Australian national birthweight percentiles by sex and gestational age, 1998–2007

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Abstract

Objective: To present updated national birthweight percentiles by gestational age for male and female singleton infants born in Australia.

Design and setting: Cross-sectional population-based study of 2.53 million singleton live births in Australia between 1998 and 2007.

Main outcome measures: Birthweight percentiles by gestational age and sex.

Results: Between 1998 and 2007, women in Australia gave birth to 2 539 237 live singleton infants. Of these, 2 537 627 had a gestational age between 20 and 44 weeks, and sex and birthweight data were available. Birthweight percentiles are presented by sex and gestational age for a total of 2 528 641 births, after excluding 8986 infants with outlying birthweights. Since the publication of the previous Australian birthweight percentiles in 1999, median birthweight for term babies has increased between 0 and 25 g for boys and between 5 g and 45 g for girls.

Conclusions: There has been only a small increase in birthweight percentiles for babies of both sexes and most gestational ages since 1991–1994. These national percentiles provide a current Australian reference for clinicians and researchers assessing weight at birth.

Birthweight remains one of the strongest predictors of infant mortality and morbidity,[1,2] and it has been established that assessing an infant's birthweight requires summary data that account for gestational age.[3] Birthweight percentiles form a reference incorporating weight and gestational age of infants at birth and are used as an adjunct for detecting neonates at higher risk of neonatal and postneonatal morbidity and growth impairment. A birthweight small or large for gestational age, often defined as being lower than the 10th percentile or higher than the 90th percentile, provides an indication of risk of perinatal morbidity and mortality.[4]

Australia's first birthweight percentiles based on national population data were published in 1999.[5] The period since this publication has seen numerous changes in maternal characteristics:

- Maternal age has increased, with the proportion of mothers aged 35 years and over increasing from 15.7% in 1998 to 22.3% in 2007.[6,7]
- The proportion of women reporting smoking during pregnancy has reduced from 18.4% in 2002[8] to 16.6% in 2007;[7] with the proportion in New South Wales reducing from 22.0% in 1994 to 13.8% in 2005.[9]
- Maternal overweight and obesity has increased in Australia, as it has in other developed countries,[10] from 34% in the 1998–2002 calendar years[11] to 50% in 2008.[12] Mothers who are overweight or obese are more likely to have an indicated preterm birth, with infants born to overweight or obese women more likely to weigh more than 4 kg.[13]
- The ethnicity of mothers in Australia has changed, with 22.0% in 1998 reporting that they were not born in Australia (7.4% were Asian born),[6] compared with 24.3% in 2007 (9.6% Asian born).[7]

Identification of babies who are small or large for gestational age is important for clinical management,[14] and Australian birthweight percentiles continue to be used for both clinical and research purposes.[15,16] Current national birthweight percentiles are therefore required.

Our study presents national birthweight percentiles for all male and female singleton infants born in Australia over the 10-year period between 1998 and 2007.

Methods

We obtained data on singleton live births between 1998 and 2007 from the National Perinatal Data Collection (NPDC) of the Australian Institute of Health and Welfare (AIHW) National Perinatal Statistics Unit. Information is included in the NPDC for all births in Australia of at least 400 g birthweight or at least 20 weeks' gestation. Birthweight is recorded to the nearest 5 g, with gestational age recorded in completed weeks based on the first day of the last menstrual period or the best available clinical estimate (including early pregnancy ultrasound examination).

We excluded implausible birthweights using a method based on Tukey's box-and-whisker plots.[17] For each sex and gestational age combination, birthweights below the first quartile minus twice the interquartile range, or above the third quartile plus twice the interquartile range, were considered outliers and were excluded from analyses.

We calculated exact percentiles, means and standard deviations of birthweight by sex for each gestational age between 20 and 44 weeks. Percentiles were tabulated and plotted by sex for each gestational age. Results for the fifth and 95th percentiles (and more extreme) are presented only for gestational ages with a minimum of 100 births, consistent with the previously published Australian percentiles. Mean birthweight was calculated by year and sex to examine any change over time.

We included births from all mothers, including mothers not born in Australia. Births were not classified by Indigenous status because of ethical restrictions on the use of the perinatal data collection.

All analyses were performed using SAS 9.2 for Windows (SAS Institute Inc, Cary, NC, USA).

The study was approved by the AIHW Ethics Committee (EC341). Approval for use of data was provided by all states and territories.

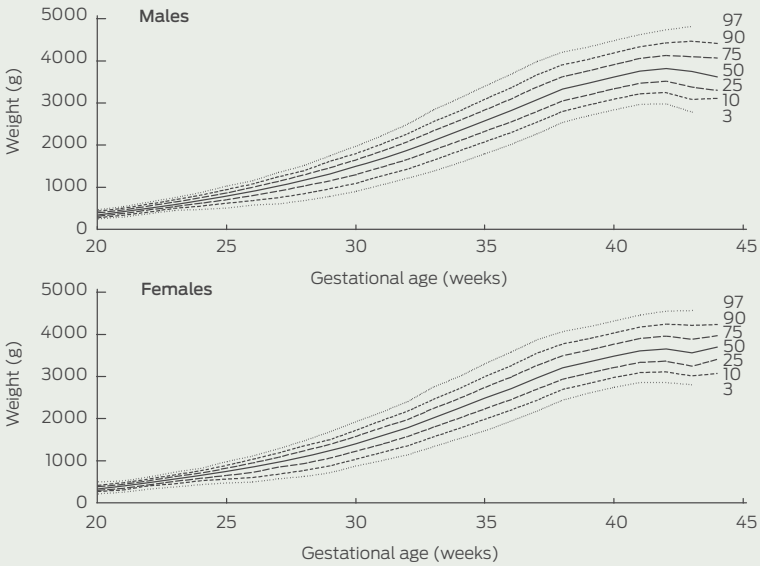
Results

Between 1998 and 2007, there were 2 539 237 live singleton births recorded (Box 1). Of these infants, 5.9% were born preterm (birth before 37 completed weeks of gestation) while 4.8% were low birthweight (< 2500 g) and 0.8% very low birthweight (< 1500 g)

1 Maternal and infant characteristics — all live singleton births, Australia, 1998–2007

Characteristic	Number (%)
Total	2 539 237
Sex of infant	
Male	1 305 356 (51.4%)
Female	1 233 284 (48.6%)
Indeterminate	146
Not stated	451
Birthweight (g)	
< 1500	19 693 (0.8%)
1500–2499	102 259 (4.0%)
2500–4499	2 368 899 (93.3%)
⩾ 4500	47 672 (1.9%)
Not stated	714 (< 0.1%)
Gestational age (weeks)	
20–31	22 911 (0.9%)
32–36	126 701 (5.0%)
37–41	2 349 889 (92.5%)
42–44	39 340 (1.5%)
> 44	12 (< 0.1%)
Not stated	384 (< 0.1%)
Maternal age (years)	
< 20	119 749 (4.7%)
20–24	387 486 (15.3%)
25–29	735 480 (29.0%)
30–34	821 946 (32.4%)
35–39	398 315 (15.7%)
⩾ 40	75 768 (3.0%)
Not stated	493 (< 0.1%)
Birth order	
1st births	1 047 055 (41.2%)
2nd or greater	1 489 629 (58.7%)
Not stated	2 553 (0.1%)
State	
New South Wales	851 912 (33.5%)
Victoria	621 556 (24.5%)
Queensland	498 582 (19.6%)
Western Australia	252 444 (9.9%)
South Australia	175 635 (6.9%)
Tasmania	56 632 (2.2%)
Australia Capital Territory	47 026 (1.9%)
Northern Territory	35 450 (1.4%)

2 Birthweight percentiles for live singleton infants born to Australian women



(Box 1). We excluded from analysis 1610 births (0.1%) for which one or more of the key variables — sex, birthweight and gestational age — was missing; among these were 12 with gestational age more than 44 weeks and 146 with sex recorded as indeterminate.

Of the 2 537 627 live singleton births with gestational age between 20 and 44 weeks and available data on sex and birthweight, 8986 (0.4%) were removed as outliers, with 7599 (0.3%) being above the higher Tukey limit, and 1387 (0.1%) being below the lower Tukey limit. Percentiles were calculated for a total of 2 528 641 births (1 300 273 males and 1 228 368 females).

Box 2 shows birthweight percentiles by gestational age for male and female infants, and exact birthweight percentiles are listed in Box 3 and Box 4. Median birthweights were lower for female than male infants at all gestational ages apart from 44 weeks. The mean birthweight remained stable between 1998 and 2007 for both male and female infants (Box 5).

Discussion

The birthweight percentiles presented are based on 10 years of high-quality population data that have been shown to be accurate and complete.[18] Our percentiles provide a reference for babies born in Australia and update those published in 1999 to better reflect the characteristics of Australian mothers. The data are sufficient in number to provide reliable percentiles for babies of early gestational age. Our approach to excluding implausible birthweights has been used in constructing birthweight percentiles in other countries.[4,19] The high quality of Australian birthweight data is demonstrated by the fact that the percentiles from the remaining observations resulted in curves that did not need smoothing.

Changes such as the increase in maternal age, obesity and use of assisted reproductive technology[7] have resulted in small increases in the gestational age- and sex-specific birthweights. Comparing term babies of the same gestational age, the median birthweight is between 0 and 25 g higher for male infants, and between 5 g and 45 g higher for female infants, than 10 years ago. Similar increases in 90th and most 10th percentiles for boys and girls were also observed. While these increases may seem small, at a population level they have a large impact. A mean increase in birthweight of 23 g between 1990 and 2005 for male babies in NSW translated into an 18% increase in those identified as large for gestational age. For female babies, an increase of 25 g translated into a 21% increase in those identified as large for gestational age.[9] Increases in age-specific 10th and 90th percentiles observed from current data will therefore increase the rate of small for gestational age and decrease the rate of large for gestational age for term births, compared with using the previous percentiles.

It is noteworthy that the mean birthweights are relatively stable over time, with a maximum variation over a decade of 13 g for male infants, and 6 g for female infants, in spite of changes in maternal characteristics associated with

3 Birthweight percentiles for live singleton male infants, Australia, 1998–2007

Gestational age (weeks)	Number of births	Mean (SD) birthweight (g)	Birthweight percentile (g)										
			1st	3rd	5th	10th	25th	50th	75th	90th	95th	97th	99th
20	230	349 (60)	210	248	254	273	310	340	390	430	450	470	500
21	335	418 (66)	270	290	300	335	375	420	460	500	540	542	575
22	401	505 (76)	350	370	390	410	460	500	554	600	630	650	690
23	395	595 (82)	390	450	470	500	540	588	650	700	730	756	800
24	640	681 (105)	426	470	500	550	618	684	750	810	850	875	970
25	715	783 (131)	440	505	530	620	700	785	865	944	995	1030	1100
26	937	894 (152)	500	576	621	680	802	900	996	1078	1130	1155	1210
27	1 069	1016 (194)	510	605	660	752	904	1030	1138	1250	1320	1352	1440
28	1 345	1146 (217)	591	680	735	844	1030	1165	1295	1395	1470	1522	1640
29	1 524	1301 (252)	662	782	860	964	1150	1311	1463	1620	1700	1757	1860
30	2105	1474 (283)	774	900	984	1091	1300	1498	1650	1800	1920	1980	2182
31	2576	1666 (304)	915	1055	1126	1270	1480	1680	1855	2028	2142	2230	2435
32	3895	1867 (331)	1075	1214	1294	1430	1659	1880	2080	2270	2405	2503	2710
33	5599	2106 (371)	1200	1381	1473	1638	1880	2106	2340	2560	2710	2845	3070
34	9824	2340 (385)	1400	1580	1690	1860	2100	2340	2580	2810	2990	3120	3343
35	16 054	2585 (408)	1600	1795	1920	2080	2330	2578	2835	3095	3275	3410	3665
36	32 747	2826 (428)	1805	2015	2120	2295	2550	2820	3095	3360	3550	3690	3930
37	73 986	3093 (449)	2050	2265	2372	2540	2800	3080	3378	3670	3865	3990	4235
38	230 003	3344 (439)	2340	2540	2640	2800	3050	3330	3625	3910	4090	4215	4445
39	293 109	3486 (430)	2510	2700	2800	2950	3195	3470	3765	4040	4220	4335	4560
40	409 976	3632 (434)	2650	2840	2940	3090	3340	3620	3915	4195	4370	4490	4708
41	192 154	3769 (438)	2780	2970	3070	3220	3470	3755	4060	4340	4515	4630	4850
42	19 804	3832 (462)	2760	2980	3095	3250	3520	3820	4130	4430	4615	4740	4970
43	797	3761 (540)	2615	2785	2935	3085	3380	3750	4100	4470	4670	4825	5180
44	53	3715 (563)	—	—	—	3110	3300	3620	4070	4415	—	—	—

4 Birthweight percentiles for live singleton female infants, Australia, 1998–2007

Gestational age (weeks)	Number of births	Mean (SD) birthweight (g)	Birthweight percentile (g)										
			1st	3rd	5th	10th	25th	50th	75th	90th	95th	97th	99th
20	197	333 (65)	190	210	230	265	290	320	374	410	450	490	525
21	256	386 (69)	210	250	270	300	340	390	433	470	510	515	530
22	333	474 (72)	260	325	355	400	425	480	520	560	589	610	620
23	376	558 (89)	320	375	400	445	506	560	615	660	700	725	800
24	528	637 (95)	380	430	480	520	580	641	700	754	793	815	860
25	599	730 (128)	410	470	498	559	645	740	817	884	940	975	992
26	809	825 (166)	428	490	520	594	717	840	940	1026	1072	1106	1186
27	879	949 (188)	500	568	598	675	840	965	1077	1175	1240	1280	1390
28	1136	1073 (230)	495	622	675	764	928	1090	1230	1347	1410	1470	1610
29	1188	1215 (252)	572	712	790	870	1055	1240	1380	1494	1595	1680	1840
30	1656	1394 (277)	725	870	918	1030	1220	1400	1571	1715	1840	1920	2130
31	2052	1582 (302)	880	1000	1060	1190	1385	1590	1780	1948	2065	2146	2338
32	3119	1772 (322)	970	1140	1230	1348	1570	1780	1970	2170	2290	2400	2620
33	4 421	2014 (356)	1180	1330	1424	1560	1790	2011	2235	2450	2616	2746	2970
34	8108	2242 (375)	1331	1525	1615	1764	2005	2240	2470	2705	2870	2995	3220
35	13 104	2486 (403)	1525	1710	1820	1980	2230	2480	2735	2995	3175	3300	3516
36	28 386	2720 (420)	1750	1940	2040	2198	2445	2710	2980	3250	3450	3575	3810
37	66 928	2979 (439)	1970	2175	2275	2430	2690	2965	3255	3545	3735	3865	4100
38	214 002	3215 (425)	2256	2440	2540	2690	2930	3200	3490	3770	3945	4062	4290
39	282 046	3351 (415)	2420	2600	2690	2830	3070	3340	3620	3890	4060	4175	4390
40	398 257	3493 (416)	2566	2740	2830	2975	3210	3480	3765	4030	4200	4316	4525
41	181 434	3619 (424)	2680	2855	2945	3090	3330	3605	3900	4170	4340	4455	4670
42	17 701	3665 (445)	2670	2850	2950	3110	3360	3650	3955	4240	4420	4545	4760
43	801	3579 (463)	2660	2800	2865	3010	3240	3560	3880	4210	4385	4560	4760
44	52	3705 (523)	—	—	—	3070	3403	3695	3965	4230	—	—	—

5 Mean birthweight (g) for live singleton infants by sex, Australia, 1998–2007

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Male	3462	3464	3470	3466	3461	3463	3463	3457	3461	3463
Female	3340	3335	3341	3341	3341	3339	3340	3338	3337	3339

birthweight.[9] This apparent contradiction can be explained by the fact that the mean birthweights are not adjusted for gestational age. For example, while rates of smoking during pregnancy have decreased, there has been a reduction in gestational age (with preterm births increasing from 6.8% of all births in 1991[20] to 7.4% in 2007[7]). Hence, the expected increase in average birthweight as a result of reduced maternal smoking may have been offset by decreased birthweights from preterm births. It is difficult to assess how other changes in maternal characteristics act together to explain the stability in mean birthweights, highlighting the need for birthweight percentiles to be presented separately by sex and gestational age.

In contrast to the birthweight percentiles published using 1991–1994 calendar year data,[5] we calculated percentiles for all singleton births in Australia. Therefore, our percentiles may not be directly comparable with the earlier percentiles derived from non-Indigenous singleton births to Australian-born mothers.

Customised birthweight percentiles have been recommended,[21] but their usefulness has been debated.[22] There are two recognised features of customised percentiles: first, they use regression-based coefficients adjusted for maternal factors; and, second, they use estimated fetal weight. It is primarily the estimate of fetal weight that contributes to improved prediction of adverse perinatal outcomes, rather than adjustment for maternal characteristics.[22] However, fetal (in-utero) weights are not routinely assessed in current practice. Furthermore, the proposition that identifying small for gestational age from customised percentiles, rather than from population reference curves, better predicts adverse outcomes is based on inconsistent evidence.[23,24] A simulation study demonstrated that the use of customised percentiles did not improve the identification of infants with intrauterine growth restriction, and concluded that, for the customisation to be useful, the factors used in the customisation model would need to explain an unrealistically high amount of variability in actual birthweight.[22] Whether differing points of view and fine areas of disagreement on customised and conventional birthweight percentiles for gestational age have important practical research or clinical implications is questionable.[25]

Australian birthweight percentiles continue to be used in clinical practice and research.[15] The percentiles presented here have a role as a basis for identifying high-risk babies and are recognisable, practical and easily incorporated into charts and presentations. These percentiles provide an up-to-date reference for clinicians and researchers.

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