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Fetal biometry at 14–40 weeks' gestation

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ABSTRACT

Normal ranges for a wide variety of biometrical parameters were established from cross-sectional data on 1040 normal singleton pregnancies resulting in livebirth at term of normal, and appropriately grown infants. Patients were selected so that the birth weight distribution was similar to that reported by Yudkin and colleagues[1] and the ranges can, therefore, be used for any population that has a simular birth weight distribution.

INTRODUCTION

This cross-sectional study establishes reference ranges with gestation for commonly used fetal biometric variables and their ratios in 1040 normal singleton pregnancies. Findings are compared to those from previous studies.

PATIENTS AND METHODS

Normal ranges for fetal biometry were established from cross-sectional data on 1040 singleton pregnancies at 14–40 weeks' gestation. The patients were selected from the database of 19 154 pregnancies that were scanned in our unit between 1987 and 1993. To select patients, the following search conditions were applied:

(1) Known last menstrual period with a cycle length of 26–30 days;

(2) No fetal abnormalities and no pregnancy complications;

(3) Livebirth at ≥ 37 weeks' gestation;

(4) Birthweight > 3rd and < 97th centile for gestation[1].

From those cases that fulfilled these criteria, the most recent 40 patients were included for each 7-day interval from 14 to 40 weeks (1040 in total). Reasons for ultrasonographic examination included:

(1) Follow-up of women participating in a first-trimester screening study for fetal nuchal translucency thickness;

(2) Follow-up after amniocentesis or chorion villus sampling;

(3) Late booking;

(4) Parental anxiety; or

(5) Detection of minor abnormalities such as pylectasia or choroid plexus cysts at the referring hospital.

In each case, fetal measurements were taken by any one of 15 experienced ultrasonographers using a curvilinear array real-time system with a 3.5 or 5.0 MHz transducer (Aloka SSD 650, Aloka, Japan). Measurements of biparietal diameter (BPD), occipitofrontal diameter (OFD), anterior and posterior cerebral ventricle diameters (Va and Vp), and hemisphere (H) were obtained from a transverse axial plane of the fetal head showing a central mid-line echo broken in the anterior third by the cavum septii pellucidi and demonstrating the anterior and posterior horns of the lateral ventricles. BPD and OFD were measured from the outer borders of the skull, and head circumference (HC) was calculated from $3.14 \times (BPD + OFD)/2$. Va was the distance between the lateral wall of the anterior horn to the mid-line and Vp was the distance between the medial and lateral walls of the posterior horn. The hemisphere was measured from the mid-line to the inner border of the skull. The transverse cerebellar diameter (TCD) and cisterna magna diameter (CM) were measured in the suboccipito-bregmatic plane of the head. The femur length (FL) was measured from the greater trochanter to the lateral condyle. For abdominal circumference (AC), a transverse section of the fetal abdomen was taken at the level of the stomach and the bifurcation of the main portal vein into its right and left branches. The anteroposterior (AD1) and transverse (AD2) diameters were measured and AC was calculated from $3.14 \times (AD1 + AD2)/2$. The following ratios were calculated: HC/AC, BPD/FL, HC/FL, AC/FL, TCD/HC, TCD/AC, BPD/OFD, Va/H and Vp/H.

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Statistical analysis

For each of the measurements and their ratios, regression analysis was applied examining linear, quadratic and cubic models for the association with gestational age (in days/7). For those measurements where the standard deviation increased or decreased with gestation, logarithmic or square root transformation was applied to stabilize variance[2]. If the quadratic or cubic terms did not improve the original linear model (an independent correlation with $p < 0.05$ and improvement of the correlation coefficient), the linear model was chosen as the best fit. Where the quadratic or cubic components did improve the model, they were included in the equation for the regression line. Equations for regression lines on transformed data were used to calculate the mean and residual SD in transformed units. To produce the reference ranges in the original units, the mean and limits of the calculated reference range in transformed units were subjected to anti-logarithmic or power transformation, as appropriate.

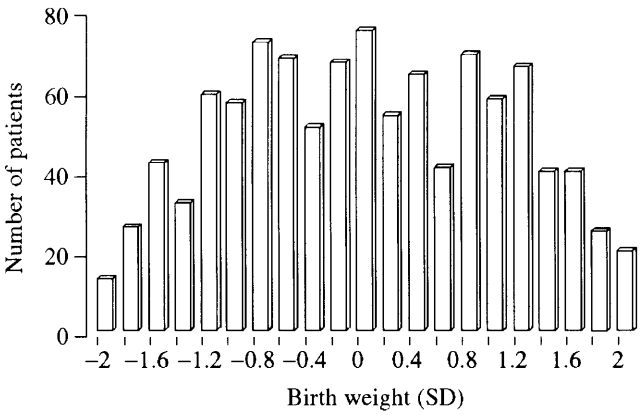


Figure 1 Histogram for distribution of birth weights in standard deviations from the normal mean[1]

RESULTS

The distribution of birth weights of the 1040 patients is shown in Figure 1; the mean was not significantly different from the normal mean for gestation (mean difference, 0.03 SD; SE, 0.03; *t*, 1.01). Formulas describing the associations between fetal measurements and gestational age are given in Table 1. Tables for medians, 5th and 95th centiles and scattergrams of individual measurements against the mid-points for gestational ranges are given in Tables 2–20 and Figures 2–20.

The weekly increase in median values for HC, AC, FL and TCD (in mm) reached a maximum at 24, 27, 21 and 28 weeks, respectively, with a decrease thereafter (Figure 21, left). For FL and HC, 50% of the total increase was achieved at 24 and 25 weeks' gestation, respectively, whereas for AC and TCD 50% was reached at 26 and 27 weeks' respectively (Figure 21, right). Table 21 summarizes the characteristics of previous studies and Tables 22–25 compare the values for median, 5th and 95th centiles at 18, 28 and 38 weeks in the present study to those in previous ones[3 21].

DISCUSSION

This study establishes normal ranges with gestation for a wide range of fetal measurements and their ratios. In this study:

(1) Each patient contributed only one set of measurements;

Table 1 Regression equations for various fetal measurements and their ratios with gestational age (*A* = coefficient for linear component, *B* = coefficient for quadratic component, *C* = coefficient for cubic component). Standard deviations (SD) are given in transformed and original units

Parameter + transformation	*n*	*Constant*	*A × gestation*	*B × gestation²*	*C × gestation³*	*SD (transformed)*	*SD (original units)*
$(FL)^{0.5}$	1040	−1.1132444	0.4263429	−0.0045992	—	0.1852	2.52
Log_{10} (AC + 9)	1040	1.3257977	0.0552337	−0.0006146	—	0.02947	17.41
Log_{10} (HC + 1)	1040	1.3369692	0.0596493	−0.0007494	—	0.01997	10.74
Log_{10} (BPD + 5)	1040	0.9446108	0.0509883	−0.0006097	—	0.02056	3.41
Log_{10} (OFD + 5)	1040	0.9676148	0.0568481	−0.0007240	—	0.02017	4.11
Log_{10} (TCD + 5)	1040	0.8129735	0.0367114	−0.0003590	—	0.02504	2.19
Log_{10} (CM + 9)	465	0.9062872	0.0160853	−0.0002059	—	0.03625	1.28
Log_{10} (Hem + 5)	1040	0.7234590	0.0474715	−0.0005620	—	0.01956	1.71
Va	838	4.8058346	0.1275596	—	—	0.8994	0.90
Vp	838	5.5165990	0.0841459	—	—	1.022	1.02
HC/AC	1040	1.3668592	0.0635481	—	—	0.06355	0.064
Log_{10} (BPD/FL)	1040	1.0205449	−0.0865895	0.0028771	−0.0000321	0.02458	0.087
Log_{10} (HC/FL + 5)	1040	1.4094384	−0.0398128	0.0013080	−0.0000146	0.01107	0.266
Log_{10} (AC/FL)	1040	1.3260806	−0.0693157	0.0023154	−0.0000248	0.02942	0.322
TCD/AC	1040	0.3050518	−0.0169052	0.0005463	−0.0000058	0.01086	0.011
Log_{10} (TCD/HC)	1040	0.3351892	−0.0669391	0.0023852	−0.0000264	0.02733	0.008
Log_{10} (Va/Hem)	838	0.5404806	−0.0854273	0.0019594	−0.0000147	0.04766	0.031
Log_{10} (Vp/Hem)	838	0.2467422	−0.0484430	0.0004638	0.0000036	0.05683	0.034
Log_{10} (BPD/OFD)	1040	−0.0449180	−0.0050203	0.0001047	—	0.01925	0.035

FL, femur length; AC, abdominal circumference; HC, head circumference; BPD, biparietal diameter; OFD, occipitofrontal diameter; TCD, transverse cerebellar diameter; CM, cisterna magna diameter; Hem, hemisphere diameter; Va, anterior cerebral ventricle diameter; Vp, posterior cerebral ventricle diameter

Table 2 Normal range for abdominal circumference (mm)

Gestational age range (weeks + days)	*Abdominal circumference* (mm)		
	5th centile	*Median*	*95th centile*
14 + 0–14 + 6	80	90	102
15 + 0–15 + 6	88	99	112
16 + 0–16 + 6	96	108	122
17 + 0–17 + 6	105	118	133
18 + 0–18 + 6	114	128	144
19 + 0–19 + 6	123	139	156
20 + 0–20 + 6	133	149	168
21 + 0–21 + 6	143	161	181
22 + 0–22 + 6	153	172	193
23 + 0–23 + 6	163	183	206
24 + 0–24 + 6	174	195	219
25 + 0–25 + 6	184	207	233
26 + 0–26 + 6	195	219	246
27 + 0–27 + 6	205	231	259
28 + 0–28 + 6	216	243	272
29 + 0–29 + 6	226	254	285
30 + 0–30 + 6	237	266	298
31 + 0–31 + 6	246	277	310
32 + 0–32 + 6	256	287	322
33 + 0–33 + 6	265	297	334
34 + 0–34 + 6	274	307	345
35 + 0–35 + 6	282	316	355
36 + 0–36 + 6	289	324	364
37 + 0–37 + 6	295	332	372
38 + 0–38 + 6	302	339	380
39 + 0–39 + 6	307	345	387

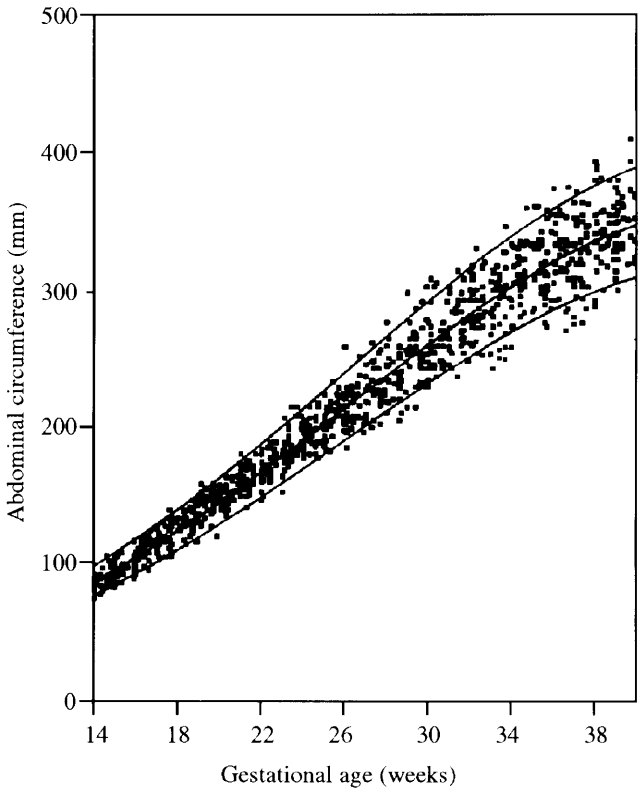


Figure 2 Individual values for fetal abdominal circumference plotted on the appropriate reference range (median, 5th and 95th centiles) with gestation

Table 3 Normal range for femur length (mm)

Gestational age range (weeks + days)	*Femur length* (mm)		
	5th centile	*Median*	*95th centile*
14 + 0–14 + 6	14	17	19
15 + 0–15 + 6	17	19	22
16 + 0–16 + 6	19	22	25
17 + 0–17 + 6	21	24	28
18 + 0–18 + 6	24	27	30
19 + 0–19 + 6	26	30	33
20 + 0–20 + 6	29	32	36
21 + 0–21 + 6	32	35	39
22 + 0–22 + 6	24	38	42
23 + 0–23 + 6	27	41	45
24 + 0–24 + 6	39	43	47
25 + 0–25 + 6	42	46	50
26 + 0–26 + 6	44	48	53
27 + 0–27 + 6	47	51	55
28 + 0–28 + 6	49	53	58
29 + 0–29 + 6	51	56	60
30 + 0–30 + 6	53	58	63
31 + 0–31 + 6	55	60	65
32 + 0–32 + 6	57	62	67
33 + 0–33 + 6	59	64	69
34 + 0–34 + 6	61	66	71
35 + 0–35 + 6	63	68	73
36 + 0–36 + 6	64	69	74
37 + 0–37 + 6	66	71	76
38 + 0–38 + 6	67	72	77
39 + 0–39 + 6	68	73	78

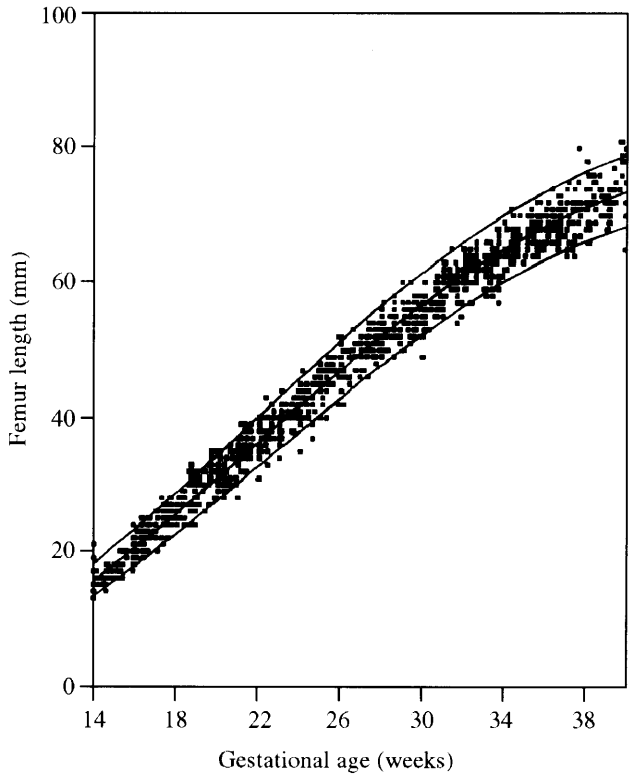


Figure 3 Individual values for fetal femur length plotted on the appropriate reference range (median, 5th and 95th centiles) with gestation

Table 4 Normal range for biparietal diameter (mm)

Gestational age range (weeks + days)	*Biparietal diameter* (mm)		
	5th centile	*Median*	*95th centile*
14 + 0–14 + 6	28	31	34
15 + 0–15 + 6	31	34	37
16 + 0–16 + 6	34	37	40
17 + 0–17 + 6	36	40	43
18 + 0–18 + 6	39	43	47
19 + 0–19 + 6	42	46	50
20 + 0–20 + 6	45	49	54
21 + 0–21 + 6	48	52	57
22 + 0–22 + 6	51	56	61
23 + 0–23 + 6	54	59	64
24 + 0–24 + 6	57	62	68
25 + 0–25 + 6	60	66	71
26 + 0–26 + 6	63	69	75
27 + 0–27 + 6	66	72	78
28 + 0–28 + 6	69	75	81
29 + 0–29 + 6	72	78	85
30 + 0–30 + 6	74	81	88
31 + 0–31 + 6	77	83	90
32 + 0–32 + 6	79	86	93
33 + 0–33 + 6	81	88	96
34 + 0–34 + 6	83	90	98
35 + 0–35 + 6	85	92	100
36 + 0–36 + 6	86	94	102
37 + 0–37 + 6	87	95	103
38 + 0–38 + 6	88	96	104
39 + 0–39 + 6	89	97	105

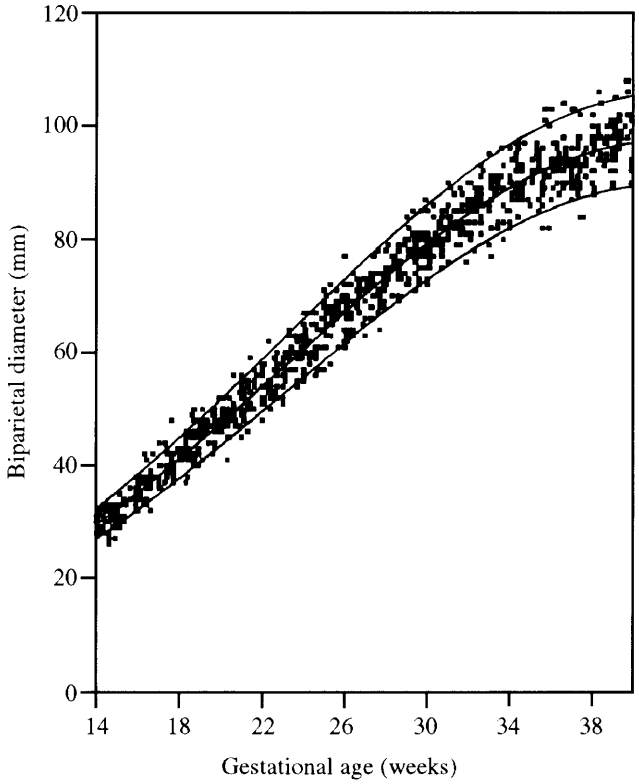


Figure 4 Individual values for fetal biparietal diameter plotted on the appropriate reference range (median, 5th and 95th centiles) with gestation

Table 5 Normal range for occipitofrontal diameter (mm)

Gestational age range (weeks + days)	*Occipitofrontal diameter* (mm)		
	5th centile	*Median*	*95th centile*
14 + 0–14 + 6	35	39	42
15 + 0–15 + 6	39	42	46
16 + 0–16 + 6	42	46	50
17 + 0–17 + 6	46	50	54
18 + 0–18 + 6	50	54	59
19 + 0–19 + 6	54	58	63
20 + 0–20 + 6	57	62	68
21 + 0–21 + 6	61	67	72
22 + 0–22 + 6	65	71	77
23 + 0–23 + 6	69	75	82
24 + 0–24 + 6	73	79	86
25 + 0–25 + 6	77	83	90
26 + 0–26 + 6	81	87	95
27 + 0–27 + 6	84	91	99
28 + 0–28 + 6	87	95	103
29 + 0–29 + 6	91	98	107
30 + 0–30 + 6	94	102	110
31 + 0–31 + 6	96	105	113
32 + 0–32 + 6	99	107	116
33 + 0–33 + 6	101	110	119
34 + 0–34 + 6	103	112	121
35 + 0–35 + 6	105	113	123
36 + 0–36 + 6	106	115	124
37 + 0–37 + 6	107	116	125
38 + 0–38 + 6	107	116	126
39 + 0–39 + 6	107	116	126

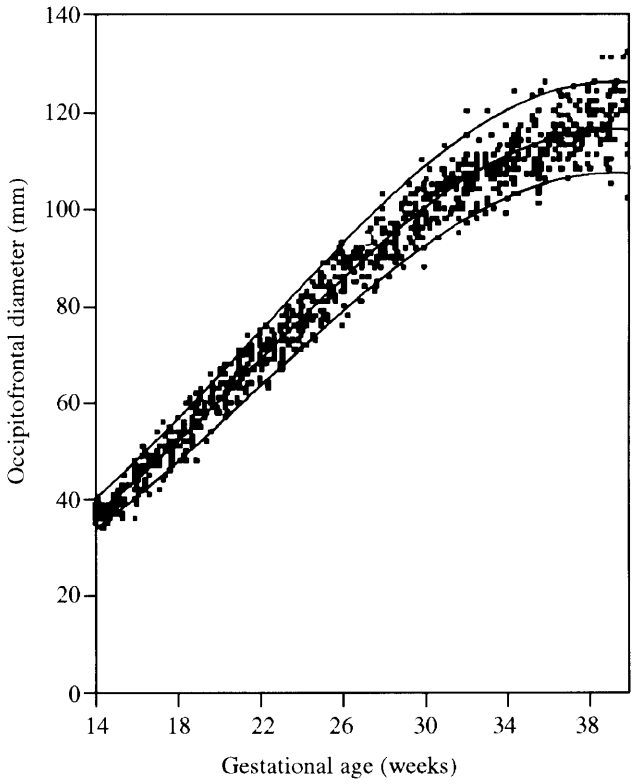


Figure 5 Individual values for fetal occipitofrontal diameter plotted on the appropriate reference range (median, 5th and 95th centiles) with gestation

Table 6 Normal range for head circumference (mm)

Gestational age range (weeks + days)	*Head circumference* (mm)		
	5th centile	*Median*	*95th centile*
14 + 0–14 + 6	102	110	118
15 + 0–15 + 6	111	120	129
16 + 0–16 + 6	120	130	140
17 + 0–17 + 6	130	141	152
18 + 0–18 + 6	141	152	164
19 + 0–19 + 6	151	163	176
20 + 0–20 + 6	162	175	189
21 + 0–21 + 6	173	187	201
22 + 0–22 + 6	184	198	214
23 + 0–23 + 6	195	210	227
24 + 0–24 + 6	206	222	240
25 + 0–25 + 6	217	234	252
26 + 0–26 + 6	227	245	264
27 + 0–27 + 6	238	256	277
28 + 0–28 + 6	248	267	288
29 + 0–29 + 6	257	277	299
30 + 0–30 + 6	266	287	309
31 + 0–31 + 6	274	296	319
32 + 0–32 + 6	282	304	328
33 + 0–33 + 6	288	311	336
34 + 0–34 + 6	294	317	342
35 + 0–35 + 6	299	323	348
36 + 0–36 + 6	303	327	353
37 + 0–37 + 6	306	330	356
38 + 0–38 + 6	308	332	358
39 + 0–39 + 6	309	333	359

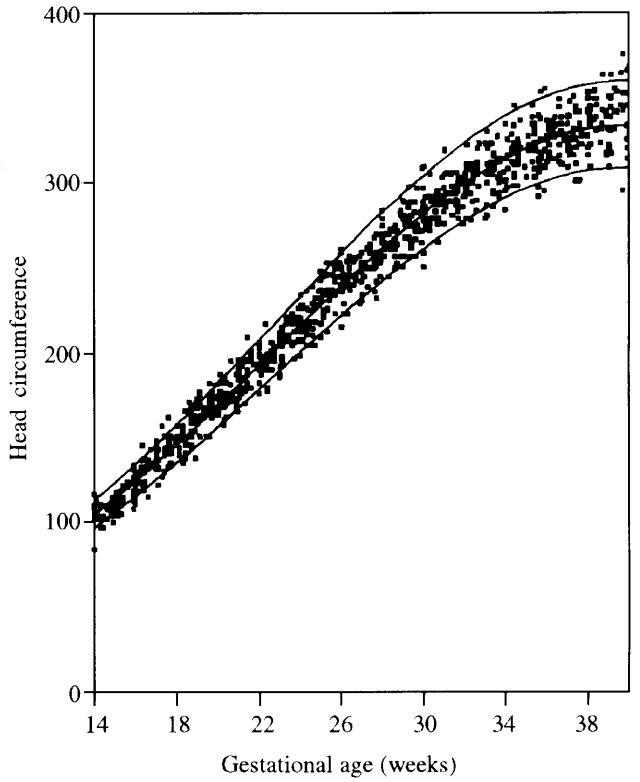


Figure 6 Individual values for fetal head circumference plotted on the appropriate reference range (median, 5th and 95th centiles) with gestation

Table 7 Normal range for transverse cerebellar diameter (mm)

Gestational age range (weeks + days)	*Transverse cerebellar diameter* (mm)		
	5th centile	*Median*	*95th centile*
14 + 0–14 + 6	12	14	15
15 + 0–15 + 6	13	15	17
16 + 0–16 + 6	14	16	18
17 + 0–17 + 6	15	17	19
18 + 0–18 + 6	16	18	21
19 + 0–19 + 6	17	20	22
20 + 0–20 + 6	19	21	24
21 + 0–21 + 6	20	22	25
22 + 0–22 + 6	21	24	27
23 + 0–23 + 6	22	25	28
24 + 0–24 + 6	24	26	30
25 + 0–25 + 6	25	28	31
26 + 0–26 + 6	26	29	33
27 + 0–27 + 6	27	31	34
28 + 0–28 + 6	29	32	36
29 + 0–29 + 6	30	33	37
30 + 0–30 + 6	31	35	39
31 + 0–31 + 6	32	36	40
32 + 0–32 + 6	34	37	42
33 + 0–33 + 6	35	39	43
34 + 0–34 + 6	36	40	44
35 + 0–35 + 6	37	41	46
36 + 0–36 + 6	38	42	47
37 + 0–37 + 6	39	43	48
38 + 0–38 + 6	40	44	49
39 + 0–39 + 6	41	45	51

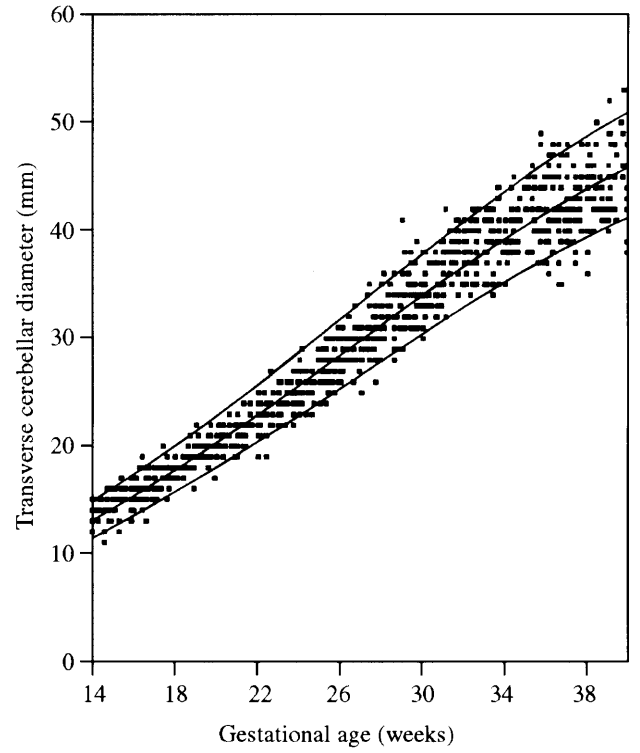


Figure 7 Individual values for fetal transverse cerebellar diameter plotted on the appropriate reference range (median, 5th and 95th centiles) with gestation

Table 8 Normal range for cisterna magna diameter (mm)

Gestational age range (weeks + days)	*Cisterna magna diameter* (mm)		
	5th centile	*Median*	*95th centile*
14 + 0–14 + 6	1.9	3.5	5.3
15 + 0–15 + 6	2.1	3.8	5.7
16 + 0–16 + 6	2.4	4.1	6.0
17 + 0–17 + 6	2.6	4.3	6.3
18 + 0–18 + 6	2.8	4.6	6.6
19 + 0–19 + 6	3.1	4.9	6.9
20 + 0–20 + 6	3.3	5.1	7.2
21 + 0–21 + 6	3.5	5.4	7.5
22 + 0–22 + 6	3.7	5.6	7.7
23 + 0–23 + 6	3.9	5.8	8.0
24 + 0–24 + 6	4.1	6.0	8.2
25 + 0–25 + 6	4.3	6.2	8.5
26 + 0–26 + 6	4.4	6.4	8.7
27 + 0–27 + 6	4.6	6.6	8.9
28 + 0–28 + 6	4.7	6.8	9.1
29 + 0–29 + 6	4.9	6.9	9.3
30 + 0–30 + 6	5.0	7.0	9.4
31 + 0–31 + 6	5.1	7.2	9.6
32 + 0–32 + 6	5.2	7.3	9.7
33 + 0–33 + 6	5.3	7.4	9.8
34 + 0–34 + 6	5.3	7.5	9.9
35 + 0–35 + 6	5.4	7.5	10.0
36 + 0–36 + 6	5.4	7.6	10.0
37 + 0–37 + 6	5.4	7.6	10.1
38 + 0–38 + 6	5.5	7.6	10.1
39 + 0–39 + 6	5.5	7.6	10.1

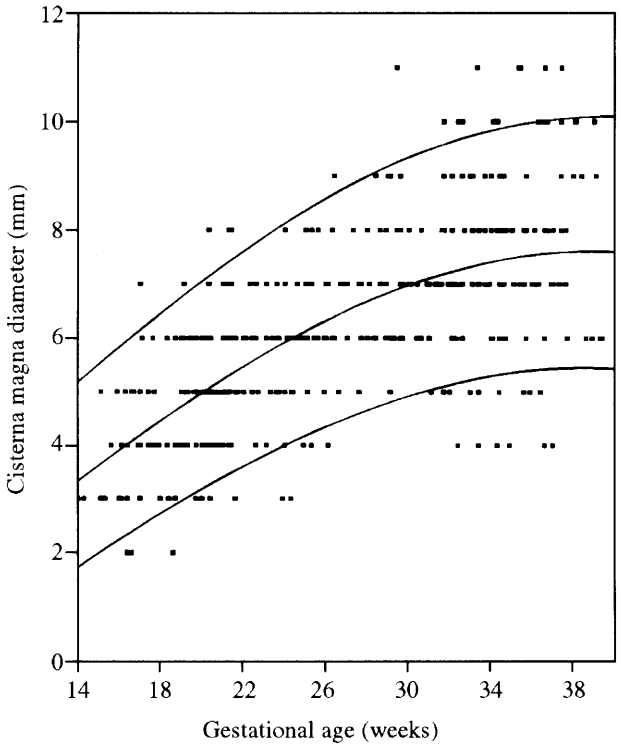


Figure 8 Individual values for fetal cisterna magna diameter plotted on the appropriate reference range (median, 5th and 95th centiles) with gestation

Table 9 Normal range for anterior cerebral ventricle diameter (mm)

Gestational age range (weeks + days)	*Anterior cerebral ventricle diameter* (mm)		
	5th centile	*Median*	*95th centile*
14 + 0–14 + 6	5.2	6.7	8.1
15 + 0–15 + 6	5.3	6.8	8.3
16 + 0–16 + 6	5.4	6.9	8.4
17 + 0–17 + 6	5.6	7.0	8.5
18 + 0–18 + 6	5.7	7.2	8.6
19 + 0–19 + 6	5.8	7.3	8.8
20 + 0–20 + 6	5.9	7.4	8.9
21 + 0–21 + 6	6.1	7.5	9.0
22 + 0–22 + 6	6.2	7.7	9.2
23 + 0–23 + 6	6.3	7.8	9.3
24 + 0–24 + 6	6.4	7.9	9.4
25 + 0–25 + 6	6.6	8.1	9.5
26 + 0–26 + 6	6.7	8.2	9.7
27 + 0–27 + 6	6.8	8.3	9.8
28 + 0–28 + 6	7.0	8.4	9.9
29 + 0–29 + 6	7.1	8.5	10.1
30 + 0–30 + 6	7.2	8.7	10.2
31 + 0–31 + 6	7.3	8.8	10.3
32 + 0–32 + 6	7.5	9.0	10.4
33 + 0–33 + 6	7.6	9.1	10.6
34 + 0–34 + 6	7.7	9.2	10.7
35 + 0–35 + 6	7.9	9.3	10.8
36 + 0–36 + 6	8.0	9.5	10.9
37 + 0–37 + 6	8.1	9.6	11.1
38 + 0–38 + 6	8.2	9.7	11.2
39 + 0–39 + 6	8.3	9.8	11.3

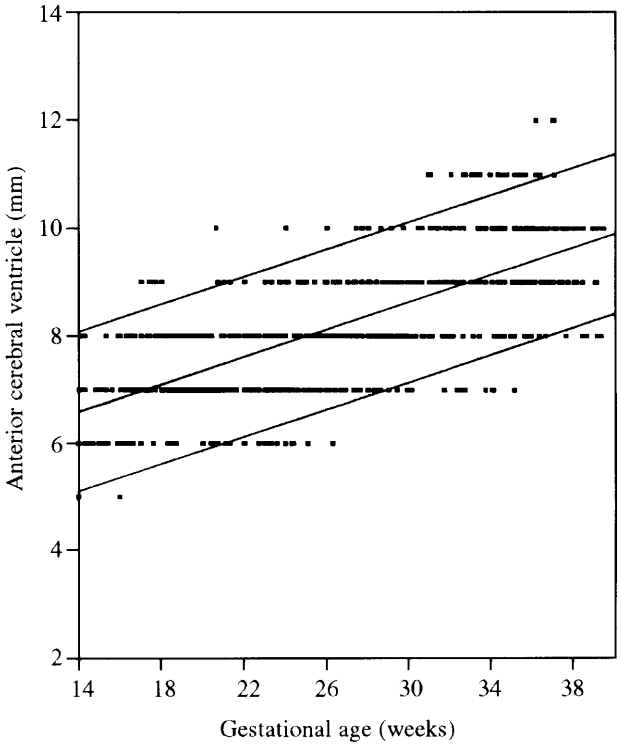


Figure 9 Individual values for fetal cerebral anterior ventricle diameter plotted on the appropriate reference range (median, 5th and 95th centiles) with gestation

Table 10 Normal range for posterior cerebral ventricle diameter (mm)

Gestational age range (weeks + days)	*Posterior cerebral ventricle diameter* (mm)		
	5th centile	*Median*	*95th centile*
14 + 0–14 + 6	5.1	6.7	8.4
15 + 0–15 + 6	5.1	6.8	8.5
16 + 0–16 + 6	5.2	6.9	8.6
17 + 0–17 + 6	5.3	7.0	8.7
18 + 0–18 + 6	5.4	7.1	8.8
19 + 0–19 + 6	5.5	7.2	8.8
20 + 0–20 + 6	5.6	7.2	8.9
21 + 0–21 + 6	5.6	7.3	9.0
22 + 0–22 + 6	5.7	7.4	9.1
23 + 0–23 + 6	5.8	7.5	9.2
24 + 0–24 + 6	5.9	7.6	9.3
25 + 0–25 + 6	6.0	7.7	9.3
26 + 0–26 + 6	6.1	7.7	9.4
27 + 0–27 + 6	6.1	7.8	9.5
28 + 0–28 + 6	6.2	7.9	9.6
29 + 0–29 + 6	6.3	8.0	9.7
30 + 0–30 + 6	6.4	8.1	9.8
31 + 0–31 + 6	6.5	8.2	9.9
32 + 0–32 + 6	6.6	8.3	9.9
33 + 0–33 + 6	6.7	8.3	10.0
34 + 0–34 + 6	6.7	8.4	10.1
35 + 0–35 + 6	6.8	8.5	10.2
36 + 0–36 + 6	6.9	8.6	10.3
37 + 0–37 + 6	7.0	8.7	10.4
38 + 0–38 + 6	7.1	8.8	10.4
39 + 0–39 + 6	7.2	8.8	10.5

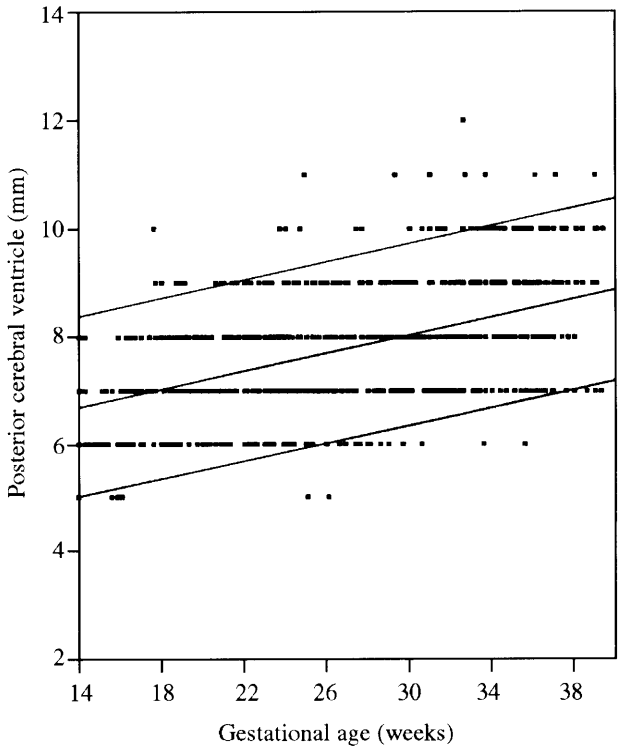


Figure 10 Individual values for fetal cerebral posterior ventricle diameter plotted on the appropriate reference range (median, 5th and 95th centiles) with gestation

Table 11 Normal range for cerebral hemisphere diameter (mm)

Gestational age range (weeks + days)	*Cerebral hemisphere diameter* (mm)		
	5th centile	*Median*	*95th centile*
14 + 0–14 + 6	13	15	16
15 + 0–15 + 6	15	16	18
16 + 0–16 + 6	16	18	19
17 + 0–17 + 6	17	19	21
18 + 0–18 + 6	19	21	23
19 + 0–19 + 6	20	22	24
20 + 0–20 + 6	22	24	26
21 + 0–21 + 6	23	25	28
22 + 0–22 + 6	25	27	30
23 + 0–23 + 6	26	29	31
24 + 0–24 + 6	28	30	33
25 + 0–25 + 6	29	32	35
26 + 0–26 + 6	31	34	37
27 + 0–27 + 6	32	35	38
28 + 0–28 + 6	34	37	40
29 + 0–29 + 6	35	38	41
30 + 0–30 + 6	36	40	43
31 + 0–31 + 6	38	41	44
32 + 0–32 + 6	39	42	46
33 + 0–33 + 6	40	43	47
34 + 0–34 + 6	41	44	48
35 + 0–35 + 6	42	45	49
36 + 0–36 + 6	42	46	50
37 + 0–37 + 6	43	47	51
38 + 0–38 + 6	43	47	51
39 + 0–39 + 6	44	48	52

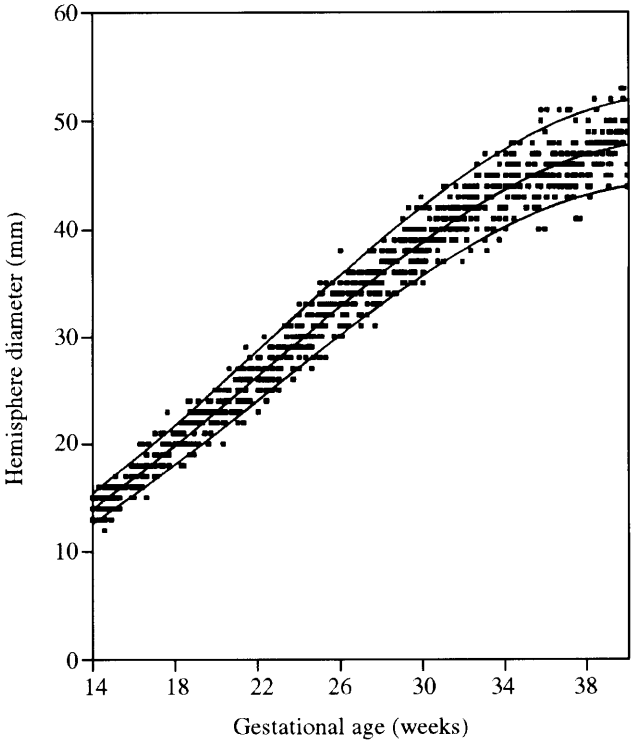


Figure 11 Individual values for fetal cerebral hemisphere diameter plotted on the appropriate reference range (median, 5th and 95th centiles) with gestation

Table 12 Normal range for head to abdominal circumference ratio

Gestational age range (weeks + days)	*Head to abdominal circumference ratio*		
	5th centile	*Median*	*95th centile*
14 + 0–14 + 6	1.12	1.23	1.33
15 + 0–15 + 6	1.11	1.22	1.32
16 + 0–16 + 6	1.10	1.21	1.31
17 + 0–17 + 6	1.09	1.20	1.30
18 + 0–18 + 6	1.09	1.19	1.29
19 + 0–19 + 6	1.08	1.18	1.29
20 + 0–20 + 6	1.07	1.17	1.28
21 + 0–21 + 6	1.06	1.16	1.27
22 + 0–22 + 6	1.05	1.15	1.26
23 + 0–23 + 6	1.04	1.14	1.25
24 + 0–24 + 6	1.03	1.13	1.24
25 + 0–25 + 6	1.02	1.12	1.23
26 + 0–26 + 6	1.01	1.11	1.22
27 + 0–27 + 6	1.00	1.10	1.21
28 + 0–28 + 6	0.99	1.09	1.20
29 + 0–29 + 6	0.98	1.08	1.19
30 + 0–30 + 6	0.97	1.08	1.18
31 + 0–31 + 6	0.96	1.07	1.17
32 + 0–32 + 6	0.95	1.06	1.16
33 + 0–33 + 6	0.94	1.05	1.15
34 + 0–34 + 6	0.93	1.04	1.14
35 + 0–35 + 6	0.92	1.03	1.13
36 + 0–36 + 6	0.91	1.02	1.12
37 + 0–37 + 6	0.90	1.01	1.11
38 + 0–38 + 6	0.89	1.00	1.10
39 + 0–39 + 6	0.88	0.99	1.09

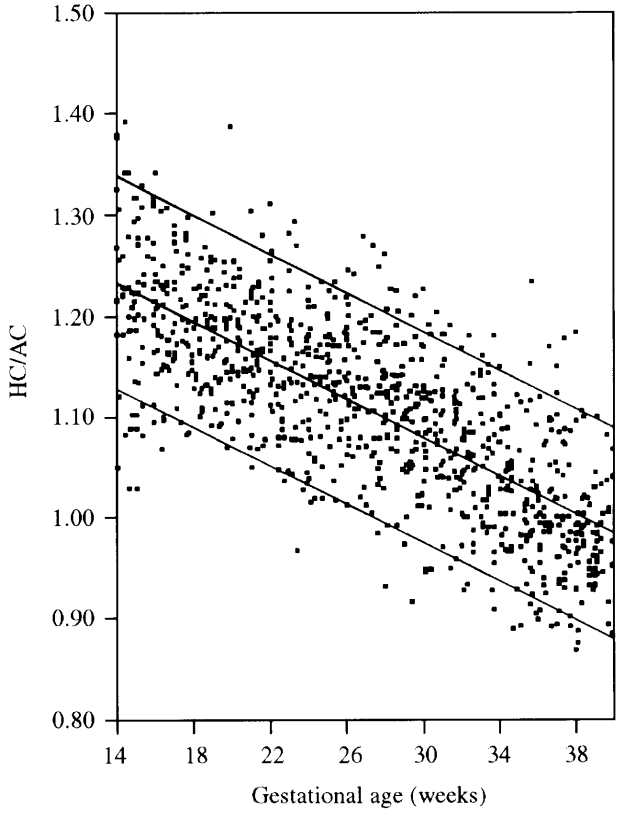


Figure 12 Individual values for fetal abdominal to head circumference ratio (HC/AC) plotted on the appropriate reference range (median, 5th and 95th centiles) with gestation

Table 13 Normal range for transverse cerebellar diameter to abdominal circumference ratio

Gestational age range (weeks + days)	*Transverse cerebellar diameter to abdominal circumference ratio*		
	5th centile	*Median*	*95th centile*
14 + 0–14 + 6	0.139	0.157	0.175
15 + 0–15 + 6	0.135	0.153	0.171
16 + 0–16 + 6	0.131	0.149	0.167
17 + 0–17 + 6	0.127	0.145	0.163
18 + 0–18 + 6	0.125	0.142	0.160
19 + 0–19 + 6	0.122	0.140	0.158
20 + 0–20 + 6	0.120	0.138	0.156
21 + 0–21 + 6	0.118	0.136	0.154
22 + 0–22 + 6	0.117	0.135	0.153
23 + 0–23 + 6	0.116	0.134	0.152
24 + 0–24 + 6	0.115	0.133	0.151
25 + 0–25 + 6	0.115	0.133	0.151
26 + 0–26 + 6	0.115	0.132	0.150
27 + 0–27 + 6	0.114	0.132	0.150
28 + 0–28 + 6	0.114	0.132	0.150
29 + 0–29 + 6	0.115	0.132	0.150
30 + 0–30 + 6	0.115	0.133	0.151
31 + 0–31 + 6	0.115	0.133	0.151
32 + 0–32 + 6	0.115	0.133	0.151
33 + 0–33 + 6	0.115	0.133	0.151
34 + 0–34 + 6	0.115	0.133	0.151
35 + 0–35 + 6	0.115	0.133	0.151
36 + 0–36 + 6	0.115	0.133	0.151
37 + 0–37 + 6	0.115	0.133	0.151
38 + 0–38 + 6	0.114	0.132	0.150
39 + 0–39 + 6	0.113	0.131	0.149

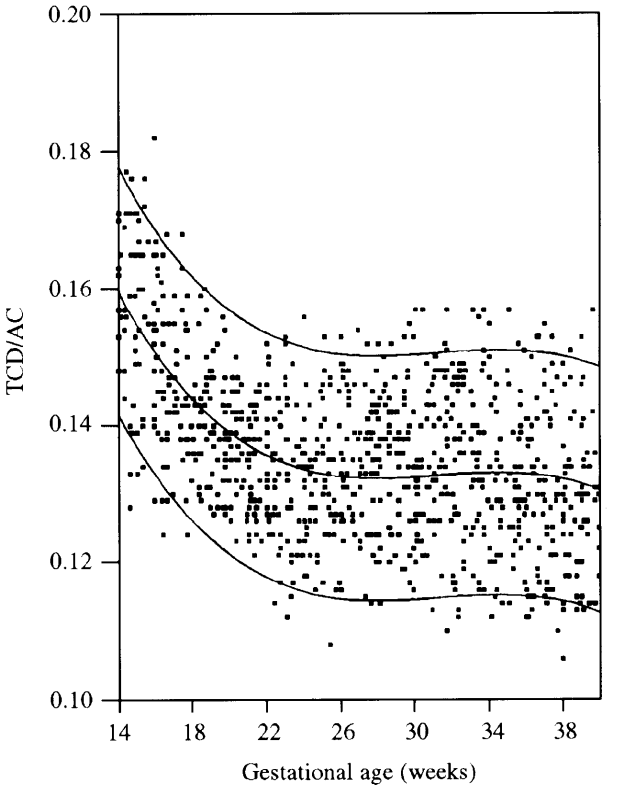


Figure 13 Individual values for fetal transverse cerebellar diameter to abdominal circumference ratio (TCD/AC) plotted on the appropriate reference range (median, 5th and 95th centiles) with gestation

Table 14 Normal range for transverse cerebellar diameter to head circumference ratio

Gestational age range (weeks + days)	*Transverse cerebellar diameter to head circumference ratio*		
	5th centile	*Median*	*95th centile*
14 + 0–14 + 6	0.118	0.130	0.145
15 + 0–15 + 6	0.114	0.126	0.140
16 + 0–16 + 6	0.111	0.123	0.137
17 + 0–17 + 6	0.109	0.121	0.134
18 + 0–18 + 6	0.107	0.119	0.132
19 + 0–19 + 6	0.106	0.118	0.131
20 + 0–20 + 6	0.105	0.117	0.130
21 + 0–21 + 6	0.105	0.116	0.129
22 + 0–22 + 6	0.105	0.116	0.129
23 + 0–23 + 6	0.105	0.116	0.129
24 + 0–24 + 6	0.105	0.117	0.130
25 + 0–25 + 6	0.106	0.118	0.131
26 + 0–26 + 6	0.107	0.119	0.132
27 + 0–27 + 6	0.109	0.120	0.133
28 + 0–28 + 6	0.110	0.121	0.134
29 + 0–29 + 6	0.111	0.122	0.136
30 + 0–30 + 6	0.113	0.124	0.137
31 + 0–31 + 6	0.114	0.125	0.139
32 + 0–32 + 6	0.115	0.128	0.140
33 + 0–33 + 6	0.117	0.129	0.141
34 + 0–34 + 6	0.117	0.129	0.143
35 + 0–35 + 6	0.117	0.130	0.144
36 + 0–36 + 6	0.117	0.130	0.144
37 + 0–37 + 6	0.117	0.130	0.145
38 + 0–38 + 6	0.117	0.130	0.145
39 + 0–39 + 6	0.117	0.130	0.144

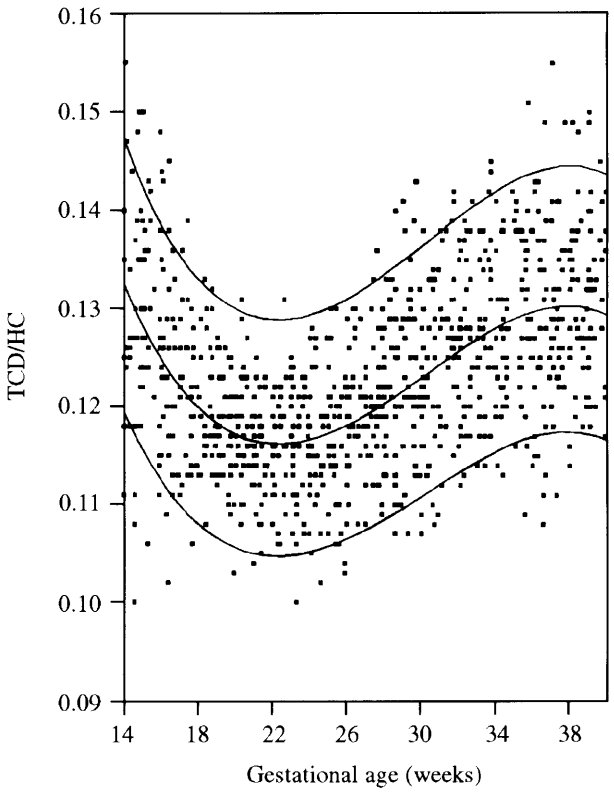


Figure 14 Individual values for fetal transverse cerebellar diameter to head circumference ratio (TCD/HC) plotted on the appropriate reference range (median, 5th and 95th centiles) with gestation

Table 15 Normal range for biparietal circumference to femur length ratio

Gestational age range (weeks + days)	*Biparietal circumference to femur length ratio*		
	5th centile	*Median*	*95th centile*
14 + 0–14 + 6	1.70	1.87	2.06
15 + 0–15 + 6	1.62	1.78	1.95
16 + 0–16 + 6	1.55	1.70	1.87
17 + 0–17 + 6	1.49	1.64	1.80
18 + 0–18 + 6	1.45	1.59	1.74
19 + 0–19 + 6	1.41	1.54	1.69
20 + 0–20 + 6	1.37	1.51	1.66
21 + 0–21 + 6	1.35	1.48	1.62
22 + 0–22 + 6	1.33	1.46	1.60
23 + 0–23 + 6	1.31	1.44	1.58
24 + 0–24 + 6	1.30	1.43	1.57
25 + 0–25 + 6	1.29	1.42	1.56
26 + 0–26 + 6	1.29	1.41	1.55
27 + 0–27 + 6	1.28	1.41	1.54
28 + 0–28 + 6	1.28	1.40	1.54
29 + 0–29 + 6	1.28	1.40	1.54
30 + 0–30 + 6	1.28	1.40	1.54
31 + 0–31 + 6	1.27	1.40	1.53
32 + 0–32 + 6	1.27	1.39	1.53
33 + 0–33 + 6	1.27	1.39	1.53
34 + 0–34 + 6	1.26	1.37	1.52
35 + 0–35 + 6	1.25	1.36	1.51
36 + 0–36 + 6	1.24	1.34	1.49
37 + 0–37 + 6	1.22	1.32	1.47
38 + 0–38 + 6	1.20	1.30	1.45
39 + 0–39 + 6	1.18	1.28	1.42

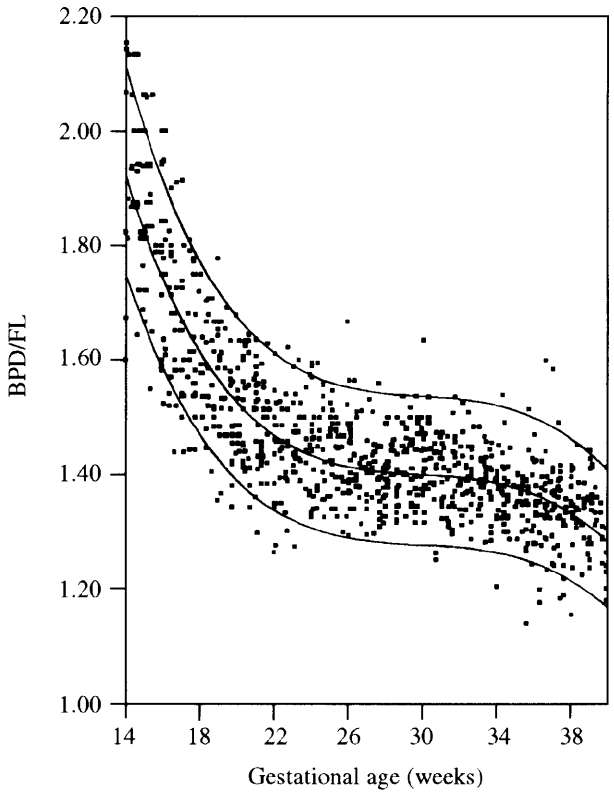


Figure 15 Individual values for fetal biparietal diameter to femur length ratio (BPD/FL) plotted on the appropriate reference range (median, 5th and 95th centiles) with gestation

Table 16 Normal range for head circumference to femur length ratio

Gestational age range (weeks + days)	*Head circumference to femur ratio*		
	5th centile	*Median*	*95th centile*
14 + 0–14 + 6	6.08	6.55	7.05
15 + 0–15 + 6	5.81	6.28	6.76
16 + 0–16 + 6	5.59	6.04	6.52
17 + 0–17 + 6	5.40	5.84	6.31
18 + 0–18 + 6	5.23	5.67	6.13
19 + 0–19 + 6	5.09	5.53	5.98
20 + 0–20 + 6	4.98	5.41	5.85
21 + 0–21 + 6	4.88	5.31	5.75
22 + 0–22 + 6	4.80	5.22	5.66
23 + 0–23 + 6	4.74	5.16	5.59
24 + 0–24 + 6	4.69	5.11	5.54
25 + 0–25 + 6	4.65	5.06	5.50
26 + 0–26 + 6	4.62	5.03	5.46
27 + 0–27 + 6	4.60	5.01	5.44
28 + 0–28 + 6	4.58	4.99	5.41
29 + 0–29 + 6	4.56	4.97	5.40
30 + 0–30 + 6	4.54	4.95	5.38
31 + 0–31 + 6	4.52	4.93	5.36
32 + 0–32 + 6	4.50	4.91	5.34
33 + 0–33 + 6	4.48	4.89	5.31
34 + 0–34 + 6	4.45	4.85	5.27
35 + 0–35 + 6	4.41	4.81	5.23
36 + 0–36 + 6	4.35	4.76	5.17
37 + 0–37 + 6	4.29	4.69	5.11
38 + 0–38 + 6	4.21	4.61	5.02
39 + 0–39 + 6	4.12	4.51	4.92

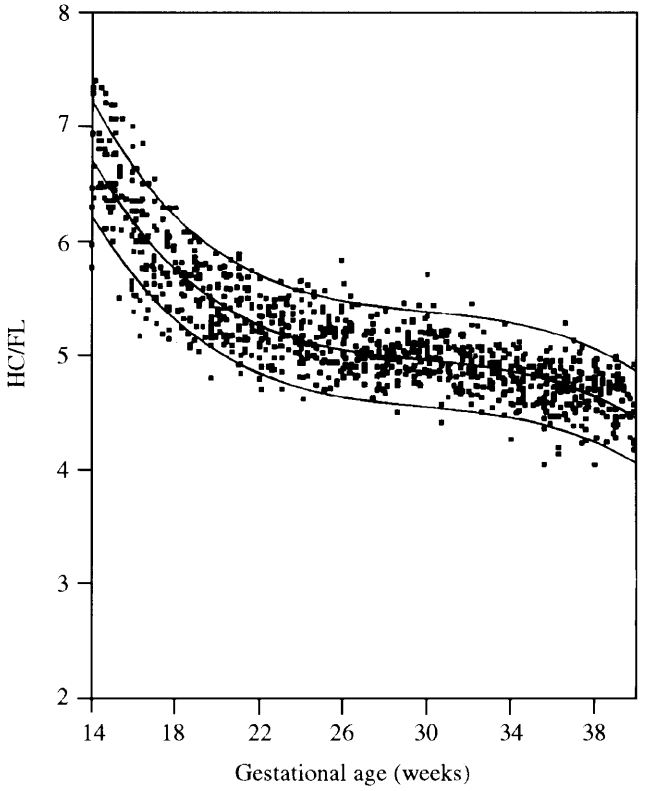


Figure 16 Individual values for fetal head circumference to femur length ratio (HC/FL) plotted on the appropriate reference range (median, 5th and 95th centiles) with gestation

Table 17 Normal range for abdominal circumference to femur length ratio

Gestational age range (weeks + days)	*Abdominal circumference to femur length ratio*		
	5th centile	*Median*	*95th centile*
14 + 0–14 + 6	4.82	5.40	6.04
15 + 0–15 + 6	4.64	5.19	5.81
16 + 0–16 + 6	4.49	5.03	5.62
17 + 0–17 + 6	4.37	4.89	5.47
18 + 0–18 + 6	4.27	4.78	5.34
19 + 0–19 + 6	4.19	4.69	5.24
20 + 0–20 + 6	4.13	4.62	5.16
21 + 0–21 + 6	4.08	4.56	5.10
22 + 0–22 + 6	4.05	4.53	5.06
23 + 0–23 + 6	4.03	4.50	5.04
24 + 0–24 + 6	4.02	4.49	5.02
25 + 0–25 + 6	4.02	4.49	5.02
26 + 0–26 + 6	4.02	4.50	5.03
27 + 0–27 + 6	4.04	4.51	5.05
28 + 0–28 + 6	4.05	4.53	5.07
29 + 0–29 + 6	4.08	4.56	5.10
30 + 0–30 + 6	4.10	4.58	5.13
31 + 0–31 + 6	4.12	4.61	5.16
32 + 0–32 + 6	4.15	4.64	5.19
33 + 0–33 + 6	4.17	4.66	5.22
34 + 0–34 + 6	4.19	4.69	5.24
35 + 0–35 + 6	4.20	4.70	5.26
36 + 0–36 + 6	4.21	4.71	5.27
37 + 0–37 + 6	4.21	4.70	5.27
38 + 0–38 + 6	4.20	4.68	5.26
39 + 0–39 + 6	4.18	4.66	5.23

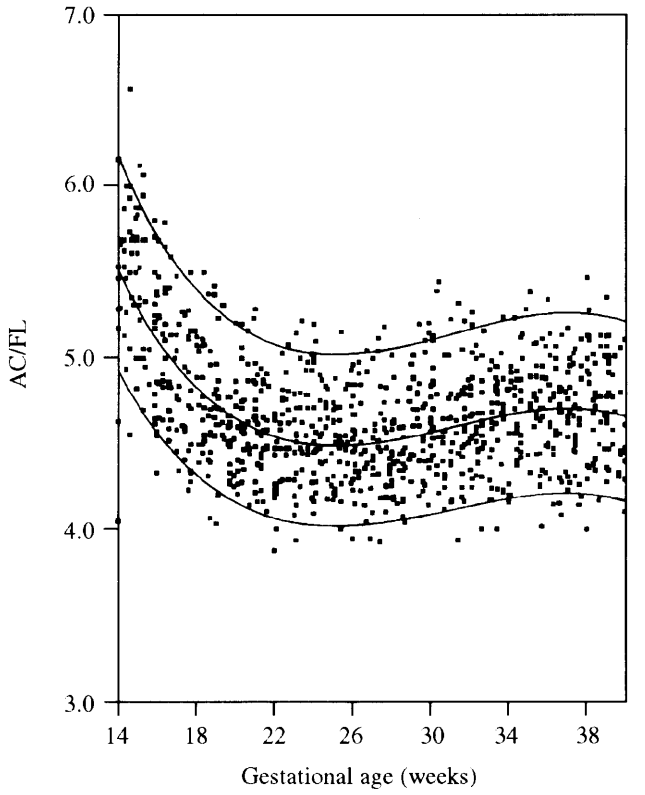


Figure 17 Individual values for fetal abdominal circumference to femur length ratio (AC/FL) plotted on the appropriate reference range (median, 5th and 95th centiles) with gestation

Table 18 Normal range for biparietal to occipitofrontal diameter ratio

Gestational age range (weeks + days)	*Biparietal to occipitofrontal diameter ratio*		
	5th centile	*Median*	*95th centile*
14 + 0–14 + 6	0.75	0.80	0.86
15 + 0–15 + 6	0.74	0.80	0.86
16 + 0–16 + 6	0.74	0.80	0.86
17 + 0–17 + 6	0.74	0.79	0.85
18 + 0–18 + 6	0.74	0.79	0.85
19 + 0–19 + 6	0.73	0.79	0.85
20 + 0–20 + 6	0.73	0.79	0.85
21 + 0–21 + 6	0.73	0.79	0.85
22 + 0–22 + 6	0.73	0.79	0.85
23 + 0–23 + 6	0.73	0.79	0.85
24 + 0–24 + 6	0.73	0.79	0.85
25 + 0–25 + 6	0.73	0.79	0.85
26 + 0–26 + 6	0.73	0.79	0.85
27 + 0–27 + 6	0.73	0.79	0.85
28 + 0–28 + 6	0.74	0.79	0.85
29 + 0–29 + 6	0.74	0.79	0.85
30 + 0–30 + 6	0.74	0.79	0.85
31 + 0–31 + 6	0.74	0.80	0.86
32 + 0–32 + 6	0.74	0.80	0.86
33 + 0–33 + 6	0.75	0.80	0.86
34 + 0–34 + 6	0.75	0.81	0.87
35 + 0–35 + 6	0.75	0.81	0.87
36 + 0–36 + 6	0.76	0.82	0.88
37 + 0–37 + 6	0.76	0.82	0.88
38 + 0–38 + 6	0.77	0.83	0.89
39 + 0–39 + 6	0.77	0.83	0.90

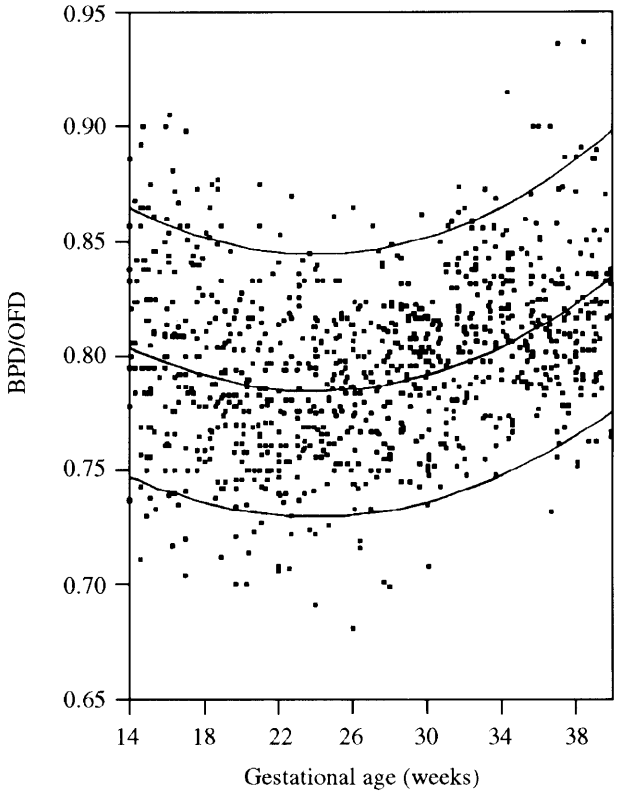


Figure 18 Individual values for fetal biparietal to occipitofrontal diameter ratio (BPD/OFD) plotted on the appropriate reference range (median, 5th and 95th centiles) with gestation

Table 19 Normal range for anterior cerebral ventricle to hemisphere diameter ratio

Gestational age range (weeks + days)	*Anterior cerebral ventricle to hemisphere diameter ratio*		
	5th centile	*Median*	*95th centile*
14 + 0–14 + 6	0.39	0.47	0.56
15 + 0–15 + 6	0.36	0.43	0.51
16 + 0–16 + 6	0.33	0.40	0.48
17 + 0–17 + 6	0.31	0.37	0.44
18 + 0–18 + 6	0.29	0.35	0.41
19 + 0–19 + 6	0.27	0.32	0.39
20 + 0–20 + 6	0.26	0.31	0.37
21 + 0–21 + 6	0.24	0.29	0.35
22 + 0–22 + 6	0.23	0.28	0.33
23 + 0–23 + 6	0.22	0.27	0.32
24 + 0–24 + 6	0.21	0.26	0.31
25 + 0–25 + 6	0.21	0.25	0.30
26 + 0–26 + 6	0.20	0.24	0.29
27 + 0–27 + 6	0.19	0.23	0.28
28 + 0–28 + 6	0.19	0.23	0.27
29 + 0–29 + 6	0.19	0.22	0.27
30 + 0–30 + 6	0.18	0.22	0.26
31 + 0–31 + 6	0.18	0.21	0.26
32 + 0–32 + 6	0.18	0.21	0.26
33 + 0–33 + 6	0.18	0.21	0.25
34 + 0–34 + 6	0.17	0.21	0.25
35 + 0–35 + 6	0.17	0.21	0.25
36 + 0–36 + 6	0.17	0.21	0.25
37 + 0–37 + 6	0.17	0.21	0.25
38 + 0–38 + 6	0.17	0.21	0.25
39 + 0–39 + 6	0.17	0.21	0.25

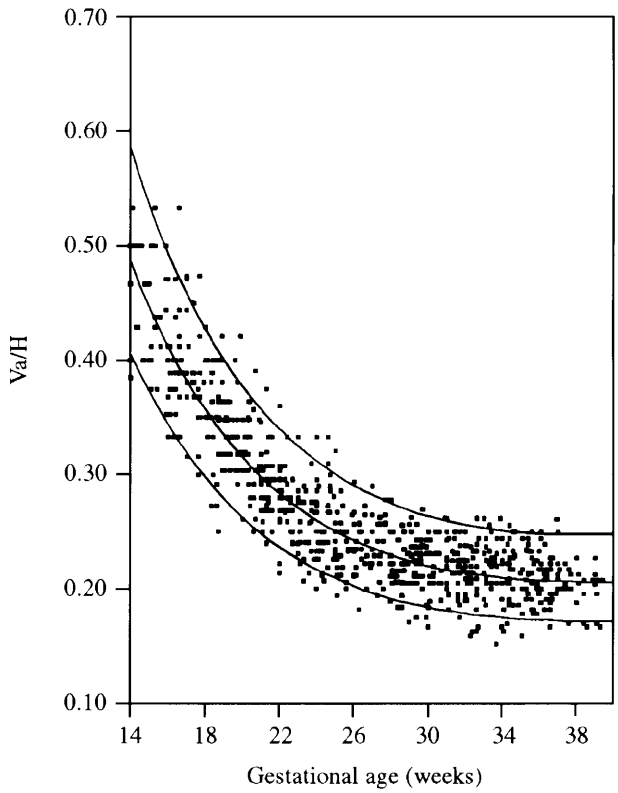


Figure 19 Individual values for fetal cerebral anterior ventricle to hemisphere diameter ratio (Va/H) plotted on the appropriate reference range (median, 5th and 95th centiles) with gestation

Table 20 Normal range for posterior cerebral ventricle to hemisphere diameter ratio

Gestational age range (weeks + days)	*Posterior cerebral ventricle to hemisphere diameter ratio*		
	5th centile	*Median*	*95th centile*
14 + 0–14 + 6	0.36	0.45	0.56
15 + 0–15 + 6	0.34	0.42	0.52
16 + 0–16 + 6	0.31	0.39	0.48
17 + 0–17 + 6	0.29	0.36	0.45
18 + 0–18 + 6	0.27	0.34	0.42
19 + 0–19 + 6	0.26	0.32	0.40
20 + 0–20 + 6	0.24	0.30	0.37
21 + 0–21 + 6	0.23	0.29	0.35
22 + 0–22 + 6	0.22	0.27	0.34
23 + 0–23 + 6	0.21	0.26	0.32
24 + 0–24 + 6	0.20	0.25	0.31
25 + 0–25 + 6	0.19	0.24	0.29
26 + 0–26 + 6	0.18	0.23	0.28
27 + 0–27 + 6	0.18	0.22	0.27
28 + 0–28 + 6	0.17	0.21	0.26
29 + 0–29 + 6	0.17	0.21	0.26
30 + 0–30 + 6	0.16	0.20	0.25
31 + 0–31 + 6	0.16	0.20	0.24
32 + 0–32 + 6	0.16	0.19	0.24
33 + 0–33 + 6	0.15	0.19	0.24
34 + 0–34 + 6	0.15	0.19	0.24
35 + 0–35 + 6	0.15	0.19	0.24
36 + 0–36 + 6	0.15	0.19	0.24
37 + 0–37 + 6	0.15	0.19	0.24
38 + 0–38 + 6	0.15	0.19	0.24
39 + 0–39 + 6	0.15	0.19	0.24

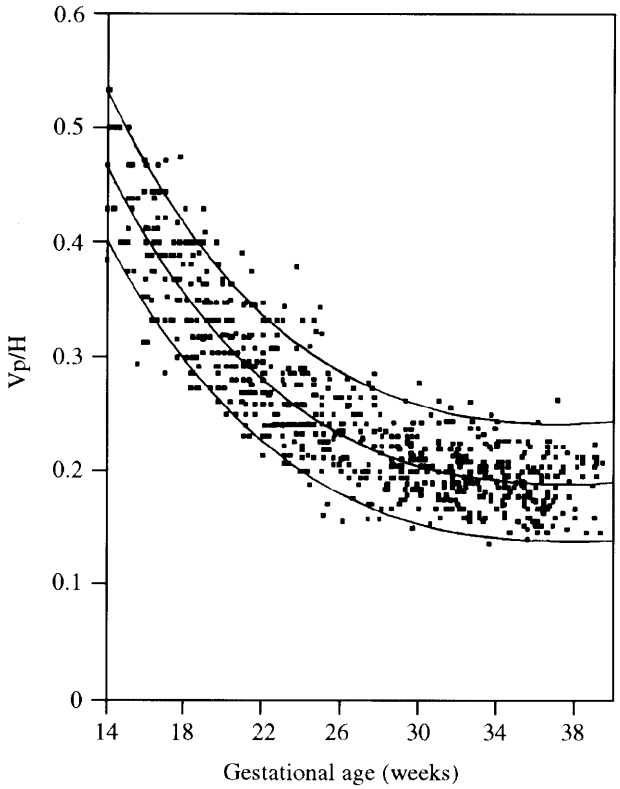
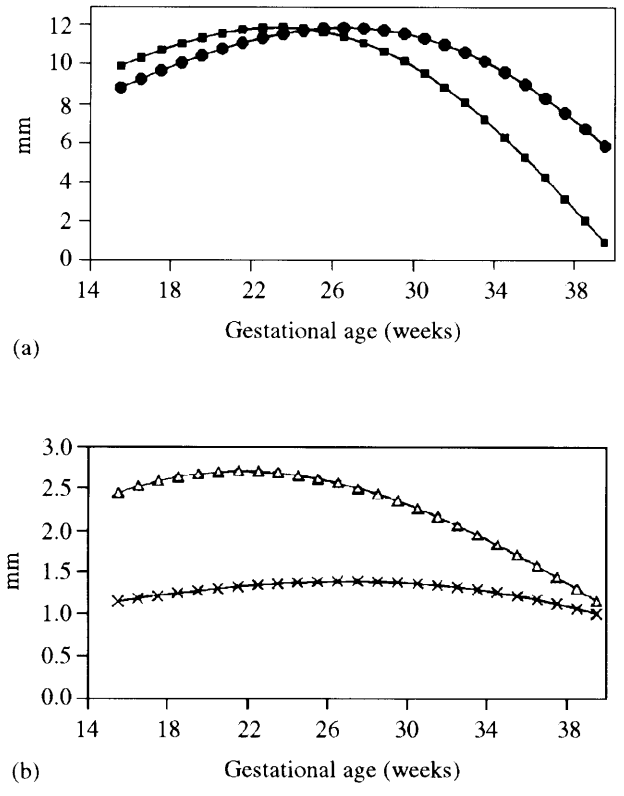


Figure 20 Individual values for fetal cerebral posterior ventricle to hemisphere diameter ratio (Vp/H) plotted on the appropriate reference range (median, 5th and 95th centiles) with gestation



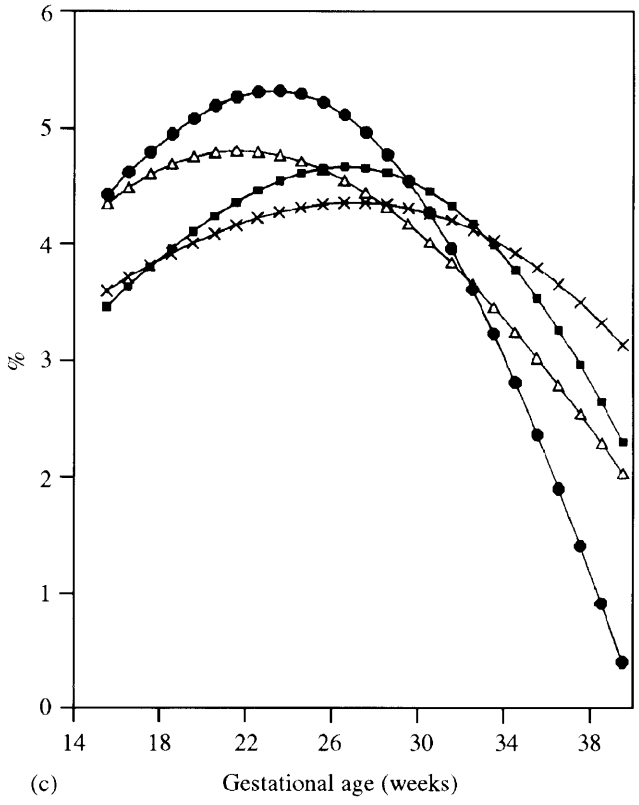


Figure 21 The change in median for gestation (a) for abdominal (AC, ■) and head (HC, ●) circumference and (b) for femur length (FL, x) and transverse cerebellar diameter (TCD, △) in mm; (c) the change in median per week expressed as percentage of the total increase between 14 and 40 weeks

Table 21 Features of different studies. Abbreviations as for Table 1

		Study design			*Study group*		*Gestational age (weeks)*		*Presentation of results*		
Reference	*Parameters*	*Entry criteria*	*Pro/retro*	*Long/cross*	*Patients*	*Observations*	*Range*	*Distribution*	*Graphs*	*Tables*	*Equation*
3	BPD	a, b, c, d	?	mixed	574	1029	13–40	even	mean + SD	mean + SD	no
4	BPD, OFD, HC	a, e, f	?	mixed	767	368–394	19–43	?	no	mean + error	mean
5*	BPD	a, c, d	?	mixed	1883	7059	14–40	?	no	mean	no
6	FL	a, b	?	mixed	411	1016	14–40	even	mean + SD	mean + SD	no
7	FL/BPD	b, e	?	mixed	256	301	23–40	?	mean + SD	no	mean + SD
8	HC, BPD, AC	a, b, c, d	pro	long	20	536	18–41	even	mean + SD	no	mean
9	BPD	a, b, f, g	?	cross	533	533	12–40	uneven	mean + SD	mean + SD	mean
10	HC	a, b, f	?	cross	400	400	15–41	uneven	scatter-gram	mean + SD	mean
11	AC	a, b, f	?	cross	400	400	15–41	uneven	mean + SD	mean + SD	mean
12	FL	a, b, f	?	cross	338	338	12–40	?	mean + SD	mean	mean
13	FL/AC	a, b, c, f	?	cross	361	361	15–42	?	mean + SD	no	mean + SD
14	CM	i	pro	cross	155	155	15–36	even	no	mean + SD	no
15	BPD, OFD, FL	a	pro	long	19	167	11–39	uneven	scatter-gram	mean + SD	mean
16	TCD, CM	a, c, d, h	pro	cross	107	107	15–30	?	mean + SD	no	mean
17	AC	a, c, d	pro	cross	197	197	18–41	uneven	no	centiles	no
18	TCD, BPD	a, e, f, g, h	pro	cross	371	371	13–40	uneven	scatter-gram	centiles	mean
19	TCD	a, f	?	cross	675	675	14–42	uneven	no	mean + SD	mean
20	TCD/AC	a, c, e, f	pro	cross	162	162	15–38	uneven	mean + SD	no	mean + SD
21	BPD, HC, AC, FL	a, b	retro	cross	8285	8285	10–44	?	mean + SD	centiles	mean
Present study	19 parameters	a, b, c, d, e, f	retro	cross	1040	1040	14–40	even	scatter-gram	centiles	median + SD

a, Known last menstrual period, regular cycle, early dating by crown–rump length; b, singleton pregnancy; c, normal birth weight/estimated fetal weight; d, term delivery; e, no pregnancy complication/fetal malformation; f, no maternal disease known to affect growth; g, normal HC/AC; h, normal BPD/FL; i, no neural tube defect; pro/retro, prospective/retrospective; long/cross, longitudinal/cross-sectional

*Combined references 3, 22–24

Table 22 Mean, 5th and 95th centiles for biparietal (BPD) and occipitofrontal (OFD) diameters and for head circumference (HC) at 18, 28 and 38 weeks' gestation

		18 weeks			*28 weeks*			*38 weeks*		
Reference	*Parameter*	*5th*	*Mean*	*95th*	*5th*	*Mean*	*95th*	*5th*	*Mean*	*95th*
3	BPD*	42	44	46	73	76	79	92	96	100
4	BPD†	—	—	—	64	75	86	82	93	105
5	BPD*	—	42	—	—	72	—	—	93	—
8	BPD*	—	38	—	—	69	—	—	89	—
9	BPD*	37	40	42	67	70	73	87	91	96
15	BPD*	41	43	45	70	74	78	89	94	99
18	BPD‡**	38	42	44	68	70	72	87	90	84
21	BPD‡	22	42	62	50	70	90	70	87	104
Present study	BPD†	39	43	47	69	75	81	88	96	104
4	OFD	—	—	—	81	97	113	105	120	136
15	OFD	46	51	55	93	99	105	102	107	112
Present study	OFD	50	54	59	87	95	103	107	116	126
4	HC	—	—	—	236	277	318	301	342	383
8	HC	—	148	—	—	273	—	—	353	—
10	HC	137	148	159	246	271	296	323	336	349
21	HC	89	158	226	191	260	329	270	320	371
Present study	HC	141	152	164	248	267	288	308	332	358

*Measurements taken from outer to inner border of the skull; †measurements taken from outer to outer border of the skull; ‡no details given; **in this study the 10th and 90th centiles rather than 5th and 95th centiles are provided

Table 23 Mean, 5th and 95th centiles for abdominal circumference (AC) and femur length (FL) at 18, 28 and 38 weeks' gestation

		18 weeks			*28 weeks*			*38 weeks*		
Reference	*Parameter*	*5th*	*Mean*	*95th*	*5th*	*Mean*	*95th*	*5th*	*Mean*	*95th*
17	AC	103	131	159	225	253	281	329	357	385
8	AC	—	125	—	—	240	—	—	355	—
11	AC	119	128	136	221	247	272	316	339	362
21	AC	69	137	206	158	234	310	246	318	390
Present study	AC	114	128	144	216	243	272	302	339	380
6	FL	27	30	32	51	54	57	67	72	77
12	FL	23	28	33	47	52	57	71	76	81
15	FL	25	28	31	53	57	61	69	75	81
21	FL	11	29	47	35	53	71	55	71	87
Present study	FL	24	27	30	49	53	58	67	72	77

Table 24 Mean, 5th and 95th centiles for transverse cerebellar (TCD) and cisterna magna (CM) diameters at 18, 28 and 38 weeks' gestation

		18 weeks			*28 weeks*			*38 weeks*		
Reference	*Parameter*	*5th*	*Mean*	*95th*	*5th*	*Mean*	*95th*	*5th*	*Mean*	*95th*
16	TCD	—	18	—	—	31	—	—	44	—
18*	TCD	17	18	19	27	31	34	40	49	55
19	TCD	16	18	20	30	33	36	41	51	62
Present study	TCD	16	18	21	29	32	37	40	44	49
16	CM	—	5	—	—	8	—	—	11	—
14	CM	0	5	10	0	5	10	0	5	10
Present study	CM	3	5	7	5	7	9	6	8	10

*In this study the 10th and 90th centiles rather than 5th and 95th centiles are provided

Table 25 Mean, 5th and 95th centiles for head to abdominal circumference (HC/AC), femur length to biparietal diameter (FL/BPD) and femur length to abdominal circumference (FL/AC) ratios at 18, 28 and 38 weeks' gestation

		18 weeks			*28 weeks*			*38 weeks*		
Reference	*Parameter*	*5th*	*Mean*	*95th*	*5th*	*Mean*	*95th*	*5th*	*Mean*	*95th*
3	HC/AC	1.07	1.18	1.29	1.05	1.13	1.22	0.92	0.98	1.05
8	HC/AC	—	1.20	—	—	1.11	—	—	0.97	—
Present study	HC/AC	1.09	1.19	1.29	0.99	1.09	1.20	0.89	1.00	1.10
20	TCD/AC	0.121	0.136	0.152	0.121	0.136	0.152	0.121	0.136	0.152
Present study	TCD/AC	0.125	0.142	0.160	0.114	0.132	0.150	0.114	0.132	0.150
17	FL/BPD	—	—	—	0.706	0.786	0.866	0.726	0.806	0.886
Present study	FL/BPD	0.572	0.634	0.696	0.650	0.712	0.775	0.694	0.757	0.820
13	FL/AC	0.205	0.215	0.225	0.209	0.219	0.229	0.213	0.223	0.233
Present study	FL/AC	0.187	0.210	0.234	0.197	0.221	0.245	0.189	0.213	0.237

(2) The pregnancies were essentially normal, as they resulted in term deliveries of infants with birth weights between the 3rd and 97th centiles;

(3) There was a wide range of gestations, from 14 to 40 weeks, gestation was calculated in days and each 7-day interval was represented by the same number of patients;

(4) The patients were selected retrospectively, the measurements were taken routinely and many ultrasonographers were involved;

(5) The population used was mixed and there was no preselection for maternal age, race and parity or fetal sex;

(6) Normal ranges were described by scattergrams, tables and equations for regression lines from which the median and standard deviation can be calculated.

All fetal measurements increase with gestational age and for most the ranges become wider while the median flattens towards the end of pregnancy (Figures 2–11). For ratios of measurements, the range is often relatively wide and, because the increase in size of different parts of the body is not synchronous (Figure 21), gestational age needs to be taken into account when interpreting findings. Thus, to diagnose or exclude ventriculomegaly (VaH and/or VpH > 97.5th centile) and to diagnose or exclude short femur or microcephaly (FL < 5th centile

and BPD/FL or HC/FL > 97.5th centile) it is necessary to obtain accurate information on gestational age. In contrast, asymmetric growth retardation (HC/AC or TCD/AC > 97.5th centile) and short femur by an alternative criterion (FL/AC < 2.5th centile) can be diagnosed even when gestation is uncertain, since these ratios remain essentially constant from 20 weeks onwards.

Previous studies provided reference ranges for either one or a few of the parameters presented here (Table 21). Furthermore, many of the studies possessed various methodological disadvantages:

(1) They pooled cross-sectional and longitudinal data;

(2) They did not provide data on pregnancy outcome or birth weight distribution, making it impossible to determine whether the given ranges are applicable to different populations;

(3) They did not provide data on the gestational age distribution of the patients or the distribution was uneven, which may influence the variation at different gestations;

(4) They were based on measurements taken prospectively, presumably under the 'ideal' circumstances of a research project, and their degree of accuracy may not be matched in good routine clinical practice;

(5) They did not provide sufficient data to allow comparison of both the mean and variation at different gestations; or

(6) They provided equations from which the normal mean but not the standard deviation for a given gestation can be calculated (Table 21).

Despite methodological differences between the various studies, the mean, 5th and 95th centiles were essentially the same except for the findings of Browne and colleages[21], where the range was much wider. In the latter study, the only selection criterion was 'known date of last menstrual period', whereas in all other studies one or more criteria to select 'normal' pregnancies were included. Thus, the ranges from Browne and colleagues[21] are reference ranges for their own population, whereas ranges from other studies are normal ranges. In the present study, patients were selected so that the birth weight distribution was similar to that reported by Yudkin and colleagues[1]. Therefore, they can be used for any population that has a similar birth weight distribution.

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