CSA. These findings suggest that both UCD and CSA can serve as a reliable predictor of gestational age

**Table 5**
Correlation between umbilical cord diameter and cross-sectional area with other foetal parameters.

| US measurements | Umbilical cord diameter | |
|---|---|---|
| | r | *p* value |
| BPD (mm) | 0.874 | 0.001 |
| HC (mm) | 0.861 | 0.001 |
| AC (mm) | 0.879 | 0.001 |
| FL (mm) | 0.874 | 0.001 |
| Estimated foetal weight (g) | 0.877 | 0.001 |
| | **Umbilical cord cross-sectional area** | |
| BPD (mm) | 0.852 | 0.001 |
| HC (mm) | 0.852 | 0.001 |
| AC (mm) | 0.865 | 0.001 |
| FL (mm) | 0.861 | 0.001 |
| Estimated foetal weight (g) | 0.865 | 0.001 |

r: Spearman's correlation coefficient.

**Table 4**
Foetal parameters based on Gestational age.

| GA(week(day)) | N (300) | UCD (mm) Mean ± SD | CSA ($cm^2$) Mean ± SD | BPD (mm) Mean ± SD | HC (mm) Mean ± SD | AC (mm) Mean ± SD | FL (mm) Mean ± SD | EFW (g) Mean ± SD |
|---|---|---|---|---|---|---|---|---|
| 14(1–6) | 9 | 7.21 ± 1.75 | 0.51 ± 0.13 | 29.84 ± 2.74 | 106.38 ± 7.61 | 89.93 ± 10.10 | 16.71 ± 3.33 | 116.76 ± 23.70 |
| 15(1–6) | 6 | 8.56 ± 1.72 | 0.54 ± 0.14 | 33.45 ± 1.65 | 123.50 ± 7.79 | 106.50 ± 8.87 | 20.28 ± 3.45 | 152.28 ± 27.30 |
| 16(1–6) | 13 | 8.83 ± 1.32 | 0.73 ± 0.17 | 35.72 ± 3.82 | 128.46 ± 14.03 | 111.32 ± 14.72 | 22.20 ± 3.31 | 171.20 ± 38.98 |
| 17(1–6) | 9 | 9.46 ± 0.91 | 0.77 ± 0.11 | 37.87 ± 2.32 | 138.56 ± 6.33 | 116.22 ± 8.17 | 25.19 ± 1.68 | 200.27 ± 22.89 |
| 18(1–6) | 9 | 10.88 ± 0.91 | 1.00 ± 0.09 | 43.50 ± 3.43 | 159.00 ± 7.37 | 132.78 ± 9.43 | 28.79 ± 1.73 | 261.33 ± 34.60 |
| 19(1–6) | 10 | 11.06 ± 1.35 | 1.10 ± 0.24 | 45.70 ± 1.86 | 168.60 ± 8.69 | 145.70 ± 10.13 | 32.55 ± 3.25 | 326.90 ± 48.20 |
| 20(1–6) | 15 | 12.97 ± 1.83 | 1.36 ± 0.35 | 47.06 ± 2.95 | 173.00 ± 12.40 | 152.20 ± 13.10 | 32.43 ± 2.07 | 353.51 ± 56.60 |
| 21(1–6) | 14 | 13.41 ± 2.04 | 1.39 ± 0.43 | 51.39 ± 2.86 | 190.71 ± 12.46 | 168.07 ± 10.33 | 36.97 ± 2.19 | 444.79 ± 62.95 |
| 22(1–6) | 12 | 14.03 ± 1.93 | 1.66 ± 0.46 | 54.37 ± 2.76 | 201.08 ± 10.64 | 178.50 ± 11.11 | 41.20 ± 2.73 | 548.83 ± 73.97 |
| 23(1–6) | 10 | 15.02 ± 1.44 | 1.67 ± 0.30 | 59.61 ± 3.47 | 214.20 ± 5.96 | 187.60 ± 9.90 | 42.86 ± 3.22 | 557.40 ± 164.63 |
| 24(1–6) | 9 | 15.61 ± 1.14 | 1.86 ± 0.39 | 60.39 ± 2.53 | 222.00 ± 13.85 | 198.56 ± 11.22 | 43.91 ± 2.10 | 694.67 ± 92.09 |
| 25(1–6) | 9 | 15.84 ± 1.74 | 1.90 ± 0.34 | 64.31 ± 3.46 | 235.33 ± 9.39 | 210.89 ± 10.07 | 47.46 ± 2.98 | 847.22 ± 102.10 |
| 26(1–6) | 11 | 17.02 ± 2.50 | 2.35 ± 0.56 | 67.84 ± 7.49 | 248.82 ± 25.19 | 232.00 ± 37.92 | 52.40 ± 9.05 | 1188.55 ± 775.75 |
| 27(1–6) | 13 | 16.70 ± 1.88 | 2.41 ± 0.49 | 69.48 ± 2.57 | 260.38 ± 13.85 | 235.46 ± 6.58 | 52.79 ± 2.81 | 1177.54 ± 123.72 |
| 28(1–6) | 12 | 18.43 ± 1.77 | 2.48 ± 0.57 | 72.76 ± 3.68 | 264.25 ± 14.88 | 243.67 ± 12.25 | 54.21 ± 2.02 | 1292.50 ± 201.39 |
| 29(1–6) | 12 | 18.40 ± 1.15 | 2.43 ± 0.39 | 75.22 ± 3.50 | 270.50 ± 5.84 | 250.67 ± 8.45 | 57.15 ± 1.94 | 1474.00 ± 199.75 |
| 30(1–6) | 12 | 18.42 ± 0.50 | 2.65 ± 0.37 | 77.42 ± 2.65 | 279.83 ± 12.24 | 265.42 ± 13.65 | 59.18 ± 2.29 | 1577.25 ± 200.54 |
| 31(1–6) | 11 | 18.88 ± 1.57 | 2.53 ± 0.57 | 80.09 ± 2.87 | 291.00 ± 9.67 | 276.00 ± 7.94 | 62.89 ± 1.69 | 1883.82 ± 117.79 |
| 32(1–6) | 12 | 19.71 ± 2.01 | 2.78 ± 0.29 | 81.77 ± 3.29 | 291.32 ± 21.52 | 279.75 ± 13.45 | 62.42 ± 2.38 | 1967.50 ± 244.60 |
| 33(1–6) | 11 | 19.98 ± 2.79 | 2.85 ± 0.27 | 84.45 ± 2.14 | 306.73 ± 5.18 | 297.45 ± 10.71 | 66.50 ± 2.72 | 2324.36 ± 193.88 |
| 34(1–6) | 15 | 19.35 ± 2.30 | 2.69 ± 0.25 | 86.35 ± 2.89 | 309.73 ± 8.63 | 306.60 ± 11.06 | 67.49 ± 1.43 | 2490.87 ± 244.48 |
| 35(1–6) | 10 | 18.76 ± 2.03 | 2.72 ± 0.52 | 87.71 ± 2.22 | 316.70 ± 7.60 | 308.00 ± 9.31 | 69.44 ± 2.41 | 2574.20 ± 240.50 |
| 36(1–6) | 18 | 19.64 ± 1.18 | 2.85 ± 0.34 | 90.29 ± 3.22 | 321.67 ± 6.94 | 327.50 ± 7.18 | 72.04 ± 1.83 | 2979.39 ± 177.33 |
| 37(1–6) | 15 | 20.02 ± 1.70 | 2.90 ± 0.28 | 91.60 ± 3.59 | 327.07 ± 10.77 | 335.00 ± 12.99 | 73.71 ± 1.70 | 3233.80 ± 278.17 |
| 38(1–6) | 11 | 19.61 ± 1.35 | 2.75 ± 0.34 | 92.16 ± 2.73 | 329.91 ± 5.82 | 342.82 ± 8.20 | 75.27 ± 1.30 | 3332.09 ± 184.74 |
| 39(1–6) | 8 | 19.69 ± 1.68 | 3.05 ± 0.28 | 94.19 ± 3.60 | 337.13 ± 7.45 | 352.50 ± 10.90 | 76.09 ± 1.65 | 3576.63 ± 357.08 |
| 40(1–6) | 4 | 22.59 ± 2.13 | 3.33 ± 0.61 | 96.30 ± 3.30 | 337.25 ± 8.96 | 356.25 ± 12.37 | 77.95 ± 2.80 | 3828.25 ± 139.30 |

**GA: Gestational age N: Frequency.**
This table shows the umbilical cord diameter, cross-sectional area as well as other foetal parameters generated from this study. The sonographic umbilical cord diameter and cross-sectional area increase as gestational age increases.

just like the commonly used foetal biometric parameters.

## Conclusion

Sonographic measurement of UCD and CSA can be adopted as useful tools during routine antenatal scan in evaluation of foetal growth in view of its strong correlation with other commonly used foetal biometric parameters. They are important indicators of foetal growth and well-being and can serve as supplementary markers particularly in cases where the conventional markers are limited or inconclusive.

## Limitation

Gross foetal body movement and variable position of the foetus could interfere with measurement; this was minimized by ensuring short scan time.

Variability in the cord size along its length, could affect the accuracy of measurements. This was minimized by taking measurements within 1 cm from the foetal umbilical insertion point.

## CRediT authorship contribution statement

**Musa A. Muslimah:** Writing – review & editing, Methodology, Investigation. **Halimat J. Akande:** Writing – review & editing, Supervision. **Hadijat O. Raji:** Writing – review & editing, Supervision. **Bola B. Olafimihan:** Writing – original draft, Supervision. **Latifat T. Aremu:** Writing – review & editing, Methodology, Investigation. **James I. Owolabi:** Writing – review & editing, Methodology. **Sadiya M. Gwadabe:** Writing – review & editing, Methodology, Investigation. **Idris O. Quadri:** Writing – review & editing, Investigation, Data curation.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Acknowledgements

My appreciation to the following persons for their support and mentorship.

Engineer Abdulmalik Abubakar.
Mrs Adisa Musa.
Prof D.A. Nzeh.
Prof O.I. Oyinloye.
Prof K.T. Braimoh.
Prof O.A.M Adesiyun

## Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ejogrb.2026.114976.

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