Charts of Thai Fetal Biometries: 4. Abdominal Circumference

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Abstract

A cross-sectional study was conducted in order to construct a new reference chart for Thai fetal abdominal circumference (AC). A total of 621 normal pregnant women between 12-41 weeks of gestation and their fetuses were recruited. Measurements were made once at a randomly assigned gestational age specifically for the purpose of this study only. Due to unfavorable fetal position in some cases, AC data were available in 615 measurements. Linear regression models were fitted separately to estimate the mean and standard deviation as functions of gestational age. Reference centiles were constructed from both equations, assuming the data were normally distributed. A new reference centiles for AC is presented and compared with previously published data. Our derived centiles were lower than those from Western studies which may partly be due to racial differences. This emphasizes the need to develop fetal biometries charts specifically for each region.

Key word : Fetal Biometries, Abdominal Circumference, Reference Centiles

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In obstetric clinical practice, fetal abdominal circumference (AC) has been used not only to estimate gestational age, but also for estimating fetal weight, detecting intrauterine growth retardation or fetal macrosomia[1-3]. In the past, many authors purposed a normogram for AC, but might have flaws in their methodology and analysis technique[4]. Altman et al have proposed the optimal approach for developing fetal size chart, using a unique design and analysis methods[5]. Chitty et al have constructed a fetal AC chart using such an approach,[6] however, the chart may be suitable for a Western population but not Thai fetuses. Also, we still have limited information on a stan-

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dard fetal AC chart for our own ppopulation. We have, therefore, constructed a new chart for Thai fetal AC between 12-41 weeks of gestation, and compared it with the results from previous studies.

MATERIAL AND METHOD

This was a cross sectional study, conducted at the Maternal-Fetal Medicine Unit, Department of Obstetric and Gynecology, Siriraj Hospital. A total of 621 pregnant women between 12-41 weeks of gestation and their fetuses were enrolled. In each fetus, AC was measured once at a randomly assigned gestational age for the purpose of this study only. The study design and sample selection procedure are discussed in detail in the methodology part of this series.

The fetal abdominal circumference was measured in a standard axial plane through the fetal abdomen. A section which was as close as possible to circular was obtained, taking care to identify the spine and descending aorta posteriorly, the umbilical vein in the anterior third and the stomach bubble in the same plane. The circumferences were measured using an ellipse mode of the ultrasound machine, which is derived from the two maximum diameters of the ellipse. All of the measurements were performed by only one operator, using a 5 MHz convex probe of the Acuson Model 128 X P4 ultrasound machine.

Statistical Analysis

We applied the methods proposed by Altman et al[5] in the analysis. The technique is described in detail in the methodology part of this series. In brief, we modeled separately the mean and standard deviation (SD) of the AC as functions of gestational age using the linear regression technique. This was based on the assumption that the measurements were normally distributed at each gestational age. Goodness of fit and normality of data were carefully assessed before the final models were chosen. Standard deviation scores (SDS) were calculated by subtracting the fitted mean from the observed data, dividing by the fitted SD and then the normal plot of SDS was examined. We plotted the SDS against gestational age and the proportion of observations below and above the 10th and 90th centiles were assessed if they were close to the expected value. Reference centiles for AC were then constructed using the combinaton of estimates from both models for mean and SD. The 100αth centile can be estimated from mean + Zα(SD), where Zα is the corresponding value from the standard normal distribution.

RESULTS

Fetal abdominal circumference data were available from 615 of 621 measurements due to unfavorable fetal position in some cases. The number of fetuses measured at each week of gestation is shown in Table 1.

The data were first transformed by taking square roots of AC. The model for the mean AC and SD was estimated separately as functions of gestational age using the stepwise linear regression technique. The regression equations for mean and SD are

Table 1. Number of fetuses measured at each week of gestation.

Gestational age (weeks)	Number of fetuses	Percentage
12	13	2.11
13	15	2.44
14	14	2.28
15	19	3.09
16	22	3.58
17	22	3.58
18	21	3.41
19	22	3.58
20	21	3.41
21	21	3.41
22	24	3.90
23	26	4.23
24	22	3.58
25	26	4.23
26	27	4.39
27	23	3.74
28	22	3.58
29	21	3.41
30	25	4.07
31	20	3.25
32	20	3.25
33	22	3.58
34	19	3.09
35	17	2.76
36	23	3.74
37	21	3.41
38	19	3.09
39	18	2.93
40	16	2.60
41	14	2.28
Total	615	100.00

$\sqrt{AC} = -0.106 + 0.748\ W - 0.007\ W^2$

$\sqrt{SD} = 1.223 - 0.124\ W + 0.005\ W^2 - 0.00007\ W^3$

where W = gestational age (weeks)

Fig. 1 shows a scatter plot of AC against gestational age with the fitted line from the regression equation. The mean model gave R^2 of 0.98 which means that the model can explain 98 per cent of the variability. Standard deviation scores (SDS) were calculated and plotted against gestational age and it shows no pattern, as shown in Fig. 2. The proportion of observation below and above the expected 10th and 90th centiles were 10.2 per cent (63 of 615) and 11.5 per cent (71 of 613) respectively. Fig. 3 shows the normal plot of SDS and we found the values lie almost on a straight line. These suggested that the models provided a good fit to the observed data and the data are normally distributed.

Reference centiles were derived from the estimated mean and SD at each week of gestation. This was calculated first in the transformed scale and then back-transformed into the original scale. The 100αth centile can be derived from mean + $Z\alpha$(SD), where the values of $Z\alpha$ are -1.88, -1.28, 0, 1.28, and 1.88 for the 3rd, 10th, 50th, 90th, and 97th centiles respectively. All the fitted centiles (in original scale) are shown in Table 2 and they were plotted with AC data and are shown in Fig. 4.

We compared our derived centiles for AC with those of Chitty et al,[6] who used the same design and analysis technique and is shown in Fig. 5. We can see that our centiles are close to theirs at the beginning of pregnancy until about 15-20 weeks of gestation, after which our lines become lower.

DISCUSSION

Fetal abdominal circumference (AC) has several applications in clinical practice such as

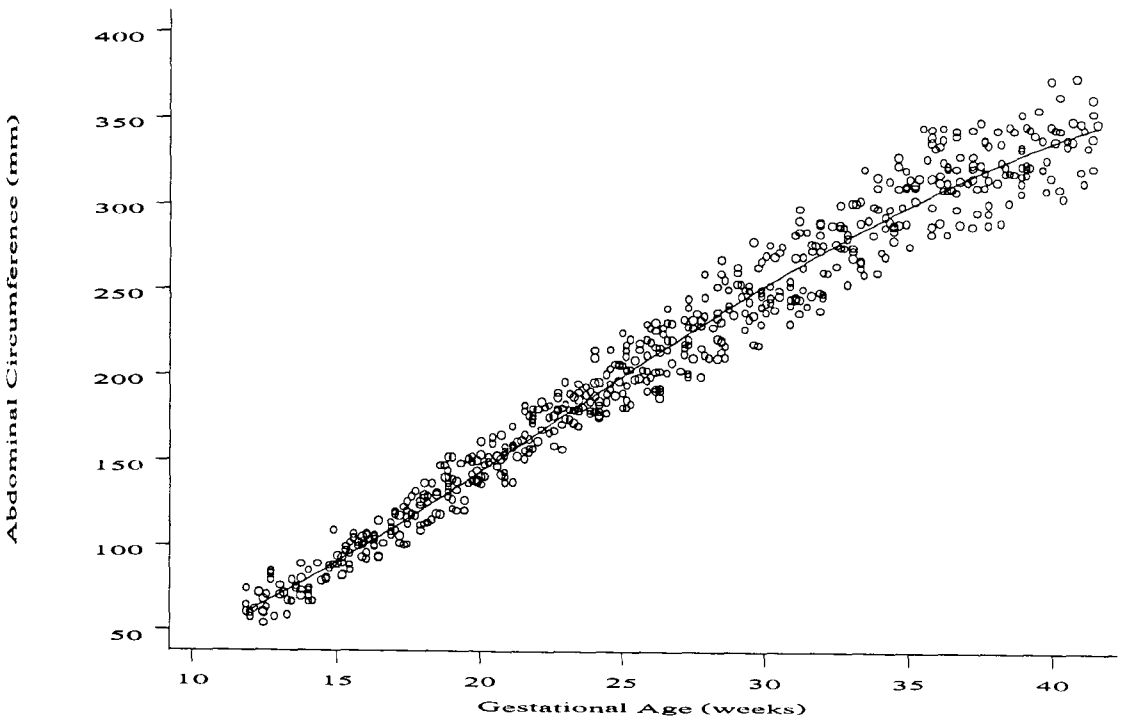

Fig. 1. Scatter plot of abdominal circumference and gestational age with curve of the fitted mean.

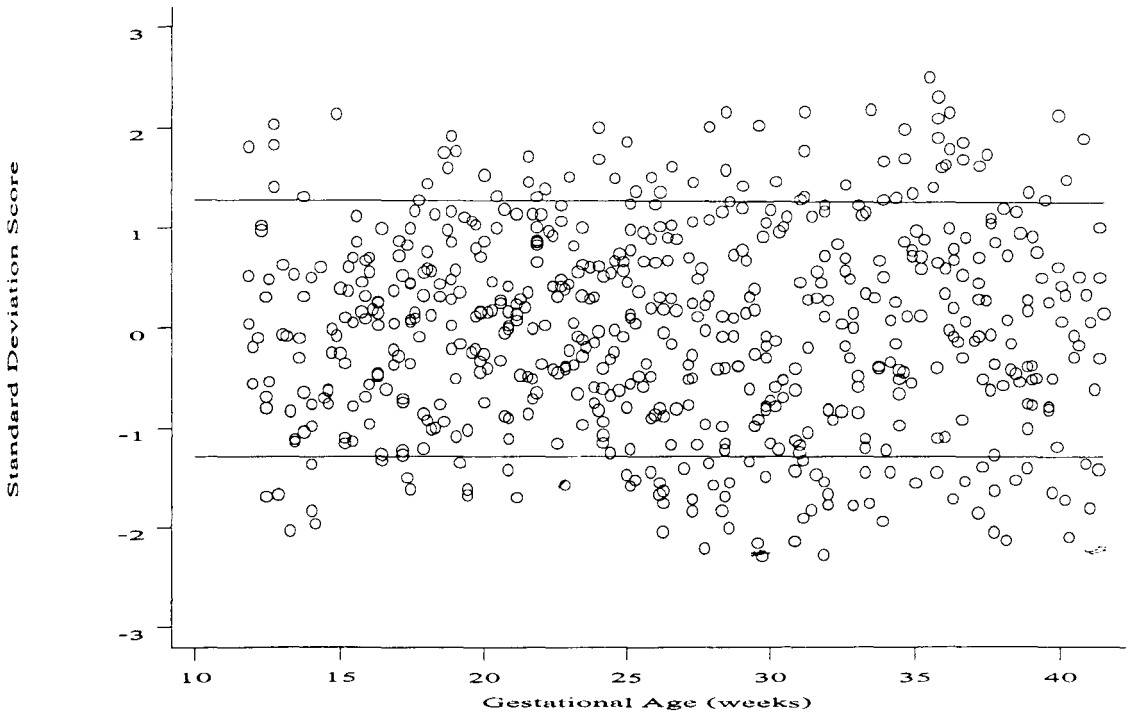

Fig. 2. Plot of SDS against gestational age, with the expected 10th and 90th centile lines.

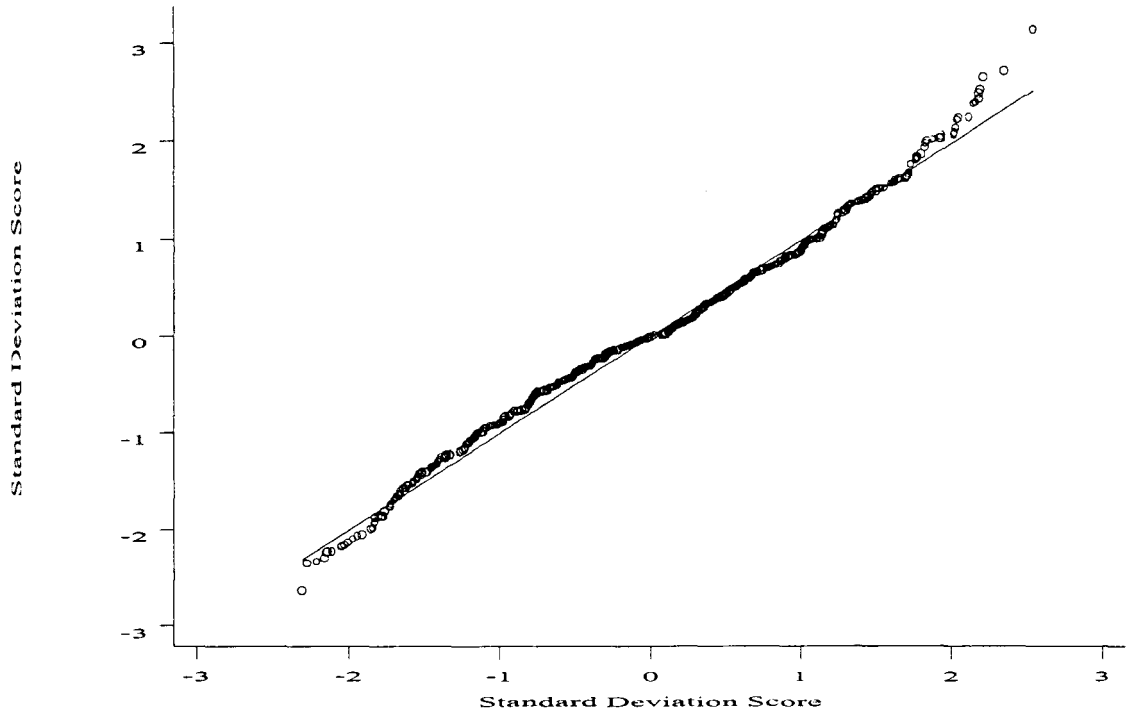

Fig. 3. Normal plot of SDS.

Table 2. Fitted centiles of Thai fetal abdominal circumference.

GA (weeks)	Centile					SD
	3rd	10th	50th	90th	97th	
12	50.86	54.16	61.56	69.44	73.28	0.144
13	60.00	63.35	70.83	78.73	82.56	0.127
14	69.49	72.90	80.49	88.45	92.30	0.114
15	79.26	82.76	90.50	98.58	102.47	0.105
16	89.25	92.85	100.80	109.08	113.06	0.099
17	99.39	103.12	111.36	119.92	124.02	0.096
18	109.63	113.53	122.13	131.04	135.30	0.095
19	119.93	124.04	133.07	142.42	146.88	0.097
20	130.25	134.59	144.13	154.00	158.71	0.099
21	140.50	145.12	155.28	165.79	170.80	0.105
22	150.79	155.69	166.47	177.61	182.93	0.110
23	160.95	166.18	177.67	189.55	195.22	0.117
24	171.02	176.59	188.85	201.52	207.56	0.125
25	180.97	186.91	199.96	213.46	219.90	0.134
26	190.78	197.10	210.96	225.33	232.18	0.144
27	200.46	207.15	221.86	237.08	244.35	0.154
28	209.98	217.04	232.58	248.65	256.34	0.163
29	219.35	226.78	243.11	260.01	268.09	0.173
30	228.57	236.33	253.42	271.10	279.55	0.181
31	237.63	245.71	263.48	281.87	290.66	0.189
32	246.54	254.89	273.26	292.26	301.34	0.194
33	255.31	263.88	282.74	302.24	311.55	0.198
34	263.95	272.69	291.89	311.74	321.23	0.199
35	272.47	281.30	300.69	320.73	330.30	0.197
36	280.88	289.72	309.12	329.15	338.71	0.191
37	289.20	297.95	317.16	336.97	346.41	0.183
38	297.44	306.01	324.79	344.13	353.34	0.170
39	305.62	313.89	331.98	350.59	359.44	0.154
40	313.76	321.60	338.73	356.31	364.66	0.135
41	321.89	329.16	345.02	361.25	368.95	0.114

calculating gestational age, estimating fetal weight, and detecting abnormal fetal growth[1-3]. There are many reports indicating that the average birth weight of Thai fetuses is lower than those of the Western population[7,8]. Moreover, several data confirmed that a different standard of ultrasound-based fetal growth is needed for different populations[9,10]. It has been suggested that fetal racial differences could account for some degree of variation in ultrasound estimation of gestational age [11,12]. Therefore, it is very important to create a new chart of fetal AC that can be used more appropriately for Thai fetuses.

We applied an alternative approach to construct the new chart as proposed by Altman et al. Linear regression technique was used to model both the mean and SD as functions of gestational age. The centiles derived from both models have taken into account the changes in variation among fetuses. Data transformation was needed in this analysis to find the simplest models that provided the best fit to the observed data without violating the normality assumption. Reference centiles were then back-transformed into original scale afterwards.

We compared our derived centiles with those from a Western population. Our centile lines are close to those of Chitty et al[6] at the beginning of gestation and become lower after about 15-20 weeks. This may be due to racial differences between populations. This finding is consistant with the previous studies and emphasizes the need to construct separate fetal biometry charts for each specific population.

The technique used in measuring abdominal circumference also plays an important role in developing reference centiles. Direct measurement around the circumference was found to be consistently greater than those derived from abdominal

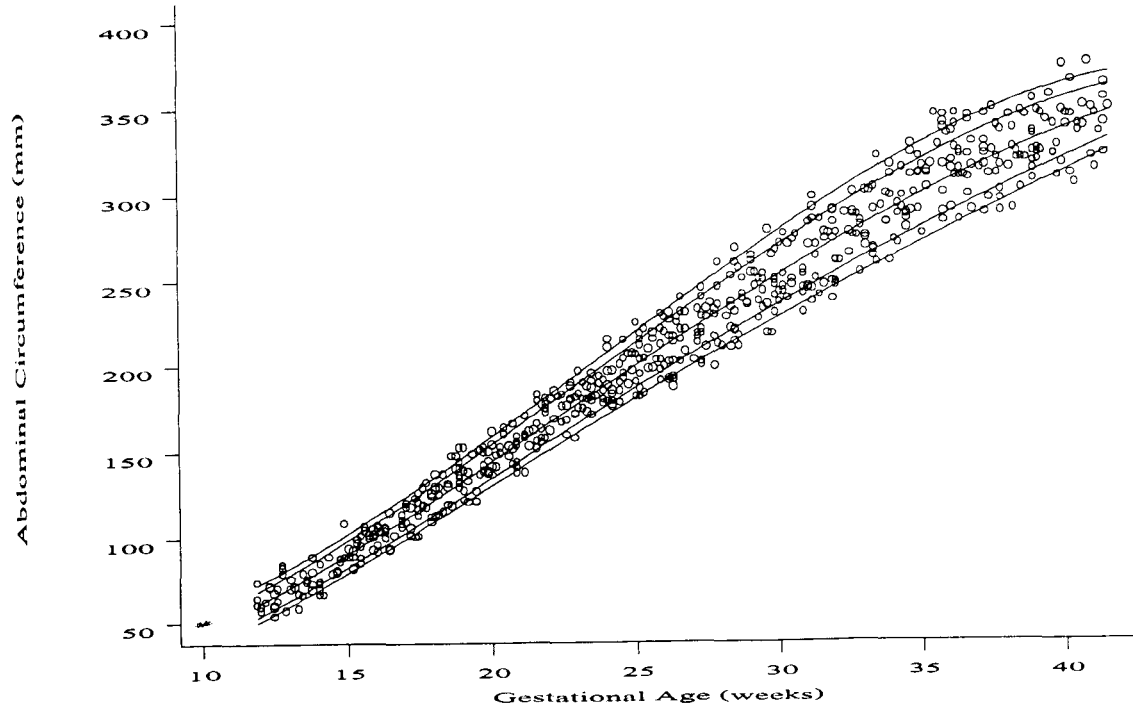

Fig. 4. Abdominal circumference data with fitted 3rd, 10th, 50th, 90th, and 97th centile lines.

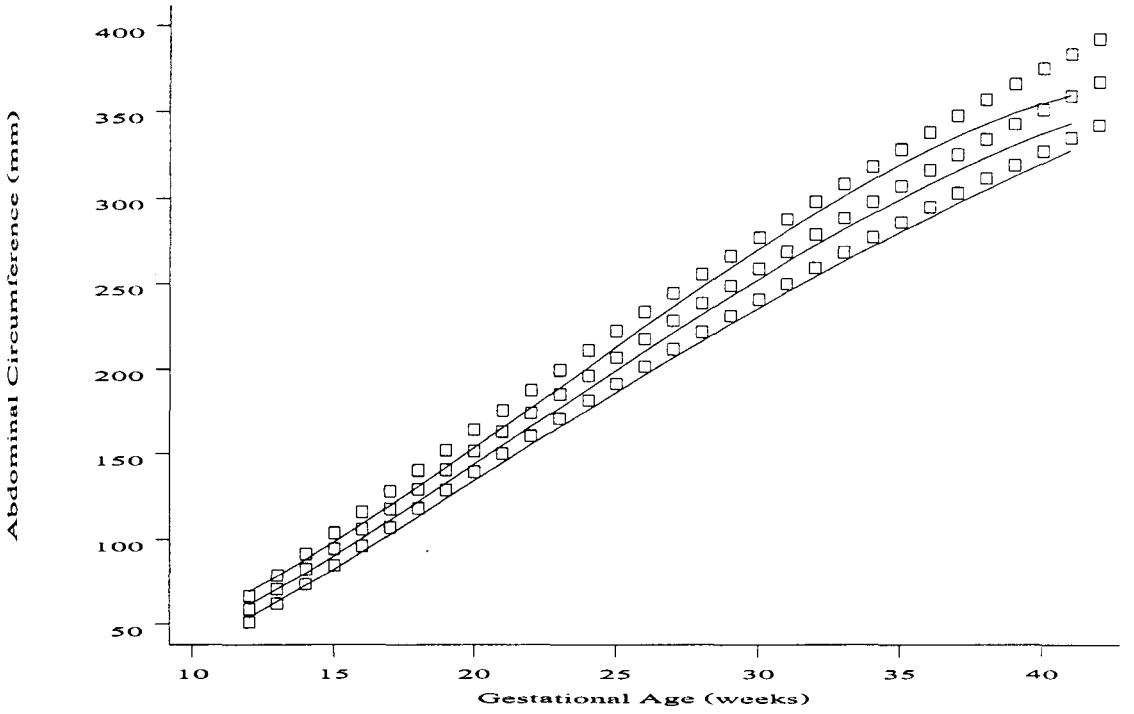

Fig. 5. Comparison of derived abdominal circumference centiles (10th, 50th, and 90th) between our study (line) and Chitty et al (square).

diameter[13]. Modern ultrasound machines now use ellipse mode, from which the circumference is derived from the two maximum diameters of the ellipse. Therefore, obstetricians should be aware of which technique is used to calculate the circumference in their particular machine so that the appropriate chart can be used.

SUMMARY

We have presented a new reference centile of abdominal circumference for Thai fetuses derived from a carefully designed prospective cross sectional study. Each fetus was measured for AC only once at a randomly assigned gestational age, specifically for the purpose of this study. Data were transformed and models for mean and SD were fitted using the stepwise linear regression method. Reference centiles were then derived combining estimates from both models and then back-transformed into original scale. Comparison was made between our derived centiles and previously published data and we found that Thai AC were close to those of the Western population until 15-20 weeks of gestation that our centiles become lower. The newly developed centile chart would be more appropriate for Thai fetuses than those previously published from Western countries.

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ตารางอ้างอิงสำหรับขนาดทารกในครรภ์ : 4. ขนาดเส้นรอบวงท้อง

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ได้ทำการศึกษาแบบตัดขวางเพื่อสร้างตารางอ้างอิง สำหรับเส้นรอบวงท้อง (Abdominal circumference) ของทารกไทย ซึ่งวัดจากการตรวจด้วยเครื่องตรวจคลื่นเสียงความถี่สูง โดยทำการศึกษาสตรีตั้งครรภ์ปกติ จำนวน 621 ราย อายุครรภ์ระหว่าง 12–41 สัปดาห์ ทำการวัดขนาดเส้นรอบวงท้องของทารกในครรภ์แต่ละรายที่อายุครรภ์ต่างๆ กัน โดยการสุ่มเพื่อการศึกษาครั้งนี้โดยเฉพาะ สามารถวัดขนาดเส้นรอบวงท้อง ได้ทั้งหมด 615 ราย ทำการวิเคราะห์ข้อมูลโดยหาสมการถดถอยเชิงเส้น สำหรับค่าเฉลี่ยและส่วนเบี่ยงเบนมาตรฐานของเส้นรอบวงท้อง ในช่วงอายุครรภ์ต่างๆ จากนั้นจึงทำการสร้างตารางอ้างอิงจากสมการทั้งสอง

ในรายงานนี้ได้นำเสนอตารางอ้างอิงสำหรับขนาดเส้นรอบวงท้องของทารกไทย และทำการเปรียบเทียบกับข้อมูลจากแหล่งอื่น พบว่าขนาดเส้นรอบวงท้องทารกไทยเล็กกว่าของทารกในประเทศทางตะวันตก แสดงถึงความสำคัญของเชื้อชาติต่อขนาดของทารกในครรภ์ ดังนั้นจึงมีความจำเป็นที่จะต้องสร้างตารางอ้างอิงเฉพาะสำหรับแต่ละภูมิภาค

คำสำคัญ : ขนาดทารกในครรภ์, เส้นรอบวงท้อง, ตารางอ้างอิง

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