Anais da Academia Brasileira de Ciências (2011) 83(2): 619-625
(Annals of the Brazilian Academy of Sciences)
Printed version ISSN 0001-3765 / Online version ISSN 1678-2690
www.scielo.br/aabc

Birth weight patterns by gestational age in Brazil

CARLOS E. PEDREIRA[1,2], FRANCISCO A. PINTO[3], SILVIA P. PEREIRA[4] and ELAINE S. COSTA[4]

[1]COPPE-PEE/UFRJ, Av. Horácio Macedo, 2030, Prédio do CT, Bloco H, 3° andar, Ilha do Fundão, Cidade Universitária, 21941-914 Rio de Janeiro, RJ, Brasil

[2]Faculdade de Medicina/UFRJ, Av. Carlos Chagas Filho, Prédio do CCS, Bloco K, 2° andar, Ilha do Fundão, Cidade Universitária, 21941-914 Rio de Janeiro, RJ, Brasil

[3]Departamento de Estatística/UFF, Rua Mário Santos Braga s/n, 24020-140 Niterói, RJ, Brasil

[4]Núcleo Transdisciplinar de Investigação em Saúde da Criança, Instituto de Puericultura e Pediatria Martagão Gesteira/UFRJ Rua Bruno Lobo, 50, Ilha do Fundão, Cidade Universitária, 21941-912 Rio de Janeiro, RJ, Brasil

Manuscript received on July 27, 2009; accepted for publication on November 19, 2010

ABSTRACT

Background and objectives. We present an updated birth weight-for-gestational-age portrait, based on nearly 8 million observations of an ethnic-mixed population. It comprises the first comprehensive charts with Brazilian data. This contribution intends to assist clinicians in classifying fetal growth, to provide a reference for investigations of predictors and to show the consequences of small and large patterns for gestational age delivery. Most of the reference data for assessing birth weight for gestational age deal with insufficient sample size, especially at low gestational age. Population-based studies with considerably large sample size refer to data collected more than 15 years ago.
Methods. We accomplished a population-based study on births in all the Brazilian states from 2003 to 2005. Results were based on 7,993,166 singletons. We constructed the 3^{rd}, 5^{th}, 10^{th}, 25^{th}, 50^{th}, 90^{th}, 95^{th} and 97^{th} smoothed percentiles curves and gender-specific tables from 22 to 43 completed weeks.
Results. The resulting tables and graphical representation provide a gender-specific reference to access the birth weights distribution according to the gestational age in the Brazilian population.
Conclusions. This is the first population-based reference constructed on a developing country data. These charts could provide an important tool to improve clinical assessment of growth in newborns.

Key words: birth weight, newborn, gestational age, fetal growth, preterm, postterm.

INTRODUCTION

After Lubchenco's article (Lubchenco et al. 1963) in the sixties, a number of reference data for assessing birth weight for gestational age have been proposed in the literature (Kramer et al. 2001, Zhang and Bowes 1995, Alshimmiri et al. 2004, Bonellie et al. 2008, Alexander et al. 1996, Shin et al. 2005, Skjærven et al. 2000). Most of them refer to developed countries and none of the underdeveloped or developing country studies are population-based. Despite the obvious importance of these contributions, some deal with methodological troubles (Kramer et al. 2001), e.g. non-population-based studies, unisex references and small sample sizes, which is especially critical for low gestational age. In fact, some of these problems derive from intrinsic challenges in constructing birth weight for gestational age charts, e.g. the requirement of population-based studies and the need of reasonable sized samples even for unfrequent events like extreme preterm. Moreover, it should be taken into account that some hardships directly follow from the birth registration documents, which can not be controlled.

In this paper we conducted a study resulting in a gender-specific reference of birth weight for gestational

Correspondence to: Carlos E. Pedreira
E-mail: carlosp@centroin.com.br

age. It was based on a dataset including all newborns in all the Brazilian states between 2003 and 2005. These are the first comprehensive charts with Brazilian data. Currently, most clinical evaluations in Brazil are based on international data. Graphical representations as well as tables for the 3^{rd}, 5^{th}, 10^{th}, 25^{th}, 50^{th}, 90^{th}, 95^{th} and 97^{th} percentiles are displayed. Brazil has a large population and a quite high birth rate, which allows the results to be based on a large sample size. This is particularly relevant for low gestational ages and on the extreme (3^{rd}, 5^{th}, 95^{th} and 97^{th}) percentiles calculation. These percentiles are frequently used as cutoffs to define if newborns are small or large for gestational age. Although formed by a considerably large number of observations, our dataset span for just 3 years, avoiding possible undesirable effects due to birth weight patterns changes in the considered period (Bonellie and Raab 1997, Chike-Obi et al. 1996).

METHODS

For this study, we used data from births in all the Brazilian states from 2003 to 2005 provided by *live birth certificates* supplied by the Brazilian General Health System (SUS). The issue of *live birth certificates* is mandatory in Brazil, and unregistered births are almost inexistent and may accordingly be disregarded. Our results were based on 7,993,166 singleton births (4,093,316 male and 3,899,832 female newborns) after exclusions. Neonates from multiple gestations (n = 169,373) and with major congenital anomalies (n = 53,891) were excluded from the dataset. Registrations with unrecorded major congenital anomalies (817,867), gestational age (79,137), birth weight (52,967) and multiple gestations (15,467) were also eliminated. We also eliminated a few (less than 0.1%) obviously erroneous measurements. Apart from these variables, the dataset also provided information on ethnicity and parity. We decided not to use this information since the physiologic-pathologic nature of ethnic differences in fetal growth is still unclear (Kierans et al. 2008). In the Brazilian birth registration documents, gestational weeks are presented in ranges: less than 22, 22 to 27, 28 to 31, 32 to 36, 37 to 41, and more than 41 weeks.

Gestational age refers to the interval, in completed weeks, between the first day of the mother's last menstrual period (LMP) and the day of delivery. It can also be any estimate of this interval based on ultrasound, a physical examination or other method. Brazilian birth registration manual recommend the use of LMP. Other methods, such as ultrasound estimation and obstetric measures, may have been also used in some cases.

The Brazilian Information System on Live Births (SINASC), implemented in 1990, covers 90% of all births in Brazil. This birth registration system includes all babies born alive, independently of the gestation age. Babies with very low gestational age are not considered to be stillborn. It is worth mentioning that babies with extremely low gestational ages have a survival rate around 50%, reflecting a considerably large net of Neonatal Intensive Care Units to assist extremely premature newborns in Brazil.

We constructed separate curves and tables for male and female newborns for the 3^{rd}, 5^{th}, 10^{th}, 25^{th}, 50^{th}, 90^{th}, 95^{th} and 97^{th} percentiles from 22 to 42 completed weeks based on smoothed estimated curves. The curves and tables were smoothed by a shape-preserving piecewise cubic interpolation method (Fritsch and Carlson 1980, Kahaner et al. 1989) using MATLAB software program (Mathworks, Natick, MA).

The relative percentual differences between previous published charts and the present paper are computed for the 10^{th}, 50^{th} and 90^{th} percentiles using the Brazilian data as reference. Relative percentual differences were calculated as:

$$\text{Relative percentual difference} = \left(\frac{\text{Brazil}_{\text{perc}} - \text{Other}_{\text{perc}}}{\text{Brazil}_{\text{perc}}}\right) \times 100.$$

Here, $\text{Brazil}_{\text{perc}}$ represents the Brazilian percentiles, while $\text{Other}_{\text{perc}}$ are the percentiles published in (Kramer et al. 2001, Zhang and Bowes 1995, Alshimmiri et al. 2004) and (Bonellie et al. 2008).

The institutional ethical research board considered that this study is exempt of approval since the data is publicly available in the Brazilian government site.

RESULTS

In Table I one can find the 3^{rd}, 5^{th}, 10^{th}, 25^{th}, 50^{th}, 90^{th}, 95^{th} and 97^{th} percentiles of birth weights for gestational age for male and female newborns, respectively.

Figure 1 shows the graphical representation of these percentiles.

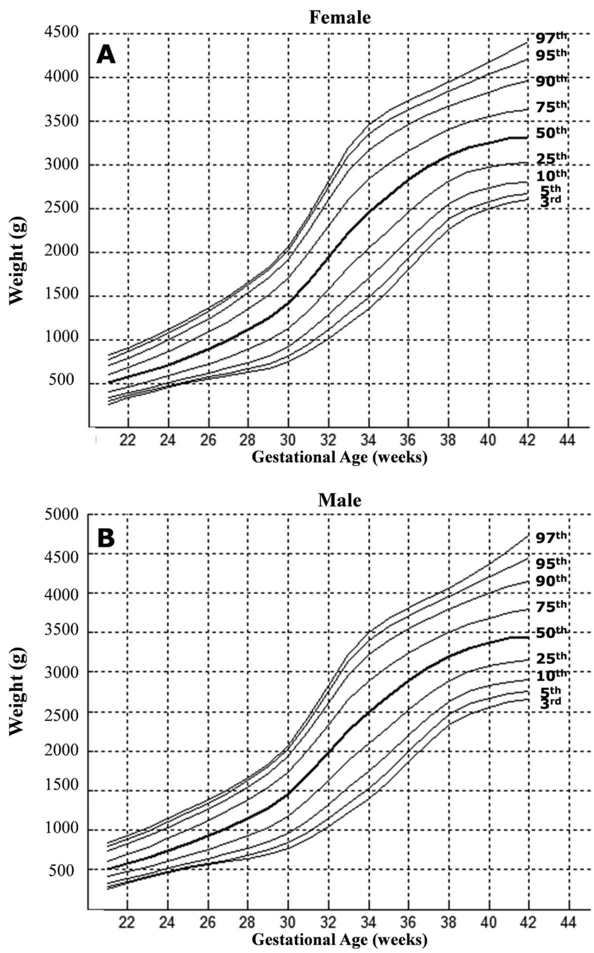

Fig. 1 – Graphical representation of the 3rd, 5th, 10th, 25th, 50th, 75th, 90th, 95th and 97th percentiles for females and males.

In Table II we present a comparative view concerning some design aspects, of the present paper and other different studies. It is worth noting that most of the previous charts was based on developed countries data and that the Brazilian charts were built up with nearly 8 million newborns, more than double the sample size of the largest early studies.

In Table III one may find a comparative tabulation of the relative percentual differences for the 10th, 50th and 90th percentiles, for males, between four previous published charts (Kramer et al. 2001, Alshimmiri et al. 2004, Bonellie et al. 2008, Alexander et al. 1996) and the present paper, used as reference. Negative and positive quantities in Table III reflect that the Brazilian percentiles were, respectively, smaller or larger, in comparison with the other four references. Negative numbers indicate that the percentiles are overestimated in comparison to the Brazilian ones, while positive values means underestimation in relation to present study percentiles. Note that all values are percentual. For instance, the male percentile 90 from Table III for 40 weeks would be overestimated by 4.1% if (Bonellie et al. 2008) reference was used.

Following the way the references are published by different authors, for Bonellie we used the average between nulliparous and multiparous for comparison purpose. Although (Alexander et al. 1996) provide the 10th percentile values for both males and females, the data is not gender-specific for most percentiles, and so the same values were used in Table III.

DISCUSSION

Birth weight for gestational age charts is an essential tool providing relevant information to clinicians regarding which newborns may be at higher risk of neonatal morbidity and subsequent mortality or developmental delay. In this paper we present the first comprehensive charts with Brazilian data.

Table II allows a comparative view of the Brazilian study presented in this paper and some of the published charts. It can be noticed that the only published population-based studies with considerably large sample size refer to data collected more than 15 years ago.

From the ethnic standards point of view, the Brazilian population is a truly melting pot. Accordingly, the present study constitutes a portrait of the birth weight for gestational age of a mixed population based on nearly 8 million observations.

Table III should be viewed with caution since the studies over ethnic and socioeconomic diversities embrace substantial methodological differences among each other. Nevertheless, it is interesting to note that the Brazilian chart produced lower percentiles (negative values in Table III) for the majority of the gestational weeks if compared to (Alexander et al. 1996). Furthermore, the 50th percentile is generally higher for the Brazilian data at very low gestational ages (up to 26th weeks) and lower at term. This may be an indication of poorer survival rates at lower gestations in Brazil.

TABLE I
Birth weight (g) for gestational age, all singletons in Brazilian population 2003 to 2005, smoothed.

Gestational age (weeks)	Percentiles																	
	3rd		5th		10th		25th		50th		75th		90th		93th		97th	
	Male	Fem	Male	Fem	Male	Fem	Male	Fem	Male	Fem	Male	Fem	Male	Fem	Male	Fem	Male	Fem
22	328	331	348	359	388	388	468	457	576	566	690	677	827	786	888	864	926	903
23	400	395	410	417	451	443	532	516	651	633	788	764	925	883	987	964	1029	1002
24	466	453	470	473	517	500	603	581	735	709	894	862	1033	992	1096	1075	1161	1111
25	521	504	528	526	582	559	678	650	826	793	1007	969	1169	1110	1215	1196	1260	1230
26	564	544	579	571	642	616	754	721	922	885	1122	1084	1270	1235	1338	1324	1383	1356
27	601	580	628	613	702	671	836	798	1027	989	1244	1210	1601	1373	1673	1663	1515	1693
28	641	619	683	660	770	735	928	886	1166	1107	1380	1351	1549	1527	1624	1620	1665	1648
29	692	669	750	720	852	816	1037	990	1283	1244	1537	1511	1719	1702	1801	1799	1840	1829
30	768	741	840	804	960	918	1176	1124	1653	1612	1732	1706	1933	1918	2024	2024	2066	2057
31	889	857	978	938	1124	1080	1380	1326	1697	1656	2012	1984	2249	2234	2363	2358	2417	2405
32	1045	1007	1150	1109	1327	1281	1625	1569	1982	1941	2336	2302	2615	2594	2758	2742	2829	2810
33	1221	1177	1340	1298	1543	1697	1876	1819	2265	2222	2647	2604	2962	2930	3130	3099	3218	3187
34	1600	1350	1530	1685	1750	1700	2100	2040	2500	2450	2890	2835	3220	3170	3400	3350	3500	3450
35	1609	1553	1746	1693	1966	1910	2309	2246	2698	2637	3071	3004	3397	3325	3572	3504	3676	3608
36	1860	1796	1997	1933	2205	2160	2524	2459	2888	2816	3234	3156	3548	3456	3713	3630	3815	3733
37	2113	2042	2247	2171	2436	2361	2725	2656	3060	2976	3378	3288	3679	3567	3834	3736	3936	3839
38	2330	2256	2457	2372	2628	2545	2890	2816	3202	3105	3500	3397	3795	3664	3949	3833	4058	3941
39	2470	2400	2590	2500	2750	2660	3000	2910	3300	3190	3600	3480	3900	3750	4070	3930	4200	4050
40	2556	2492	2668	2577	2823	2728	3072	2964	3369	3248	3682	3545	3996	3828	4196	4027	4366	4168
41	2622	2564	2727	2636	2878	2780	3127	3004	3423	3292	3751	3598	4079	3895	4319	4117	4546	4284
42	2650	2600	2750	2660	2900	2800	3150	3020	3450	3310	3800	3630	4150	3950	4440	4200	4735	4400

TABLE II
Different published studies for assessing birth weight for gestational age.

Region	n	Gender-specific	Population-based	years
Brazil (Pedreira et al. present paper)	7,993,166	yes	Yes	2003-2005
Scotland (Bonellie et al. 1997)	100,133	yes	Yes	1998-2003
Korea (Shin et al. 2005)	118,538	yes	No	2001
Kuwait (Alshimmiri et al. 2004)	35,768	yes	No	1998-2000
Norway (Skjærven et al. 2000)	1,800,000	yes	Yes	1987-1998
Canada (Kramer et al. 2001)	676,605	yes	Yes	1994-1996
United States (Alexander et al. 1996)	3,134,879	no*	Yes	1991
United States (Zhang et al. 1995)	3,427,009	yes	Yes	1989
United States (Lubchenco et al. 1963)	5,635	yes	No	1948-1961

* only the 10^{th} percentile values are provided for both males and females.

Overall, despite the methodological discrepancies and the expected consequent diversion in percentile values, the Brazilian chart is quite consistent with previous studies. The greatest divergences appeared in relation to (Alshimmiri et al. 2004) charts, which are maybe explained by its quite small sample size. It should be noticed that the differences among these studies may be in part attributed to differences in the statistical procedures applied in different papers.

Several approaches are concerned with misestimation of the gestational age for a proportion of newborns (Kramer et al. 2001, Bonellie et al. 2008, Platt et al. 2001, Oja et al. 1991, Hutcheon and Platt 2008). This misclassification may produce curves that are not smooth or biologically plausible. Undesirable effects like bumps in extreme percentiles, specially around weeks 28 to 30, have been reported (Kramer et al. 2001, Bonellie et al. 2008). We did not observe these distortions in our curves maybe because of the huge size of the sample.

We hope the presented charts will be useful to clinicians in classifying fetal growth. They may also contribute as a reference for investigations of predictors and to show the consequences of small and large patterns for gestational age delivery. At last, some limitations should be acknowledged. Our study is cross-sectional, as all population-based gestational age references. Possible bias due to missing data caused by the absence of the weights of the fetuses still in utero (Hutcheon and Platt 2008) is also common to all charts, including ours. Finally, the accurate determination of the gestational age in population-based studies is an open challenge for all charts and the practical adequacy of different measures is a stirring investigation problem (Wingate et al. 2007).

ACKNOWLEDGMENTS

This work has been partially supported by grants from Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), and Fundação Carlos Chagas Filho de Amparo à Pesquisa do Estado do Rio de Janeiro (FAPERJ).

RESUMO

Background e objetivos. Apresentamos um retrato atualizado de peso-por-idade-gestacional, baseado em quase 8 milhões de observações em uma população etnicamente misturada. Estas constituem as primeiras tabelas com dados brasileiros. Esta contribuição pretende dar assistência aos clínicos na classificação do crescimento fetal, e prover uma referência para pesquisas de prognósticos e consequências em partos com padrões pequenos e grandes para a idade gestacional. A maior parte dos dados de referência para estimar peso-por-idade-gestacional sofre de tamanho de amostra insuficiente, especialmente em baixa idade gestacional. Os estudos populacionais com uma amostra de tamanho considerável se referem a dados coletados há mais de 15 anos.

Métodos. Nós realizamos um estudo populacional baseado em nascimentos em todos os estados brasileiros de 2003 a 2005. Os resultados foram baseados em 7.993.166 nascimentos de gravidez única. Nós construímos curvas suavizadas e tabelas gênero-específicas de 22 a 43 semanas completas para os percentiles 3°, 5°, 10°, 25°, 50°, 90°, 95° e 97°.

TABLE III

Relative percentual differences in percentiles for Male (all values are %). The present paper was taken as reference.

Gestational	10th percentile				50th percentile				90th percentile			
age (weeks)	Kramer	Alexander	Alshimmiri	Bonellie	Kramer	Alexander	Alshimmiri	Bonellie	Kramer	Alexander	Alshimmiri	Bonellie
22	–3.5	3.0	22.6	–	16.9	13.9	–1.6	–	29.0	0.1	49.7	–
23	–5.2	2.5	23.6	–	9.6	10.6	–4.4	–	22.8	4.6	47.4	–
24	–5.8	3.6	17.6	15.2	6.1	8.3	–9.2	12.5	18.3	5.4	44.2	19.5
25	–6.0	4.2	8.6	10.6	3.8	5.7	–17.3	8.3	16.6	0.9	39.9	15.2
26	–6.8	2.7	0.7	7.2	1.5	2.5	–24.2	6.9	11.4	–7.3	35.2	13.5
27	–8.6	0.1	–3.1	2.3	–0.6	–0.8	–26.3	4.9	8.8	–16.7	31.1	11.4
28	–10.8	–3.7	–3.5	–3.9	–2.4	–4.4	–24.5	1.8	6.7	–27.6	28.7	8.3
29	–13.2	–8.6	–2.4	–8.9	–3.8	–8.7	–22.4	–0.5	5.2	–37.3	27.9	5.7
30	–16.5	–13.0	1.2	–11.2	–3.7	–12.7	–21.8	–0.8	4.9	–40.2	28.5	5.2
31	–12.0	–13.7	6.8	–9.1	–0.1	–13.0	–19.8	2.2	8.0	–32.8	31.3	8.2
32	–8.9	–12.7	8.6	–4.9	3.8	–11.1	–16.8	6.5	11.3	–22.4	33.6	12.3
33	–6.8	–11.8	6.5	–2.0	6.1	–8.5	–16.1	8.8	12.9	–13.8	33.9	16.3
34	–6.6	–11.4	3.1	–1.0	5.6	–6.7	–16.7	8.6	11.5	–8.8	31.7	13.2
35	–6.4	–9.8	0.9	–0.3	3.6	–4.9	–18.0	6.7	7.8	–5.9	27.7	9.8
36	–5.2	–6.7	–0.3	0.3	1.5	–3.0	–20.2	4.2	3.9	–3.4	23.4	5.5
37	–4.7	–4.3	–1.2	0.2	–0.6	–1.9	–20.2	1.6	0.4	–2.1	19.8	1.8
38	–5.2	–3.3	–1.4	–1.5	–2.8	–1.9	–19.2	–1.1	–2.2	–1.9	17.6	–1.0
39	–7.0	–3.7	–2.2	–3.8	–5.0	–3.0	–18.8	–3.3	–3.8	–2.1	16.4	–2.3
40	–9.1	–3.8	–3.1	–7.1	–7.2	–3.7	–18.9	–6.2	–5.1	–1.6	15.9	–4.1
41	–10.5	–2.4	–3.1	–10.0	–9.0	–3.0	–18.2	–8.9	–6.1	–0.4	16.2	–5.7
42	–11.5	–1.2	–2.9	–11.4	–10.6	–2.1	–17.4	–10.0	–6.8	1.3	17.4	–5.5

Resultados. As tabelas e representações gráficas resultantes proveem uma referência gênero-específica para acessar a distribuição de peso ao nascimento de acordo com a idade gestacional na população brasileira.

Conclusões. Esta é a primeira referência populacional construída com dados de um país em desenvolvimento. Estas tabelas podem prover uma importante ferramenta para melhorar a avaliação clínica do crescimento em recém-natos.

Palavras-chave: peso ao nascimento, recém-nascido, idade gestacional, crescimento fetal, pré-termo, pós-termo.

REFERENCES

Alexander GR, Himes JH, Kaufman RB, Mor J and Kogan M. 1996. A United States national reference for fetal growth. Obstetrics & Gynecology 87: 163–168.

Alshimmiri MM, Al-Saleh EA, Alsaeid K, Hammoud MS and Al-Harmi JA. 2004. Birth weight percentiles by gestational age in Kuwait. Arch Gynecol Obstet 269: 111–116.

Bonellie S, Chalmers J, Gray R, Greer I, Jarvis S and Williams C. 2008. Centile charts for birth weight for gestational age for Scottish singleton births. BMC Pregnancy Childbirth 25: 8–15.

Bonellie SR and Raab GM. 1997. Why are babies getting heavier? Comparison of Scottish births from 1980 to 1992. BMJ 315: 1205.

Chike-Obi U, David RJ, Coutinho R and Wu SY. 1996. Birth weight Has Increased Over a Generation. Am J Epidemiol 164: 563–569.

Fritsch FN and Carlson RE. 1980. Monotone Piecewise Cubic Interpolation, SIAM. J Num Anal 17: 238–246.

Hutcheon JA and Platt RW. 2008. The missing data problem in birth weight percentiles and thresholds for small-for-gestational-age. Am J Epidemiol 167: 793–796.

Kahaner D, Moler C and Nash S. 1989. Numerical Methods and Software. London: Prentice Hall, 495 p.

Kierans WJ, Joseph KS, Luo ZC, Platt R, Wilkins R and Kramer MS. 2008. Does one size fit all? The case for ethnic-specific standards of fetal growth. BMC Pregnancy Childbirth 8: 1.

Kramer M, Platt RW, Wen SW, Joseph KS, Allen A, Abrahamowicz M, Blondel B, Bréart G and Fetal/Infant Health Study Group of the Canadian Perinatal Surveillance System. 2001. A new and improved population-based reference for birthweight for gestational age. Pediatrics 108: E35.

Lubchenco L, Hansman C, Dressler M and Boyd E. 1963. Intrauterine growth as estimated from liveborn birth weight data at 24 to 42 weeks of gestation. Pediatrics 32: 793–800.

Oja H, Korainen M and Rantakallio P. 1991. Fitting mixture models to birth weight data: a case study. Biometrics 47: 883–897.

Platt RW, Abrahamowicz M, Kramer MS, Joseph KS, Mery L, Blondel B, Bréart G and Wen SW. 2001. Detecting and eliminating erroneous gestational ages: a normal mixture model. Stat Med 20: 3491–3503.

Shin SM, Chang YP, Lee ES, Lee YA, Son DW, Kim MH and Choi YR. 2005. Birth Weight, Very Low Birthweight Rates and Gestational Age-Specific Birth weight Distribution of Korean Newborn Infants. J Korean Med Sci 20: 182–187.

Skjærven R, Gjessing HK and Bakketeig LS. 2000. Birth weight by gestational age in Norway. Acta Obst et Gynec Scand 796: 440–449.

Wingate MS, Alexander GR and Buekens P. 2007. Comparison of Gestational Age Classifications: Date of Last Menstrual Period *vs.* Clinical Estimate. Ann Epidemiol 17: 425–430.

Zhang J and Bowes W Jr. 1995. Birth-weight-for-gestational-age patterns by race, sex, and parity in the United States population. Obstet Gynecol 86: 200–208.