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The In Utero and in the Postnatal Period Growth in Human Newborns

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Abstract

We made an analysis of several published curves concerning the human fetal and postnatal growth assessed by the three classical parameters including their velocity changes: the body weight, the length and the head circumference. The called fetal curves have a diagnostic purpose on the normality of growth during the fetal life. They derived from measurements go from 25 to 42 weeks. Among these diagnostic charts, the best from a mathematical and statistical points of views is the one of publishes by "Dombrowski". Several other analyzed fetal curves may be criticized for not meeting all the criteria of a statistical normal population, mainly concerning the body weight. The called combined fetal and postnatal curves go from 25 to 60 weeks. They allow to make an appreciation of the normal of postnatal growth; they take into account the interruption of fetal life and the adaptation of growth for the priority of growth follows a different vector in this type of situations. Among these combined charts, the "Gairdner" and "Battisti" meet the criteria for all parameters. The analysis of velocity (their variability over time) of the different parameters of growth considered individually or as ratios between them has also been useful. The clinician having in care fragile neonates (those born before 30 weeks or below 1000g or those combining a prematurity and a fetal growth restriction) has an important task. It is to offer the best nutrition to them and to see if their growth is optimal as this can be important for the future. The clinician needs hence to plot longitudinally, on an appropriate curve , the three parameters of growth (body weight, length and head circumference). That should be done on a combined chart instead diagnostic curve. On the other hand, a reliable ratio emerged has a highly correlated index to optimal growth, and it can be used from 25 to 60 weeks of post-conceptional age (PCA) :

d BW g/d HC cm = 44 PCA – 1138 ($r = 0.973$, $p < 0.00001$). By using that formula derived by two important and easy parameters (the body weight and the head circumference), on can appreciate the adequacy of growth whatever the considered moment in that period of life.

Keywords: Fetal growth; Prematurity; Nutrition; Postnatal growth

Introduction

Growth in general, and even more when it concerns a fragile neonate or child, is an important and constant aspect of care for the family and for the medical staff [1-9]. Growth is made of different dimensions, not having the same priority at a given time [1-16]. A compromised growth during special periods can be associated or followed by an abnormal development [4,12-37]. The most frequently used parameters for assessing growth are:

i. the body weight and length, the circumferences of head and (left) arm, the skin folds; these are ***the absolute indices*** ;

ii. there are also ***the relative indices*** such as the ponderal index, the body mass or Quetelet's index: they are the ratios among different parameters. These indices have the purpose to assess the harmony of growth.

iii. ***the velocity indices*** have the purpose to assess the variability over a period of time of a given parameter, and hence to appreciate the influence of nutritional or endocrine factors.

The present work makes the analysis of the different growth charts concerning the fetal, neonatal and postneonatal periods. It aims to bring to the clinician pragmatic tools to appreciate the adequacy of nutrition and the longitudinal growth of the most fragile newborns: those born before 30 weeks, those having a body weight below 1000 g, those combining a prematurity and retarded intrauterine growth. For these situations are being questionable at least during the hospital period till 60 weeks post conceptional age or PCA [12-37]. Concerning these populations, the simple questions « which curve, what parameters of growth should be chosen?» may become complex (35b).

Population, Methods and Statistics

The growth charts

It is not possible to retain all the till now published charts. Some are even updated owing different social and demographic factors [18,27-56]. One has to make the following ***classification between the curves***.

1. In the real fetal curves, measurements are done during intra-uterine life by ultrasounds methods [12,41,50,56].

2. In so called fetal or diagnostic curves , measurements are done as soon as possible at birth in babies born at differents gestational ages, these being gathered in progression of gestational age classes:«Lubchenco», «Usher-Mclean», «Babson» and «Dombrowski» curves are some examples of these.

3. In the combined charts, the populations are comprising the same babies measured at birth and also during their postnatal period extended to 60 weeks post conceptional age:«Dunn», «Gairdner», «Cope» et«Battisti» curves are representative of these.

The classical longitudinal curves starting at term after a normal fetal life are not valuable owing to the intervention of prematurity [4,6,7]. The combined charts take into account:

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- The spontaneous evolution following the already in utero began growth's trajectoire,
- The «placental fatigue» normally observed at the end of a normal pregnancy: this phenomenon is actually explained by the placental fibrosis and the relative restrained intrauterine space or volume. This last aspect explains the flattened shape of curves observed at the end of fetal life.

That «natural fetal programme» is then relayed by the baby own neuroendocrine mechanisms allowing him or her to be followed by the definitve line expressed by centiles or standard deviations of mean values, and usually observed at 4-6 months after term [4,6,7,9].

In the postnatal curves, growth is evaluated in a longitudinal way: that is by plotting during time the consecutive increments of the different dimensions, most often during the hospital stay [10,19,27,34,44,50,51], either for singletons, or twins or even triplets, or taking into account a special starting point such as a body weight < 1000g or a gestational age < 30 weeks. Most complete data are however being found in "Babson", "Battisti", "Dombrowski", "Gairdner", "Lubchenco" and "Usher-Mclean" works. For that reason, those charts have thoroughly been analysed.

Considered items in the analysis are: the statistical normality of the population, the body weight and length, the head circumference, the arm circumference, the weekly gains in those parameters in dividing the babies' lives in multiple periods, also the relative gains (obtained ratios) in weight over length or over head circumference, the mathematical correlations of the different indices with gestational ages.

The statistical calculation: of data providing the results of median, mean and mode values, the results of (simple and multiple) regression coefficients and of variations coefficients, and the sample volume for population follows the appropriate recommendations [57,58].

Results

Analysis of normality of populations presented in the different works

All the described curves have a sufficient sample to reach the statistical significance.

A population can be considered as normal from a statistical point of view if median = mean = mode. Moreover, the coefficient of variation of a given parameter has to be comprised between 4 and 18 %.

In Table 1, one can find for the different parameters in every populations the coefficients of variation (CV in %), which is the ratio of the standard deviation over the mean times 100. The CV is given for each parameter: body weight (BW), length (BL) and head circumference (HC). As far as BW is concerned, one can see that normality of population is not found for «Lubchenco» and «Usher-Mclean». Those for «Gairdner» are limit. The greatest variations are found in «Lubchenco».

- Among the so called fetal (and hence diagnostic) curves, the best one from a statistical point of view is «Dombrowski».
- Among the combined curves, both are equivalent for the 3 considered parameters, and the values reach the statistical requirements.

Analysis of the correlations between the different parameters of growth and the gestational age

The mathematical analysis of data in different curves is obviously fastidious. However, that gives the possibility to build up the formulas with the correlation (r) and determination (r2) coefficients between the different parameters of growth and the gestational age given in Table 2 [57,58]. These coefficients have elevated values (0.98 à 0.99), traducing a very high association force between the parameters and the PCA.

The original data and curves can be found in the respective references.

Author(s), year(s)	Intervals in weeks , parameters	CV : BW	CV : BL	CV : HC
Babson, 1970,1976	26-42 ; 26-92 ; BW,BL,HC	14	8	9
Battisti, 1992	25-60 ; BW,BL,HC,PI	13	7	6
Dombrowski	1992, 26-42 ; BW,BL,HC	13	5.3	4
Gairdner 1971	26-60 ; BW,BL,HC	17	4.4	4
Lubchenco 1966, 1970	26-42 ; BW,BL,HC, PI	22	11	10
Usher-McLean 1969	25-44 ; BW,BL,HC	26	8	6

Table 1: Analysis of the coefficients of variation (CV) for the 3 parameters of growth: body weight (BW), length (BL).

Author	PCA and BW	PCA and BL	PCA and HC
Babson *	BW= 176 PCA – 3696, SD = 2401 ; r = . 99	BL = 0.8 PCA + 17.5, SD = 10.8 ; r = . 99	HC= 0.48 PCA + 14, SD = 6.63 ; r = . 98
Battisti *	=174 APC – 3665, SD = 434 ; r = .99	= 0.9 APC + 11.5, SD = 4; r= . 99	= 0.6 APC + 9.72, SD = 2.4 ; r= . 98
Dombrowski *	= 174 APC – 3732, SD = 1262; r=.99	= 1.06 APC + 6.64, SD = 7.8; r=. 99	= 0.721 APC + 5.3, SD = 5.3; r = . 98
Gairdner *	= 206 APC – 5051, SD = 2672; r = . 98	= 0.89 APC +13.6, SD = 13; r =. 99	= 0.5 APC + 13.94, SD = 6.5; r = . 98
Lubchenco *	= 163 APC – 3375, SD = 1303; r =. 99	= 1.25 APC + 2.5, SD = 7.1; r =. 99	= 0.58 APC + 10.5, DS = 4.8; r =. 97
Usher-McLean *	= 177 APC – 3741, SD = 1350; r =. 99	T= 1.11 APC +7, SD = 8.35; r =. 99	= 0.81 APC + 3.1, SD = 6.2; r=.99

* the original data can be found in the respective references.

Table 2: Mathematical correlations between PCA and parameters of growth in the differents charts.

Périods in weeks	d BW g	d BL cm	d HC cm	dBWg/dBLcm	dBWg/dHCcm	dBLcm/dHCcm
26-28	115 (70- 160)	1 (.85-1.15)	1.1 (0.9 -1 .2)	115 (35-115)	110 (100-133)	0.9 (0.95-1)
28-30	145 (100- 190)	1.13 (0.63-1.63)	0.9 (0.7 – 1.3)	125 (90-160)	164 (115-213)	1.34 (0.44-2.24)
30-32	170 (108-232)	1.2 (.94– 1.54)	0.7 (0.7-1.3)	182 (86-288)	242 (117-376)	1.35 (0.9-1.79)
32-34	208 (148-268)	1.23 (.94- 1.54)	0.8 (0.65-0.95)	178 (70-286)	253 (153-353)	1.56 (0.97-2.15)
34-36	242 (167-317)	1 (0.6 – 1.4)	0.7 (0.15-0.9)	272 (174-370)	392 (184-600)	1.5 (1.1-2.5)
36-38	213 (129 – 297)	0.8 (0.3 – 1.3)	0.5 (0.2-0.8)	273 (166-380)	459 (87-731)	1.8 (1.1-2.5)
38-40	143 (43-243)	0.7 (0.1 – 1.3)	0.33 (0.13-0.53)	310 (0- 645)	621 (0-1321)	2.4 (0.5-0.34)
40-42	70 (0 – 168)	0.25 (0 – 0.6)	0.17 (0 – 0.48)	280 (0 – 583)	420 (0 – 400)	1.47 (0- 1.25)
Mean	170 (57 – 283)	0.9 (.15 – 1.65)	0.6 (0.04-1.1)	223 (82-366)	355 (14-686)	1.66 (0.88 – 2.44)

Table 3: Analysis of velocities (weekly increments) for BW, BL and HC, and also the relative indices of them (data with their mean and 95 % confidence intervals values).

All these associations can be compared to each other with a very good reliability as the standard deviations are comprised between 6 and 8 % of variation. The following formulas resume the associative relationshipsand may be use in either senses: predicting the value of a parameter of growth according to a given post-conceptional age or vice versa.

Weight in g = 175 PCA weeks – 3665 (SD = 13 %)

Length in cm = PCA weeks + 11 (SD = 8 %)

HC in cm = 0.6 PCA weeks + 10 (SD = 6 %)

Analysis of the weekly increments by the 3 parameters of growth during the different periods of post-conceptional age

In this point, the different curves are examined one by one during the different «slices» of PCA. Each parameter of growth, in their absolute relative values are being considered in their increments for the corresponding periods.

Concerning the absolute values: the gains for weight are highest for the 34-36 weeks period; for length, this is for the 32-34 weeks period; and for head circumference, that is for the 28-30 weeks period. It is even only after that last period that length increment is trepassing the HC increment. The always more increasing influence of insulin and the so called "placental fatigue" on the other hand can explain these different profiles [2-4,8,12-14,73].

Concerning the relative values: one can observe that the highest values are found at the end of pregnancy. The disparity of body growth over head growth is obvious after 34 weeks, and over length that is obvious after 36 weeks. The significant correlations among the relative values of growth's parameters are found solely for the following ratios:

- [d W g / d HC cm] per week = 44 PCA – 1138, SD = 13 %, r = 0.973;
- [d L cm / d HC cm] per week = 0.094 PCA – 1.543, SD 14 %, r = 0.88;

On a clinical point of view, the strongest correlation is found when increment in weight is related to increment in HC, which is practical as these parameters are more easy to obtain than the length, even if

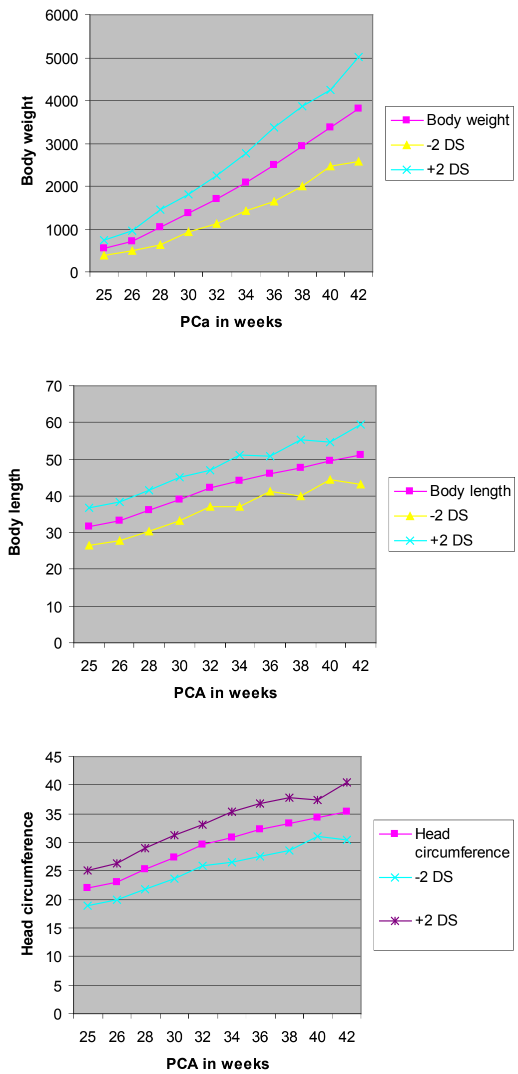

Figure 1: DOMBROWSKI chart: « PCA in weeks, BW in g, BL in cm, and Hc in.

that last parameter has very important value for appreciating «growth» [4,6,7].

Discussion

The normal growth during any time of life has always been important for the clinician. A ***«normal» growth*** is defined by the presence of parameters being comprised in normal values and presenting a sort of harmony between them. Normality is however differently defined among the existing charts: the mean values +/- 2 standard deviations, the centiles (from the 3 or 10th to the 97 or 90th centile, the mean values and the 90 or 95th confidence intervals. On the other hand, a growth is said to be ***abnormal*** if the parameters are insufficient or excessive in their absolute values, or if either their velocities are outside the normal values. The conditions leading to a normal growth allow to reduce:

- the complications due to hypoxia in utero, or birth asphyxia;
- and also the mortalities or morbidities following a prematurity, an abnormal growth.

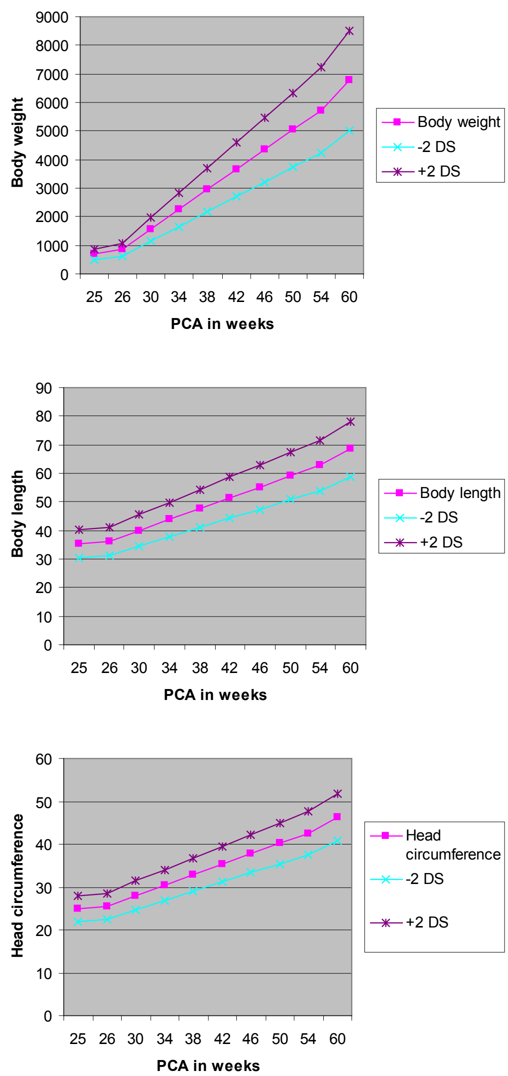

Figure 2: BATTISTI chart: « PCA in weeks, BW in g, BL in cm, and HC in cm.

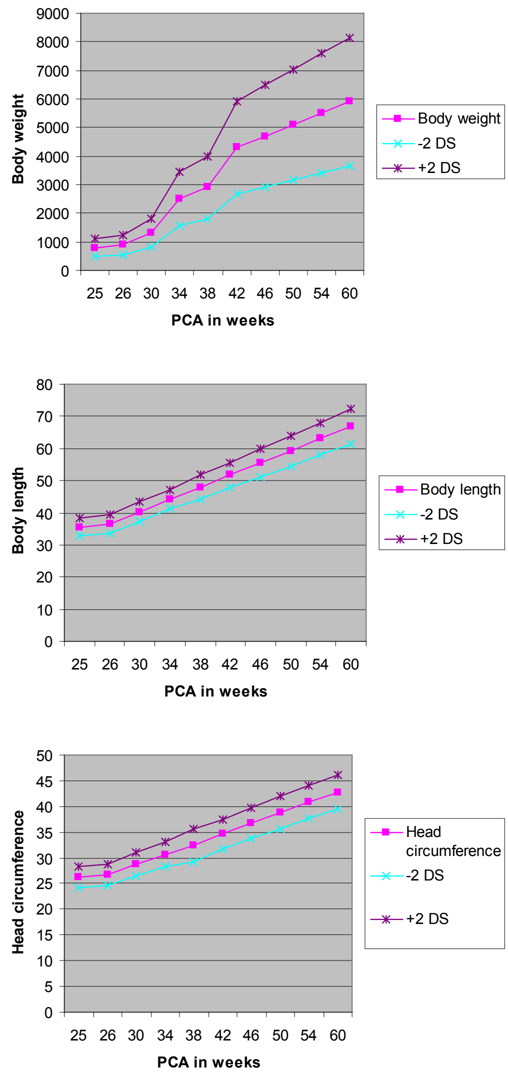

Figure 3: GAIRDNER chart: « PCA in weeks, BW in g, BL in cm, and HC in cm.

At the end, the most fragile babies being those born with a birth weight below 1000g or below 30 weeks. And also those combining a prematurity and growth retardation [2-5,8,9,14].

The body weight is the easiest parameter to obtain. It is supposed to resume growth in all its dimensions: the cerebral mass (14-15 % of BW), the lentgh (the bones represent 35- 40 % BW) and the soft tissues (the skeletal muscles: 20-25 % BW, the skin and its annexes: 15 % BW, the white adipose tissue: 2 % BW at 28 weeks and 14 % BW at term [4,8,11]. The body weight remains a major parameter, but other (mainly the HC) might have priority. And that is obvious in cases of intrauterine of postnatal growth retardation. For these reasons, it would be better to use charts satisfying the statistical parameters for normality of populations in the different parameters. What the BW is concerned, the «Lubchenco» and«Usher-Mclean» are questionable. The «Babson», «Dombrowski», «Gairdner» et «Battisti» respond to the statistical criteria of normality concerning the 3 parameters. Moreover, the last two charts remain valuable till 60 weeks PCA and hence should perhaps more used in the neonatal units, and also during the 5 months after term. That can avoid the need to «correct» for prematurity the postnatal growth. The «Dunn» chart has values only for the BW. The first two charts («Babson» and «Dombrowski») should be used for a diagnostic purpose at birth. These type of charts do not offer the predictive correction due to noticeable changes observed during th first 2 weeks following birth (as it can be done by other type of charts: see «Dancis» for BW and «Gross» for HC).

The ponderal index and body mass index, even if criticized in the literature, have a real value after 34 weeks PCA for PI and after 36 weeks for BMI [4,8,73]. They should be used solely for diagnostic purpose at birth. The relative indices are clearly show different values during fetal life (Table 2).

In the specific situation of a fragile neonate, it is important for the clinician to have the possibility to appreciate the adequacy between the weekly observed growth and offered nutrition either by parenteral or enteral routes. The importance of nutrition in its quality, quantity an rapidity for an optimal long term development have extensively been studied [3,4,5,8,10,13,15,16,17,18-26,50,55,59-73].

In order to obtain that, it is important to plot the observed weekly increments for the parameters of growth on an appropriate chart. However, and as it is not always easy to get all the parameters, one may use two parameters of growth (BW and HC) which are combined in the following mathematical formula:

dBW in g / d HC cm = 44 PCA weeks – 1138 (SD = 13 %, r = 0.973, $p < 0.0001$

It allows two precise conclusions or predictions:

- If PCA is known, it can appreciate the adequacy of weekly growth. For examples: at 34 PCA weeks, 1 cm of gain in HC must be accompanied of a gain in BW of 358 g and vice versa; at 28 PCA weeks, these numbers are 94 g BW, and 422 g BW at term.
- If PCA is not known, it can predict the PCA from the observed ratio [d BW / d HC].

Conclusions

The neonatal growth's charts for a diagnostic purpose are not equivalent, mainly concerning the body weight. The combined growth's charts should instead be used to appreciate the postnatal growth of a prematurely neonate, and that till 20 weeks or 5 months after term.

Globally, the growth has to be appreciated by following several parameters, either by plotting them individually on a appropriate chart, either by using a relative index (a ratio between two parameters) which takes into account the variability over time of body weight and head circumference.

References

1. Dancis J, O'connell Jr, Holt Le Jr (1948) A grid for recording the weight of premature infants. J Pediatr 33: 570-572.
2. Godwin JW, Godden JO, Chance GW (1976) Perinatal medicine, Longman, Toronto.
3. Smith CA, Nelson NM (1976) The physiology of the newborn. Charles C Thomas Publisher, Springfield-Illinois.
4. Falkner F, Tanner JM (1978) Human growth (2 volumes). Baillère Tindall.
5. Sinclair JC (1978) Temperature regulation and energy metabolism in the newborn. Monographs in Neonatology. Grune-Stratton, New-York.
6. Tanner JM (1978) Foetus into man. Open Books, London.
7. Tanner JM, Preece MA (1989) The physiology of human growth. Cambridge University Press.
8. Davis JA, Dobbing J (1981) Scientific foundations of Paediatrics. Heinemann, London.
9. Polin RA, Fox WW (1992) Feta land neonatal physiology (2 volumes). WB Saunders Company.
10. Battisti O (1990) La croissance du prématuré en alimentation entérale: effets de la diète et du satus pondéral à la naissance. Prix Nestlé.
11. Battisti O (1998) Les fondements de la nutrition durant la période fœtale et néonatale. Nutrition in the VLBW infants, XVI Annual meeting of neonatalogy; Rocourt.
12. Miller HC, Merritt TA (1979) Fetal growth in humans. Year Book Medical Publishers, Chicago.
13. Monset-Couchard M, Minkowski A (1981) Physiological and biochemical basis for perinatal medicine. S Karger, Basel.
14. Harding R, Bocking AD (2001) Fetal growth and development. Cambridge University Press.
15. Jonxis JHP (1978) Growth and development of the full-term and premature infant., Excerpta Medica, Amsterdam.
16. Dobbing J, Sands J (1973) Quantitative growth and development of human brain. Arch Dis Child 48: 757-767.
17. Kirschbaum TH (1984) Intrauterine growth retardation. Seminars in Perinatol, 8: 1-72.
18. Babson SG, Henderson NB (1974) Fetal undergrowth: relation of head growth to later intellectual performance. Pediatrics 53: 890-894.
19. Gross SJ, Kosmetatos N, Grimes CT, Williams ML (1978) Newborn head size and neurological status. Predictors of growth and development of low birth weight infants. Am J Dis Child 132: 753-756.
20. Gross SJ, Oehler JM, Eckerman CO (1983) Head growth and developmental outcome in very low-birth-weight infants. Pediatrics 71: 70-75.
21. Lucas A (1987) Does diet in preterm infants influence clinical outcome? Biol Neonate 52 Suppl 1: 141-146.
22. Brennan TL, Funk SG, Frothingham TE (1985) Disproportionate intra-uterine head growth and developmental outcome. Dev Med Child Neurol 27: 746-750.
23. Clark RH, Thomas P, Peabody J (2003) Extrauterine growth restriction remains a serious problem in prematurely born neonates. Pediatrics 111: 986-990.
24. Lucas A, Morley R, Cole TJ, Gore SM, Lucas PJ, et al. (1990) Early diet in preterm babies and developmental status at 18 months. Lancet 335: 1477-1481.
25. Lucas A, Gore SM, Cole TJ, Bamford MF, Dossetor JF, et al. (1984) Multicentre trial on feeding low birthweight infants: effects of diet on early growth. Arch Dis Child 59: 722-730.
26. Georgieff MK, Hoffman JS, Pereira GR, Bernbaum J, Hoffman-Williamson M (1985) Effect of neonatal caloric deprivation on head growth and 1-year developmental status in preterm infants. J Pediatr 107: 581-587.
27. Lubchenco L, Hansman C, Boyd E (1966) Intrauterine growth in length and head circumference as estimated from live births at gestational ages from 26 to 42 weeks. Pediatrics 37: 403-408.
28. Usher R, McLean F (1969) Intrauterine growth of live-born Caucasian infants at sea level: standards obtained from measurements in 7 dimensions of infants born between 25 and 44 weeks of gestation. J Pediatr 74: 901-910.
29. Babson SG (1970) Growth of low-birth-weight infants. J Pediatr 77: 11-18.
30. Gairdner D, Pearson J (1971) A growth chart for premature and other infants. Arch Dis Child 46: 783-787.
31. Babson SG, Benda GI (1976) Growth graphs for the clinical assessment of infants of varying gestational age. J Pediatr 89: 814-820.
32. Largo RH, Wälli R, Duc G, Fanconi A, Prader A (1980) Evaluation of perinatal

growth. Presentation of combined intra- and extrauterine growth standards for weight, length and head circumference. Helv Paediatr Acta 35: 419-436.

33. Wilcox AJ (1981) Birth weight, gestation, and the fetal growth curve. Am J Obstet Gynecol 139: 863-867.
34. Gross SJ, Eckerman CO (1983) Normative early head growth in very-low-birth-weight infants. J Pediatr 103: 946-949.
35. Dunn PM (1985) A perinatal growth chart for international reference. Acta Paediatr Scand Suppl 319: 180-187.
36. Gill A, Yu VY, Bajuk B, Astbury J (1986) Postnatal growth in infants born before 30 weeks' gestation. Arch Dis Child 61: 549-553.
37. Georgieff MK, Sasanow SR (1986) Nutritional assessment of the neonate. Clin Perinatol 13: 73-89.
38. Battisti O, Swartebroeck Y, Armengol AR, Lamboray AM, Dubois P, et al. (1987) Comparative study of various methods of gestational age assessment at birth. Rev Med Liège 42: 780-785.
39. Bertino E, Milani S, Fabris C, De Curtis M (2007) Neonatal anthropometric charts: what they are, what they are not. Arch Dis Child Fetal Neonatal Ed 92: F7-F10.
40. Cope I (1987) A perinatal growth chart for international reference. Aust N Z J Obstet Gynaecol 27: 45.
41. Larsen T, Petersen S, Greisen G, Larsen JF (1990) Normal fetal growth evaluated by longitudinal ultrasound examinations. Early Hum Dev 24: 37-45.
42. Elster AD, Bleyl JL, Craven TE (1991) Birth weight standards for triplets under modern obstetric care in the United States, 1984-1989. Obstet Gynecol 77: 387-393.
43. Medchill MT, Peterson CM, Kreinick C, Garbaciak J (1991) Prediction of estimated fetal weight in extremely low birth weight neonates (500-1000 g). Obstet Gynecol 78: 286-290.
44. Hata T, Deter RL, Hill RM (1991) Individual growth curve standards in triplets: prediction of third-trimester growth and birth characteristics. Obstet Gynecol 78: 379-384.
45. Dombrowski MP, Wolfe HM, Brans YW, Saleh AA, Sokol RJ (1992) Neonatal morphometry. Relation to obstetric, pediatric, and menstrual estimates of gestational age. Am J Dis Child 146: 852-856.
46. Arbuckle TE, Wilkins R, Sherman GJ (1993) Birth weight percentiles by gestational age in Canada. Obstet Gynecol 81: 39-48.
47. Gardosi J, Chang A, Kalyan B, Sahota D, Symonds EM (1992) Customised antenatal growth charts. Lancet 339: 283-287.
48. Alexander GR, Himes JH, Kaufman RB, Mor J, Kogan M (1996) A United States national reference for fetal growth. Obstet Gynecol 87: 163-168.
49. Royston P, Wright EM (1998) How to construct 'normal ranges' for fetal variables. Ultrasound Obstet Gynecol 11: 30-38.
50. Pauls J, Bauer K, Versmold H (1998) Postnatal body weight curves for infants below 1000 g birth weight receiving early enteral and parenteral nutrition. Eur J Pediatr 157: 416-421.
51. Ehrenkranz RA, Younes N, Lemons JA, Fanaroff AA, Donovan EF, et al. (1999) Longitudinal growth of hospitalized very low birth weight infants. Pediatrics 104: 280-289.
52. Wright CM, Booth IW, Buckler JM, Cameron N, Cole TJ, et al. (2002) Growth reference charts for use in the United Kingdom. Arch Dis Child 86: 11-14.
53. Kramer MS, Morin I, Yang H, Platt RW, Usher R, et al. (2002) Why are babies getting bigger? Temporal trends in fetal growth and its determinants. J Pediatr 141: 538-542.
54. Niklasson A, Engstrom E, Hard AL, Wikland KA, Hellstrom A (2003) Growth in very preterm children: a longitudinal study. Pediatr Res 54: 899-905.
55. Fenton TR (2003) A new growth chart for preterm babies: Babson and Benda's chart updated with recent data and a new format. BMC Pediatr 3: 13.
56. Thame M, Osmond C, Bennett F, Wilks R, Forrester T (2004) Fetal growth is directly related to maternal anthropometry and placental volume. Eur J Clin Nutr 58: 894-900.
57. Hill AB (1977) A short textbook of medical statistics. Unibooks, Hodder and Stoughton, London.
58. Bernard MP, Lapointe C (1987) Mesures statistiques en épidémiologie. Presses Universitaires du Québec, Québec.
59. Atkinson SA, Bryan MH, Anderson GH (1981) Human milk feeding in premature infants: protein, fat, and carbohydrate balances in the first two weeks of life. J Pediatr 99: 617-624.
60. Chessex P, Reichman BL, Verellen GJE, Putet G, Smith JM, et al. (1981) Influence of postnatal age, energy intake, and weight gain on energy metabolism in the very low-birth-weight infant. J Pediatr 99: 761-766.
61. Chessex P, Reichman BL, Verellen GEJ, Putet G, Smith JM, et al. (1981) Relation between heart rate and energy expenditure in the newborn. Pediatr Res 15: 1077-1082.
62. Reichman B, Chessex P, Putet G, Verellen G, Smith JM, et al. (1981) Diet, fat accretion, and growth in premature infants. N Engl J Med 305: 1495-1500.
63. Gross SJ (1983) Growth and biochemical response of preterm infants fed human milk or modified infant formula. N Engl J Med 308: 237-241.
64. Hendrickse WA, Spencer SA, Roberton DM, Hull D (1984) The calorie intake and weight gain of low birth weight infants fed on fresh breast milk or a special formula milk. Eur J Pediatr 143: 49-53.
65. Putet G, Senterre J, Rigo J, Salle B (1984) Nutrient balance, energy utilization, and composition of weight gain in very-low-birth-weight infants fed pooled human milk or a preterm formula. J Pediatr 105: 79-85.
66. Roberts SB, Lucas A (1985) The effects of two extremes of dietary intake on protein accretion in preterm infants. Early Hum Dev 12: 301-307.
67. Micheli JL, Schutz Y (1987) Protein metabolism and postnatal growth in very low birthweight infants. Biol Neonate 52 Suppl 1: 25-40.
68. Lindblad BS (1988) Perinatal nutrition. Academic press.
69. Heird WC, Kashyap S (1989) Protein and energy requirements of low birth weight infants. Acta Paediatr Scand Suppl 351: 13-23.
70. Beaufrere B, Putet G, Pachiaudi C, Salle B (1990) Whole body protein turnover measured with 13C-leucine and energy expenditure in preterm infants. Pediatr Res 28: 147-152.
71. Tsang RC, Lucas A, Gauy R, Zlotkin S (1993) Nutritional needs of the preterm infant. Williams Wilkins.
72. Räihä NC (1994) Protein metabolism during pregnancy. Raven Press.
73. Battaglia FC (1997) Placental function and fetal nutrition. Lippincott-Raven.