Charts of Thai Fetal Biometries: 3. Femur Length

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Abstract

A cross-sectional study was conducted in order to construct a new reference chart for Thai fetal femur length (FL). A total of 621 normal pregnant women between 12-41 weeks of gestation and their fetuses were enrolled. Measurements were made once at a randomly assigned gestational age specifically for the purpose of this study only. Femur length data were available in 608 measurements due to unfavorable fetal position in some cases. Linear regression technique was used to model separately the mean and standard deviation as functions of gestational age. Reference centiles were constructed from a combination of both models, assuming the data were normally distributed. A new reference centiles chart for FL is presented and compared with previously published data. While our derived centiles were clearly lower than those from Western studies, they were found comparable with those from a Thai study. This demonstrated the important effect of racial differences between populations on fetal biometries and elucidates the need to develop fetal biometries charts specifically for each region.

Key word : Fetal Biometries, Femur Length, Reference Centiles

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Femur length is the second most common parameter for prediction of gestational age. Several reports have mentioned its usefulness in prenatal diagnosis of dwarfism syndrome[1]. Many investigators have evaluated and created femur length charts, but many of their studies might have weaknesses in the study design and analysis[2]. In this study, we have produced a new femur length chart for Thai fetuses between 12-41 weeks of gestation and compared it with previously published data.

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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 recruited. Fetal femur length was measured once at a randomly assigned gestational age for the purpose of this study only. The study design and sample selection is discussed in detail in the methodology part of this series.

The femur was identified by rotating the transducer until the full longest femur was seen in a plane as close as possible at right angle to the ultrasound beam. The body of the femur should display an acoustic shadow sufficient to conceal the detail behind it, and the end of the femur should be sharply depicted[3]. A straight measurement was made from the center of the U-shape at each end of the femur bone[4]. All the measurements were performed by only one well-trained investigator using a 5 MHz convex probe of the Acuson model 128 XP4 ultrasound machine.

Statistical Analysis

We applied the analysis methods proposed by Altman et al[2] with our data. 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 BPD as functions of gestational age using the linear regression technique, based on the assumption that the measurements at each gestaional age were normally distributed. 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 normal plot of SDS was examined. A plot of SDS of each observed data against gestational age was made and the proportion of observations below and above the 10th and 90th centiles were determined if they were close to the expected value. Reference centiles for femur length were derived from both regression equations. The 100αth centile can be estimated from mean + Zα(SD), where Zα is the corresponding value from the standard normal distribution.

RESULTS

Fetal femur length data were available from 608 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 model for the mean femur length was estimated using the stepwise linear regression technique. Standard deviations (SD) were modeled as a function of gestational age using the same regression technique. The regression equations for mean and SD are

$$FL = -31.545 + 3.218\ W - 0.0004\ W^3$$

$$SD = 1.424 + 0.00067\ W^2$$

where FL = femur length (mm), and W = gestational age (weeks)

Fig. 1 shows a scatter plot of femur length against gestational age with the fitted line from the equation above. The regression model for the mean gave R^2 value of 0.98 which means that the model

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

Gestational age (weeks)	Number of fetuses	Percentage
12	12	1.97
13	14	2.30
14	13	2.14
15	19	3.12
16	22	3.62
17	22	3.62
18	21	3.45
19	22	3.62
20	21	3.45
21	21	3.45
22	24	3.95
23	26	4.28
24	22	3.62
25	26	4.28
26	26	4.28
27	23	3.78
28	21	3.45
29	20	3.29
30	26	4.28
31	20	3.29
32	20	3.29
33	21	3.45
34	20	3.29
35	17	2.80
36	23	3.78
37	21	3.45
38	18	2.96
39	17	2.80
40	16	2.63
41	14	2.30
Total	608	100.00

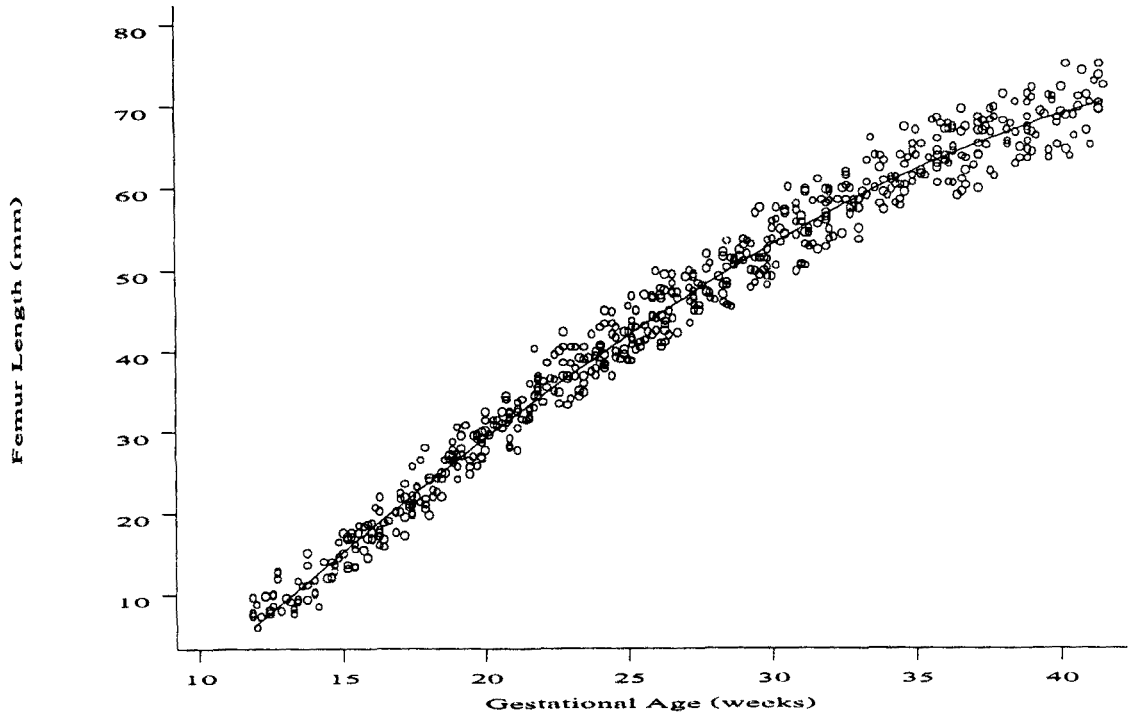

Fig. 1. Scatter plot of femur length and gestational age with curve of the fitted mean.

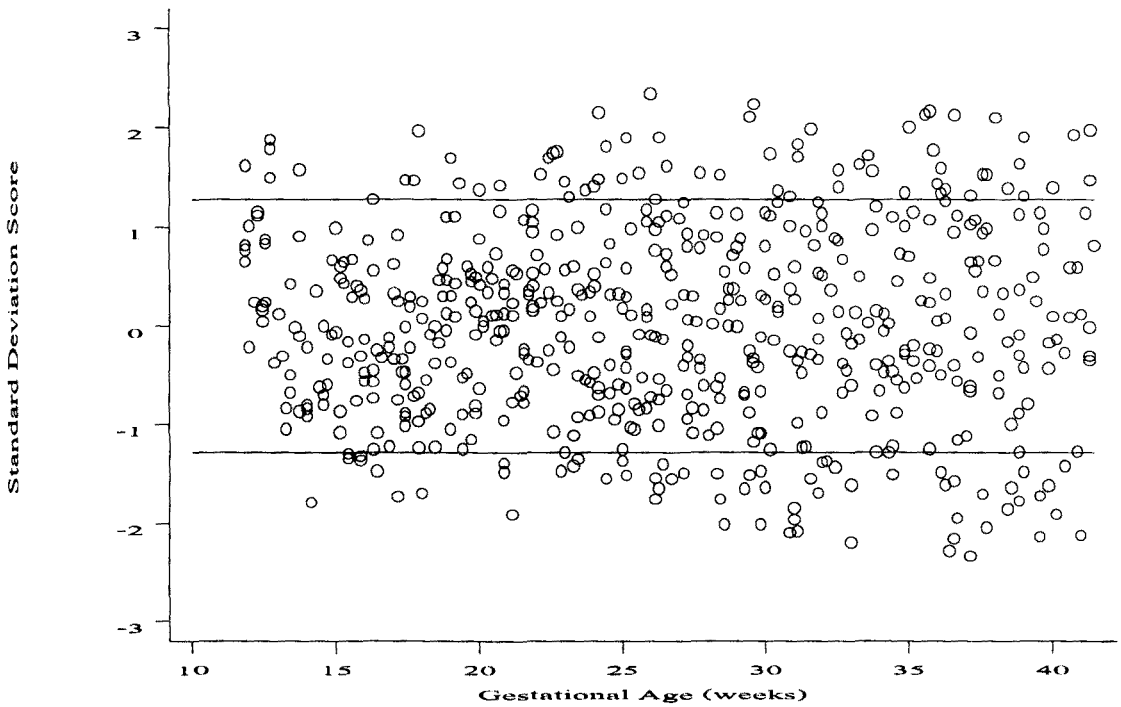

Fig. 2. Plot of SDS against gestational age, with the expected 10th and 90th centile lines.

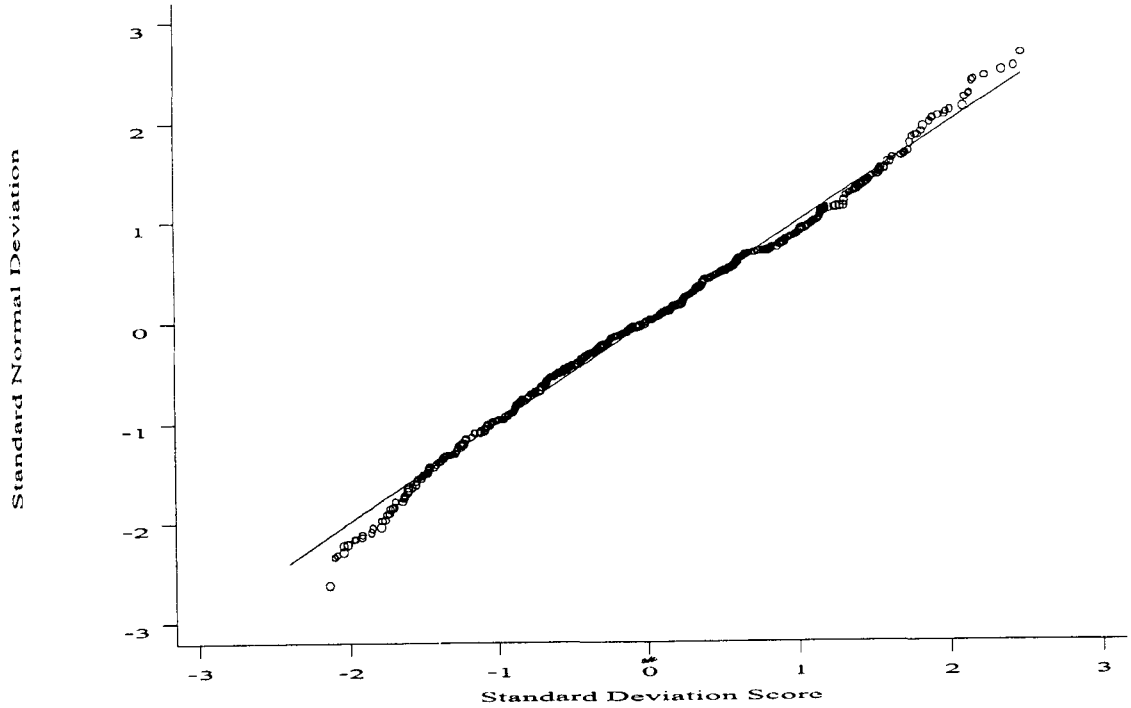

Fig. 3. Normal plot of SDS.

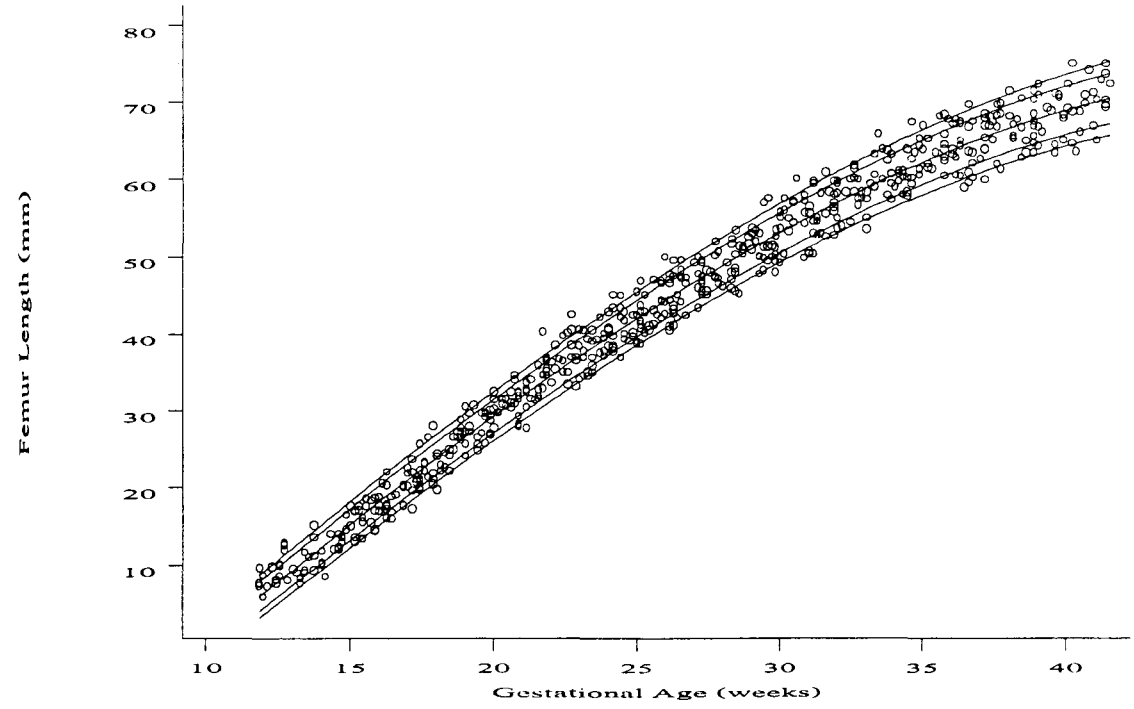

Fig. 4. Femur length data with fitted 3rd, 10th, 50th, 90th, and 97th centile lines.

Table 2. Fitted centiles of Thai fetal femur length.

GA (weeks)	Centile					SD
	3rd	10th	50th	90th	97th	
12	3.46	4.36	6.31	8.26	9.17	1.52
13	6.44	7.36	9.33	11.30	12.21	1.54
14	9.38	10.31	12.30	14.30	15.23	1.55
15	12.29	13.23	15.25	17.26	18.21	1.57
16	15.15	16.10	18.15	20.19	21.15	1.59
17	17.97	18.94	21.01	23.08	24.05	1.62
18	20.74	21.72	23.83	25.93	26.91	1.64
19	23.46	24.46	26.59	28.73	29.73	1.66
20	26.13	27.14	29.31	31.48	32.49	1.69
21	28.75	29.78	31.98	34.18	35.21	1.72
22	31.30	32.35	34.59	36.83	37.88	1.75
23	33.80	34.86	37.14	39.42	40.49	1.78
24	36.24	37.32	39.64	41.96	43.04	1.81
25	38.60	39.71	42.07	44.43	45.53	1.84
26	40.91	42.03	44.43	46.84	47.96	1.88
27	43.13	44.28	46.73	49.18	50.32	1.91
28	45.29	46.46	48.95	51.45	52.62	1.95
29	47.37	48.56	51.11	53.65	54.84	1.99
30	49.37	50.58	53.18	55.78	56.99	2.03
31	51.29	52.53	55.18	57.83	59.07	2.07
32	53.13	54.39	57.10	59.80	61.06	2.11
33	54.88	56.17	58.93	61.69	62.98	2.15
34	56.54	57.86	60.67	63.49	64.80	2.20
35	58.11	59.45	62.33	65.21	66.55	2.24
36	59.59	60.96	63.89	66.83	68.20	2.29
37	60.96	62.36	65.36	68.36	69.76	2.34
38	62.24	63.67	66.74	69.80	71.23	2.39
39	63.42	64.88	68.01	71.14	72.60	2.44
40	64.49	65.98	69.18	72.38	73.87	2.49
41	65.45	66.98	70.25	73.51	75.04	2.55

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 10.8 per cent (66 of 608) and 11.3 per cent (69 of 608) respectively. Fig. 3 shows the normal plot of SDS with the values lying almost in a straight line. These suggested that the models provided a good fit to the data.

Reference centiles were calculated from the estimated mean and SD at each week of gestation. The 100αth centile can be calculated from mean + Zα(SD), where Zα are -1.88, -1.28, 0, 1.28, and 1.88 for the 3rd, 10th, 50th, 90th, and 97th centiles respectively. The fitted centiles are shown in Table 2 and they were plotted with femur length data and are shown in Fig. 4.

We compared our derived centiles for FL with those of Chitty et al,[5] as shown in Fig. 5. The 10th, 50th, 90th centile lines of our study were lower at every gestational age. Our fitted 50th and 90th centile lines are approximately the same as their 10th and 50th lines respectively. On the other hand, we found that the centiles are comparable with those from Chiang Mai University study[6] at all gestational ages, as shown in Fig. 6. However, it should be noted that our derived centile curves are smoother than theirs.

DISCUSSION

We have constructed a new femur length chart for Thai fetuses between 12-41 weeks of gestation from a cross-sectional analysis of 608 measurements. Although femur length charts have been created by many investigators, some based their

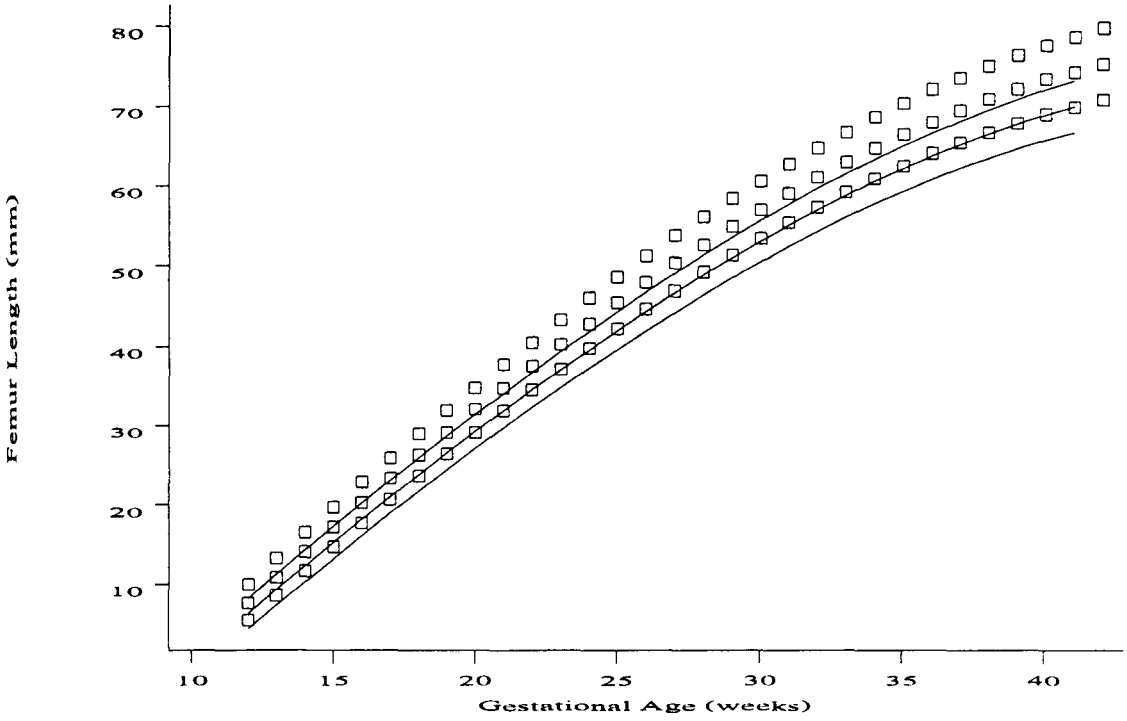

Fig. 5. Comparison of derived femur lenght centiles (10th, 50th, and 90th) between our study (line) and Chitty et al (square).

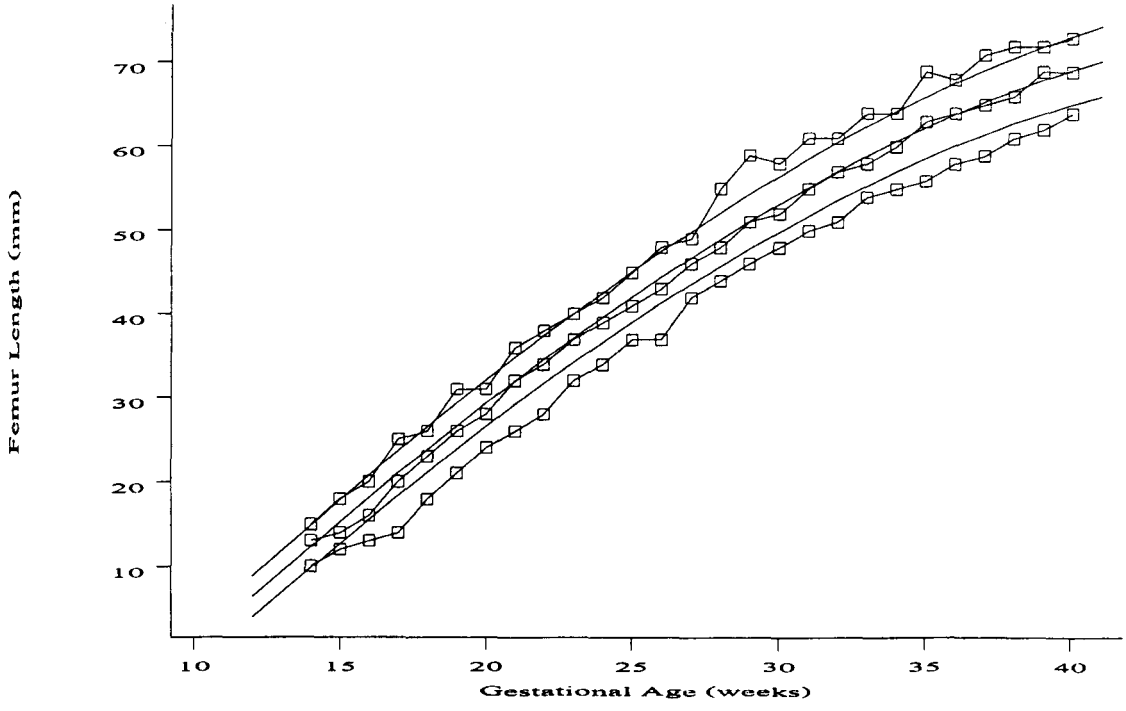

Fig. 6. Comparison of derived 5th, 50th, and 95th femur lenght centiles of our study (line) and those of Chiang Mai University (connected square).

results on only a small number of fetuses[7]. Some of these studies collected their data longitudinally with multiple measurements in the same fetus[7,8]. This type of data might be more appropriate for fetal growth study than fetal size and it might result in centiles that were too close together.

One important problem of the previous studies was that they have not taken into account the change in variability among fetuses with gestational age in their analysis. Such changes in variability have been demonstrated. For example, Hadlock et al[9] have shown that the variability of femur length (in terms of ± 2 SD) in predicting gestational age was ± 9.5 days between 12-23 weeks of gestation and increased to ± 22 days afterwards. With this regard, we modeled the variability separately from the mean as a function of gestational age using the linear regression technique. Finally, we combined both estimations to construct the reference centiles.

We compared our derived femur length centiles with those of Chitty et al,[5] which used the same methodology. All the centile lines from our study are lower at every gestational age. Our fitted 50th, 90th centile lines are approximately the same as their 10th, 50th lines respectively. On the other hand, we found that our centiles are close to those derived from a Chiang Mai University study[6]. This may be due to racial differences between populations. Some investigators have suggested that there may be race variations in femur length. It has been demonstrated that average fetuses of Latin-American origin have a femur length shorter than that of white Anglo-Saxons. Pathological studies in adults indicate the possibility that the black population may have femurs that are on average longer than those observed in white Anglo-Saxons[10]. Studies on Thai fetuses have shown that Thai fetal femur lengths are shorter than those from Western populations[6]. Also, the average birth weight of a Thai baby is lower than those of Europeans and Americans[11].

Although our results are comparable with those from a study at Chiang Mai University,[6] which combined cross-sectional and longitudinal data, our centile lines are smoother. This may be the result of using a non-parametric approach to develop the reference centiles. Despite the study being conducted in a large sample of 435 pregnant women with 1208 measurements, more precise estimates can be achieved by having a larger number of observations at each week of gestation, which is the main drawback of this approach. This demonstrates the effect of different methodology and analysis technique on the study results.

SUMMARY

We have constructed a new reference centiles chart of femur length for Thai fetuses from a cross-sectional study of 621 pregnant women. Each fetus was measured once at a randomly assigned gestational age for the purpose of this study only. The mean and SD of femur length were modeled separately as functions of gestational age, using the linear regression technique. Reference centiles were derived from the combination of both estimates. We compared our results with others and found that Thai fetal femur length is smaller than that of Western populations. The reference centiles are comparable with a Thai study. However, there still are some differences that may be due to methodological differences.

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ตารางอ้างอิงสำหรับขนาดทารกในครรภ์ : 3. ขนาดความยาวกระดูกต้นขา

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ได้ทำการศึกษาแบบตัดขวางเพื่อสร้างตารางอ้างอิง สำหรับความยาวของกระดูกต้นขา (Femur length) ของทารกไทย ซึ่งวัดจากการตรวจด้วยเครื่องตรวจคลื่นเสียงความถี่สูง โดยทำการศึกษาสตรีตั้งครรภ์ปกติ จำนวน 621 ราย อายุครรภ์ระหว่าง 12–41 สัปดาห์ ทำการวัดขนาดความยาวของกระดูกต้นขาของทารกในครรภ์แต่ละรายที่อายุครรภ์ต่างๆ กัน โดยการสุ่ม เพื่อการศึกษาครั้งนี้โดยเฉพาะ สามารถวัดขนาดความยาวของกระดูกต้นขา ได้ทั้งหมด 608 ราย ทำการวิเคราะห์ข้อมูลโดยหาสมการถดถอยเชิงเส้น สำหรับค่าเฉลี่ยและส่วนเบี่ยงเบนมาตรฐานของความยาวของกระดูกต้นขาในช่วงอายุครรภ์ต่างๆ จากนั้นจึงทำการสร้างตารางอ้างอิงจากสมการทั้งสอง

ในรายงานนี้ได้นำเสนอตารางอ้างอิงสำหรับขนาดความยาวของกระดูกต้นขาของทารกไทย และทำการเปรียบเทียบกับข้อมูลจากแหล่งอื่น พบว่าขนาดความยาวของกระดูกต้นขาที่ได้จากการศึกษาครั้งนี้ใกล้เคียงกับที่เคยมีรายงานจากการศึกษาในทารกไทย แต่ขนาดดังกล่าวเล็กกว่าของทารกในประเทศทางตะวันตก แสดงถึงความสำคัญของเชื้อชาติต่อขนาดของทารกในครรภ์ ดังนั้นจึงมีความจำเป็นที่จะต้องสร้างตารางอ้างอิงเฉพาะสำหรับแต่ละภูมิภาค

คำสำคัญ : ขนาดทารกในครรภ์, ความยาวกระดูกต้นขา, ตารางอ้างอิง

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