Fetal size and dating: charts recommended for clinical obstetric practice

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Introduction

The charts and tables presented here represent those recommended by BMUS for routine use. The application of the recommended charts in clinical practice has not been addressed as dating policies and the identification of growth related problems should form part of locally derived protocols.

General guidance

Dating measurements are used to confirm the postmenstrual dates (if known) or to estimate the gestational age (GA) of the fetus when the menstrual history is unknown or unreliable. Normally the earliest technically satisfactory measurement will be the most accurate for dating purposes. Once the gestational age has been assigned, later measurements should be used to assess fetal size and should not normally be used to reassign gestational age.

For dating charts the known variable [crown-rump length (CRL) or head circumference (HC)] is plotted along the horizontal X axis, and the unknown variable gestational age (GA) on the vertical Y axis. Size charts plot the GA on the X axis and the size variable on the Y axis. The plotting of measurements on a dating chart can cause confusion to the inexperienced operator. Since a measurement acquired to date a pregnancy is made only once, it is recommended that look-up tables are used for dating purposes in preference to charts. In view of this, only dating tables are presented here.

Fetal size can be assessed using either look-up tables or fetal size charts. The latter are more appropriate. For serial measurements, charts give a visual representation of the fetal size parameters on consecutive occasions. The position of measurements within the normal range can also be assessed.

It is recommended that departments, which adopt the charts/tables in this document, check that any data programmed into their ultrasound and computerised patient management systems use the GA and size equations given here.

The use of the biparietal diameter (BPD)

The BPD measurement is dependant on head shape (which can be quantified using the cephalic index), whilst the head circumference measurement is independent of head shape. Therefore for fetuses with a dolicocephalic head shape, the head circumference will be within expected limits, but the BPD recorded will be smaller than the normal value for a given GA. If the BPD measurement is used to date such pregnancies, they will incorrectly be assigned a gestational age which is less than that expected from the last menstrual period (LMP) or the head circumference measurement. This effect of using the BPD for dating pregnancies has been reported by two groups (Hadlock *et al.*,[1] Altman and Chitty).[2]

In view of the inaccuracies that may result from using the BPD measurement, the BMUS Fetal Measurements Working Party was of the opinion that the BPD should not be used in routine clinical practice for the estimation of gestational age or the appropriateness of fetal size in later pregnancy. Charts and tables for BPD measurements are therefore not presented in this document.

Measurements for the estimation of gestational age (dating)

The measurements of choice for pregnancy dating are gestation dependent as shown below (Table 1).

Crown-rump length (6–13 weeks)

Accurate dating of pregnancy is critical to the quality of the national screening programme for Down's syndrome. Whilst it is recommended practice that all pregnancies are dated by ultrasound using crown-rump length rather than menstrual dates (NICE Antenatal Care Guidelines),[3] in overall terms the difference in gestational ages calculated by the various formulae available makes little difference to the management of the pregnancy.

However, a difference of one or two days gestational age can alter a Down's screening result from high chance to low chance or *vice versa*. It is therefore essential that all laboratories involved in any form of serum screening, and all ultrasound packages used in calculating risk from nuchal translucency, use the same formula for calculating gestational age from crown-rump length measurement.

The perfect formula does not exist, but following detailed consultation between BMUS, the Fetal Measurements Foundation and the NHS National Screening Programme, it has been agreed that the equation given below will be adopted by all parties and by biochemistry laboratories involved in serum screening.

The recommended equation for calculation of gestational age from crown rump length is

$$GA = 8\cdot052 \times (CRL \times 1\cdot037)^{1/2} + 23\cdot73$$

A dating table containing values derived from this equation is provided in Appendix 1.

Technique

CRL measurements can be carried out trans-abdominally or trans-vaginally. A midline sagittal section of the whole embryo

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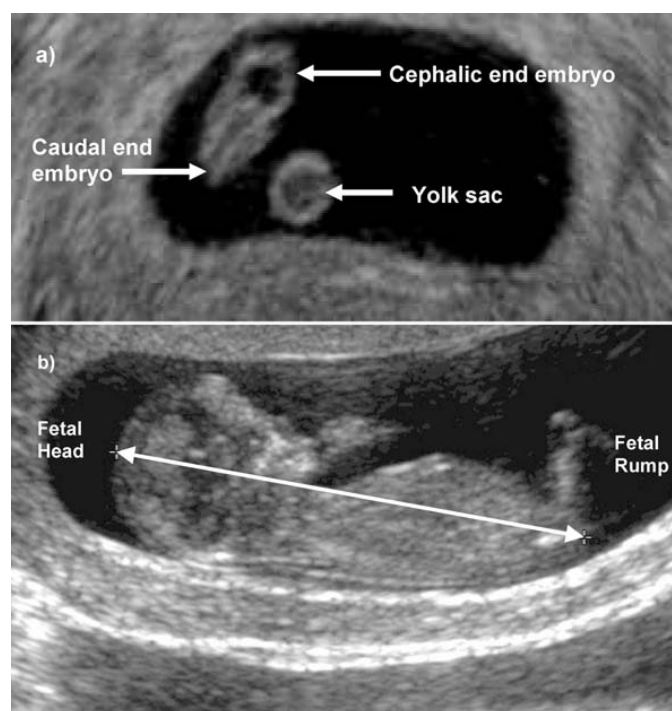
Figure 1. Measurement of CRL at (a) 6 weeks and (b) 13 weeks.

or fetus should be obtained, ideally with the embryo or fetus horizontal on the screen so that the line between crown and rump is at 90° to the ultrasound beam. Linear callipers should be used to measure the maximum unflexed length, in which the end points of crown and rump are clearly defined (Fig. 1*a* and *b*). The best of three measurements should be taken.

In very early gestations, care must be taken to avoid inclusion of the yolk sac (Fig. 1*a*) in the measurement of CRL, as this will overestimate the gestational age. It must be remembered that flexion increases with increasing gestation. In measuring a flexed fetus, the gestational age will be underestimated and it may be more appropriate to use the HC if the fetus remains flexed at 13 weeks or more.

Head circumference (13–25 completed weeks)

The recommended values are those of Altman and Chitty[2] using the derived option as shown in Appendix 2. This involves calculating the HC from measurements of the biparietal diameter (BPD) and the occipital-frontal diameter (OFD) using the expression

$$HC = \pi(BPD + OFD)/2$$

Note that the BPD measurement uses the 'outer-to-outer' calliper positioning as described later.

Many modern ultrasound machines have the capability to derive the HC directly from the diameters (BPD and OFD) of

Table 1. Measurements for estimation of gestational age (dating).

Measurement	Gestational age range
Crown-rump length (CRL)	6 to 13 weeks
Head circumference (HC)	†13 to 25 completed weeks
Femur length* (FL)	†13 to 25 completed weeks

*If head measurements are not feasible or appropriate, estimation of gestational age should be made using FL.
†These measurements can be used beyond the gestation indicated, but the imprecision around the estimate will increase significantly.
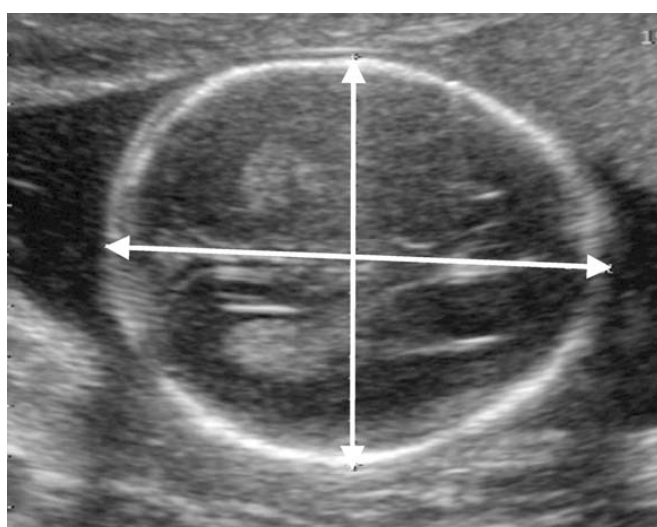
Figure 2. Estimation of fetal HC from measurements of OFD ('outer to outer') and BPD ('outer to outer').

the head, using the ellipse facility. Deriving the head circumference in this way is acceptable providing the above equation is used. As the formulae used to derive a circumference may differ between manufacturers, departments should ensure that their machine's software uses the correct formula.

GA should be estimated from HC using the following formula

$$\log_e(GA) = 0{\cdot}010611HC - 0{\cdot}000030321HC^2$$
$$+ 0{\cdot}43498 \times 10^{-7}HC^3 + 1{\cdot}848$$

Technique

A cross-sectional view of the fetal head at the level of the ventricles should be obtained.

The following landmarks should be identified and the image frozen (Fig. 2):

- rugby football shape;
- centrally positioned, continuous midline echo broken at one third of its length by the cavum septum pellucidum;
- anterior walls of the lateral ventricles centrally placed around the midline;
- the choroid plexus should be visible within the posterior horn of the ventricle in the distal hemisphere.

Measurements of OFD and BPD should be taken from an image with the midline echo lying as close as possible to the horizontal plane, such that the angle of insonation of the ultrasound beam is 90°.

To measure the OFD, the intersection of the callipers should be placed on the outer border of the occipital and frontal edges of the skull at the point of the midline ('outer to outer') across the longest part of the skull (Fig. 2). To measure the BPD, the intersection of the callipers should be placed on the outer border of the upper and lower parietal bones ('outer to outer') across the widest part of the skull (Fig. 2). Provided a technically good image is obtained, a single measurement of both BDP and OFD is adequate.

Femur length (13–25 completed weeks)

The recommended values are those of Altman and Chitty[2] as shown in Appendix 3.
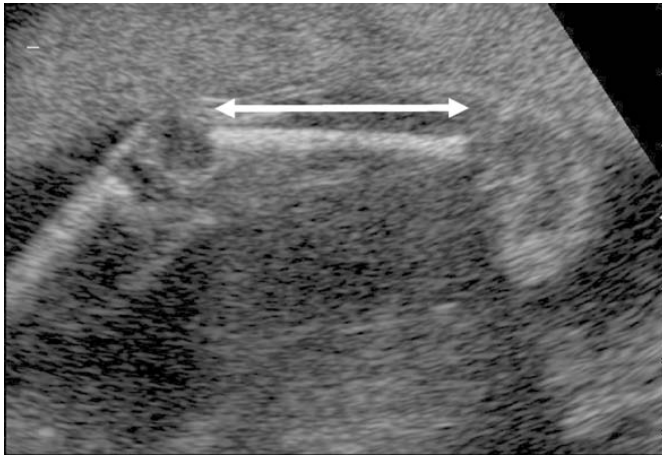
Figure 3. Measurement of femur length.

GA should be estimated from FL using the following formula

$$\log_e(GA) = 0\cdot034375FL - 0\cdot0037254FL \times \log_e(FL) + 2\cdot306$$

Technique

The femur should be imaged lying as close as possible to the horizontal plane, such that the angle of insonation of the ultrasound beam is 90° (Fig. 3). Care should be taken to ensure that the full length of the bone is visualised and the view is not obscured by shadowing from adjacent bony parts. Provided a technically good image is obtained, a single measurement is adequate.

Measurements for the estimation of fetal size

Fetal size charts are used to compare the size of a fetus (of known gestational age) with reference data and to compare the size of a fetus on two or more different occasions. This can be performed using look up tables or charts, but as it is easier to identify any deviation from normal by plotting measurements on charts, the use of charts is recommended.

The measurements of choice for the estimation of fetal size are shown in Table 2 below. As with dating, because of the potential inaccuracies with the BPD measurement, it is recommended that the head circumference is used to evaluate fetal head size rather than the BPD. For all parameters given below, a single measurement should be used, provided it is of good technical quality and obtained using the techniques and planes described.

Head circumference

The recommended values are those of Chitty *et al.*[4] using the derived option as shown in Appendix 4.

Table 2. Measurements for estimation of fetal size.

Measurement	Gestational age range
Head circumference (HC)	13 to 42 completed weeks
Abdominal circumference (AC)	13 to 42 competed weeks
Femur length (FL)	13 to 42 competed weeks
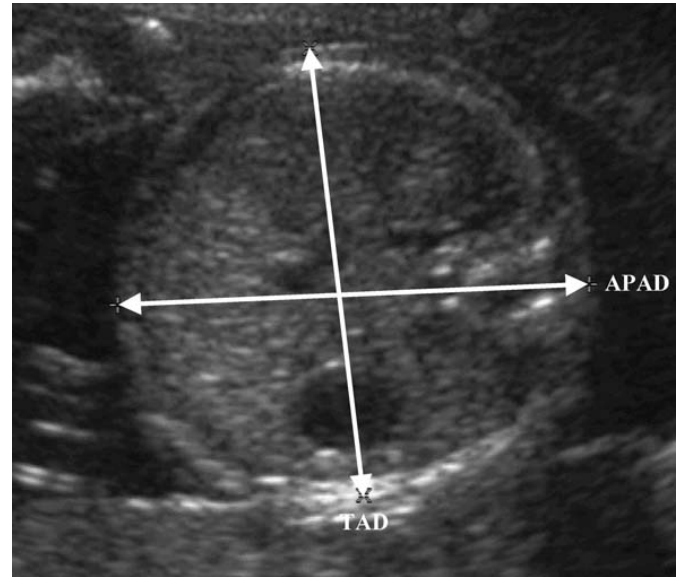
Figure 4. Measurement of AC using the abdominal diameters method.

The recommended equation for estimating HC from GA is

$$HC = -109\cdot7 + 15\cdot16GA - 0\cdot002388GA^3$$

Technique

This is as described above.

Abdominal circumference

The recommended values are those of Chitty *et al.*[5] using the derived option as shown in Appendix 5.

The recommended equation for estimating AC from GA is

$$AC = -85\cdot84 + 11\cdot92(GA) - 0\cdot0007902(GA)^3$$

Technique

The fetal AC is measured on a transverse section through the fetal abdomen that is as close as possible to circular in shape. Care must be taken to identify the spine and descending aorta posteriorly, the umbilical vein in the anterior one third of the abdomen and the stomach bubble in the same plane (Fig. 4).

The transverse abdominal diameter (TAD) and anterior-posterior abdominal diameter (APAD) are measured. To measure the APAD, the callipers are placed on the outer borders of the body outline, from the posterior aspect of the skin covering the spine, to the anterior abdominal wall. The TAD is measured at 90° to the APAD, across the abdomen at the widest point.

The data used are those for an AC derived from measurements of two orthogonal diameters d_1 and d_2 using the expression $AC = \pi(d_1 + d_2)/2$.

Femur length

The recommended values are those of Chitty *et al.*[6] as shown in Appendix 6.

The recommended equation for estimating FL from GA is

$$FL = -32\cdot43 + 3\cdot416GA - 0\cdot0004791GA^3$$

Technique

This is as described above.

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Acknowledgements

Other contributors to this document include Dr Kevin Martin, Dr Paul Chamberlain and Dr Diz Shirley.

The BMUS Fetal Measurements Working Party would like to acknowledge the helpful comments received from many members of the Society during the preparation of this document.

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Appendix 1

Table 1. Crown rump length dating table.

CRL (mm)	GA (weeks+days)		
	50th centile	5th centile	95th centile
5	6+0	5+2	6+5
6	6+2	5+4	7+0
7	6+3	5+6	7+1
8	6+5	6+0	7+2
9	6+6	6+2	7+4
10	7+1	6+3	7+5
11	7+2	6+4	8+0
12	7+3	6+5	8+1
13	7+4	7+0	8+2
14	7+5	7+1	8+3
15	7+6	7+2	8+4
16	8+1	7+3	8+5
17	8+2	7+4	8+6
18	8+3	7+5	9+0
19	8+3	7+6	9+1
20	8+4	8+0	9+2
21	8+5	8+1	9+3
22	8+6	8+1	9+4
23	9+0	8+2	9+5
24	9+1	8+3	9+6
25	9+2	8+4	9+6
26	9+3	8+5	10+0
27	9+3	8+6	10+1
28	9+4	8+6	10+2
29	9+5	9+0	10+3
30	9+6	9+1	10+3
31	9+6	9+2	10+4
32	10+0	9+2	10+5
33	10+1	9+3	10+6
34	10+2	9+4	10+6
35	10+2	9+5	11+0
36	10+3	9+5	11+1
37	10+4	9+6	11+1
38	10+4	10+0	11+2
39	10+5	10+0	11+3
40	10+6	10+1	11+3
41	10+6	10+2	11+4
42	11+0	10+2	11+5
43	11+0	10+3	11+5
44	11+1	10+3	11+6
45	11+2	10+4	11+6
46	11+2	10+5	12+0
47	11+3	10+5	12+1
48	11+4	10+6	12+1
49	11+4	10+6	12+2
50	11+5	11+0	12+2
51	11+5	11+1	12+3
52	11+6	11+1	12+4
53	11+6	11+2	12+4
54	12+0	11+2	12+5
55	12+1	11+3	12+5
56	12+1	11+3	12+6
57	12+2	11+4	12+6
58	12+2	11+4	13+0
59	12+3	11+5	13+0
60	12+3	11+6	13+1
61	12+4	11+6	13+1
62	12+4	12+0	13+2
63	12+5	12+0	13+3
64	12+5	12+1	13+3
65	12+6	12+1	13+4
66	12+6	12+2	13+4
67	13+0	12+2	13+5
68	13+0	12+3	13+5
69	13+1	12+3	13+6
70	13+1	12+4	13+6
71	13+2	12+4	14+0
72	13+2	12+5	14+0
73	13+3	12+5	14+0
74	13+3	12+6	14+1
75	13+4	12+6	14+1
76	13+4	13+0	14+2
77	13+5	13+0	14+2
78	13+5	13+0	14+3
79	13+6	13+1	14+3
80	13+6	13+1	14+4

Appendix 2

Table 2. Head circumference dating table: calculated from outer to outer BPD and OFD measurements (after Altman & Chitty).[2]

Head circumference (mm)	GA (weeks + days) 50th centile	5th centile	95th centile
80	12 + 4	11 + 3	13 + 5
85	12 + 6	11 + 6	14 + 1
90	13 + 2	12 + 2	14 + 4
95	13 + 5	12 + 4	15 + 0
100	14 + 1	13 + 0	15 + 3
105	14 + 4	13 + 3	15 + 5
110	15 + 0	13 + 6	16 + 1
115	15 + 3	14 + 2	16 + 4
120	15 + 6	14 + 5	17 + 0
125	16 + 2	15 + 1	17 + 3
130	16 + 4	15 + 4	17 + 6
135	17 + 0	15 + 6	18 + 2
140	17 + 3	16 + 2	18 + 5
145	17 + 6	16 + 5	19 + 1
150	18 + 2	17 + 1	19 + 3
155	18 + 5	17 + 4	19 + 6
160	19 + 1	17 + 6	20 + 2
165	19 + 3	18 + 2	20 + 5
170	19 + 6	18 + 5	21 + 1
175	20 + 2	19 + 1	21 + 4
180	20 + 5	19 + 3	22 + 0
185	21 + 1	19 + 6	22 + 3
190	21 + 4	20 + 2	22 + 6
195	22 + 0	20 + 4	23 + 2
200	22 + 2	21 + 0	23 + 5
205	22 + 5	21 + 3	24 + 2
210	23 + 1	21 + 5	24 + 5
215	23 + 4	22 + 1	25 + 1
220	24 + 0	22 + 4	25 + 5
225	24 + 3	22 + 6	26 + 1
230	24 + 6	23 + 2	26 + 5
235	25 + 3	23 + 5	27 + 1
240	25 + 6	24 + 1	27 + 5
245	26 + 2	24 + 3	28 + 2
250	26 + 5	24 + 6	28 + 6
255	27 + 2	25 + 2	29 + 3
260	27 + 5	25 + 5	30 + 0
265	28 + 2	26 + 1	30 + 4
270	28 + 6	26 + 4	31 + 2
275	29 + 3	27 + 0	32 + 0
280	30 + 0	27 + 3	32 + 4
285	30 + 4	27 + 6	33 + 3
290	31 + 1	28 + 3	34 + 1
295	31 + 5	28 + 6	35 + 0
300	32 + 3	29 + 3	35 + 6
305	33 + 1	30 + 0	36 + 5
310	33 + 6	30 + 3	37 + 4
315	34 + 4	31 + 0	38 + 4
320	35 + 3	31 + 5	39 + 4

Appendix 3

Table 3. Femur length dating table (after Altman & Chitty).[2]

| Femur length (mm)	GA (weeks + days) 50th centile	5th centile	95th centile
10	13 + 0	12 + 1	13 + 6
11	13 + 2	12 + 3	14 + 1
12	13 + 4	12 + 5	14 + 4
13	13 + 6	13 + 0	14 + 6
14	14 + 1	13 + 1	15 + 1
15	14 + 3	13 + 3	15 + 3
16	14 + 5	13 + 5	15 + 6
17	15 + 0	14 + 0	16 + 1
18	15 + 2	14 + 2	16 + 3
19	15 + 5	14 + 4	16 + 6
20	16 + 0	14 + 6	17 + 1
21	16 + 2	15 + 1	17 + 3
22	16 + 4	15 + 3	17 + 6
23	16 + 6	15 + 5	18 + 1
24	17 + 2	16 + 0	18 + 4
25	17 + 4	16 + 2	18 + 6
26	17 + 6	16 + 4	19 + 2
27	18 + 2	16 + 6	19 + 5
28	18 + 4	17 + 1	20 + 0
29	18 + 6	17 + 4	20 + 3
30	19 + 2	17 + 6	20 + 5
31	19 + 4	18 + 1	21 + 1
32	20 + 0	18 + 3	21 + 4
33	20 + 2	18 + 5	22 + 0
34	20 + 5	19 + 1	22 + 2
35	21 + 0	19 + 3	22 + 5
36	21 + 3	19 + 5	23 + 1
37	21 + 5	20 + 1	32 + 4
38	22 + 1	20 + 3	24 + 0
39	22 + 4	20 + 5	24 + 3
40	22 + 6	21 + 1	24 + 6
41	23 + 2	21 + 3	25 + 2
42	23 + 5	21 + 6	25 + 5
43	24 + 1	22 + 1	26 + 1
44	24 + 3	22 + 4	26 + 4
45	24 + 6	22 + 6	27 + 1
46	25 + 2	23 + 2	27 + 4
47	25 + 5	23 + 4	28 + 0
48	26 + 1	24 + 0	28 + 3
49	26 + 4	24 + 3	29 + 0
50	27 + 0	24 + 5	29 + 3
51	27 + 3	25 + 1	30 + 0
52	27 + 6	25 + 4	30 + 3
53	28 + 2	26 + 0	31 + 0
54	28 + 5	26 + 2	31 + 3
55	29 + 2	26 + 5	32 + 0
56	29 + 5	27 + 1	32 + 3
57	30 + 1	27 + 4	33 + 0
58	30 + 4	28 + 0	33 + 4
59	31 + 1	28 + 3	34 + 1
60	31 + 4	28 + 6	34 + 4
61	32 + 1	29 + 2	35 + 1
62	32 + 4	29 + 5	35 + 5
63	33 + 1	30 + 1	36 + 2
64	33 + 4	30 + 4	36 + 6
65	34 + 1	31 + 0	37 + 3
66	34 + 4	31 + 3	38 + 0
67	35 + 1	32 + 0	38 + 5

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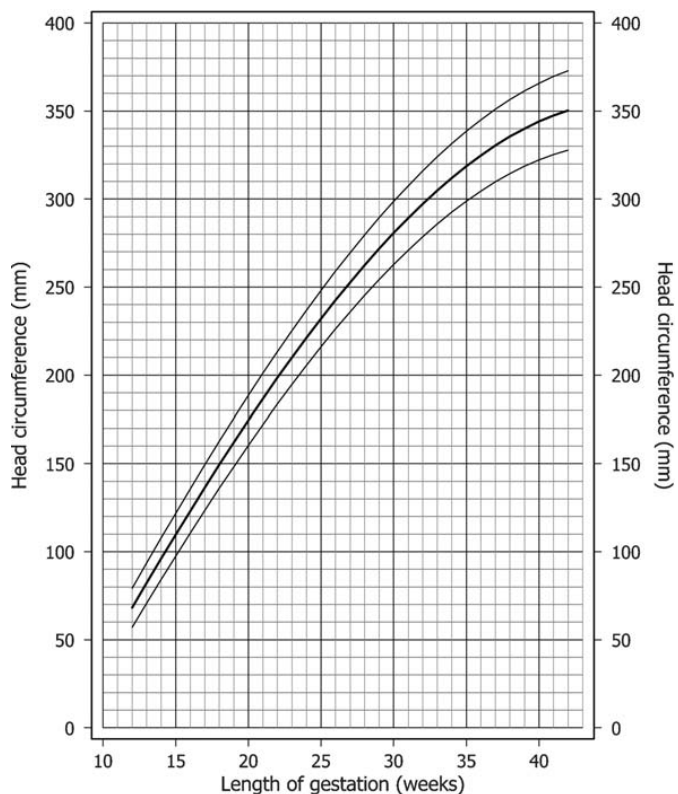
Appendix 4

Figure 5. Head circumference size chart (after Chitty *et al.*).[4]
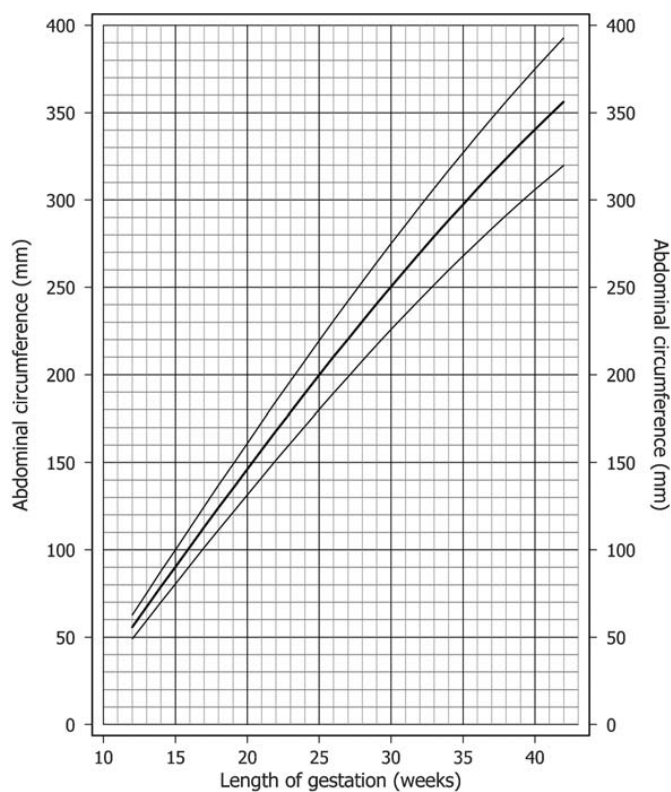
Appendix 5

Figure 6. Abdominal circumference size chart (after Chitty *et al.*).[5]

Table 4. Head circumference size table (after Chitty *et al.*).[4]

| GA (weeks) | Head circumference (mm) | | |
	50th centile	5th centile	95th centile
12	68·1	57·1	79·2
13	82·2	70·8	93·6
14	96·0	84·2	107·8
15	109·7	97·5	121·9
16	123·1	110·6	135·7
17	136·4	123·4	149·3
18	149·3	136·0	162·7
19	162·0	148·3	175·7
20	174·5	160·4	188·6
21	186·6	172·1	201·1
22	198·5	183·6	213·3
23	210·0	194·8	225·3
24	221·2	205·6	236·9
25	232·1	216·1	248·1
26	242·6	226·2	259·0
27	252·7	235·9	269·5
28	262·5	245·3	279·6
29	271·8	254·3	289·4
30	280·7	262·8	298·7
31	289·2	270·9	307·6
32	297·3	278·6	316·0
33	304·9	285·8	324·0
34	312·0	292·6	331·5
35	318·7	298·8	338·5
36	324·8	304·6	345·0
37	330·4	309·8	351·0
38	335·5	314·5	356·5
39	340·0	318·7	361·4
40	344·0	322·3	365·8
41	347·4	325·3	369·6
42	350·3	327·7	372·8

Table 5. Abdominal circumference size table (after Chitty *et al.*).[5]

| GA (weeks) | Abdominal circumference (mm) | | |
	50th centile	5th centile	95th centile
12	55·8	49·0	62·6
13	67·4	59·6	75·2
14	78·9	70·1	87·7
15	90·3	80·5	100·1
16	101·6	90·9	112·4
17	112·9	101·1	124·7
18	124·1	111·3	136·9
19	135·2	121·5	149·0
20	146·2	131·5	161·0
21	157·1	141·4	172·9
22	168·0	151·3	184·7
23	178·7	161·0	196·4
24	189·3	170·6	208·0
25	199·8	180·1	219·5
26	210·2	189·5	230·8
27	220·4	198·8	242·1
28	230·6	207·9	253·2
29	240·5	216·9	264·2
30	250·4	225·8	275·0
31	260·1	234·5	285·7
32	269·7	243·1	296·3
33	279·1	251·5	306·7
34	288·4	259·8	317·0
35	297·5	267·9	327·0
36	306·4	275·8	337·0
37	315·1	283·6	346·7
38	323·7	291·2	356·3
39	332·1	298·6	365·7
40	340·4	305·8	374·9
41	348·4	312·9	383·9
42	356·2	319·7	392·7

Appendix 6
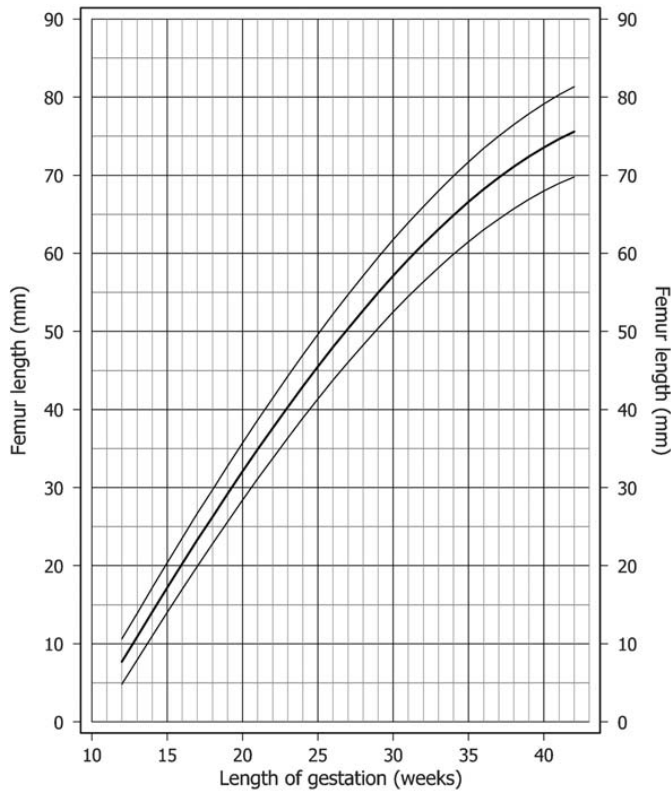
Figure 7. Femur length size chart (after Chitty *et al.*).[6]

Table 6. Femur length size table (after Chitty *et al.*).[6]

GA (weeks)	Femur length (mm) 50th centile	5th centile	95th centile
12	7·7	4·8	10·6
13	10·9	7·9	13·9
14	14·1	11·0	17·2
15	17·2	14·0	20·4
16	20·3	17·0	23·6
17	23·3	19·9	26·7
18	26·3	22·8	29·7
19	29·2	25·6	32·8
20	32·1	28·4	35·7
21	34·9	31·1	38·6
22	37·6	33·8	41·5
23	40·3	36·4	44·3
24	42·9	38·9	47·0
25	45·5	41·4	49·6
26	48·0	43·7	52·2
27	50·4	46·0	54·7
28	52·7	48·3	57·1
29	55·0	50·4	59·5
30	57·1	52·5	61·7
31	59·2	54·5	63·9
32	61·2	56·4	66·0
33	63·1	58·2	68·0
34	64·9	59·9	69·9
35	66·6	61·5	71·7
36	68·2	63·0	73·4
37	69·7	64·4	75·0
38	71·1	65·7	76·5
39	72·4	66·9	77·9
40	73·6	68·0	79·1
41	74·6	68·9	80·3
42	75·6	69·8	81·3