Clinical and Community Studies

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Birth-weight-gestational-age standards help to identify infants in need of special care and to determine causes and means for preventing retardation of intrauterine growth. Previously published standards either were based on small samples, data several decades old or characteristics of subpopulations in the United States or they were not specific for type of birth and sex. We compared the data for live births in 1972 with those in 1986 to develop current Canadian standards for type of birth (singleton or twin) and sex. We found that the 10th, 50th and 90th percentile figures for weight were slightly higher in 1986 than in 1972 for term deliveries (at 37 weeks' gestation or later), but the figures were virtually unchanged for preterm deliveries. The availability of reliable population-based standards should enhance the clinician's ability to identify true cases of retardation or acceleration of intrauterine growth.

Les normes du poids de naissance en regard de l'age gestationnel vent utiles a la reconnaissance des nouveau-nes qui auront besoin de veins particuliers et a la recherche des causes de l'hypotrophie intra-uterine et done des manieres de la prevenir. Les normes publiees jusqu'ici ou bien detent de plusieurs annees reposaient sur de petite echantillons ou representaient des sous- populations des États-Unis, ou bien n'etaient pas precisees selon le sexe et le genre de naissance (simple ou gemellaire). Tenant compte de ces deux variables nous comparons les naissances vivantes en 1972 et en 1986 afin de definir des normes actuelles pour le Canada. Dans les naissances a terme (soit a partir de 37 semaines de gestation) les 10e, 50e et 90e centiles du poids vent un peu plus eleves en 1986 qu'en 1972, mais dans les naissances prematurees ils n'ont presque pas varie. Le clinicien qui a a sa disposition des normes fermes tirees de la population où il exerce est mieux à meme de reconnaitre les cas de retard ou d'avance de la croissance intra- uterine.

Birth weight and gestational age are two key determinants of infant death and disability. Identification- of infants at risk is necessary not only to investigate the social and environmental influences on low birth weight and premature birth but also to identify infants who need special care. Small-for-gestational-age (SGA) babies have an increased incidence of perinatal asphyxia and its sequelae, symptomatic hypoglycemia, congenital malformations, chronic intrauterine infection and massive pulmonary hemorrhage.1 Conversely, injuries due to delivery are more common among very large infants, regardless of gestational age, than among low-birth-weight infants.1 If the infant is unusually large in relation to gestational age the mother may be diabetic or prediabetic, or there may have been an error in calculating the gestational age.2

Appropriate classification of infants at birth also forms the basis for epidemiologic studies of factors that contribute to the size of babies in relation to gestational age.

Several methods have been used to classify infants with the use of birth-weight-gestational age categories. Some authors report the mean and two standard deviations of birth weight by gestational age; however, the usual method is to specify percentiles of birth weight for each completed week of gestation. SGA infants are specifically deemed by birth-weight criteria at given gestational ages. The 10th percentile curve of birth weight has been used to identify infants with suspected intrauterine growth retardation. It has been hypothesized that SGA newborns include those who are small because of poor fetal or maternal nutrition that retarded fetal growth, because of unknown reasons or because of a combination of maternal and fetal characteristics known to have modest effects on birth weight, such as the fetus's sex and the altitude during pregnancy.3

The concept of the classification of infants into risk groups according to birth weight and gestational age first emerged with the publication of intrauterine growth standards in 1963.2 These standards enabled the identification of infants who were large or small for gestational age. Since then several standards have been published in Canada4-7 and in other countries.8,9

Many of these subsequent reports, however, confirmed that the median weight reported in the study published in 1963 from the high-altitude state of Colorado2 was lower than that observed in areas at sea

level.5,8 Another reason for not universally adopting the Colorado standards or those of the other earlier reports is that during the 1970s the median birth weight of infants in the United States (and presumably in Canada) steadily increased.l0 In addition, most of the studies were confined to subpopulations in the United States, and therefore the results cannot be generalized to Canadian populations. Standards have been reported from several Canadian studies over the last 20 years, but all of the studies involved relatively small populations from individual hospitals4-6 or a single community.7

It has been recommended that separate standards be sought for a subpopulation only when some unique and seemingly intrinsic advantage or disadvantage for the offspring is associated with gestational age-specific birth-weight categories.11 Perinatal death is a widely used criterion. Separate standards according to sex and type of birth (singleton or twin) are recommended, because at a given weight for gestational age girls have an advantage in perinatal survival over boys, as have twins over singletons. However, infants of a given birth weight have the same risk of death regardless of parity, maternal age or social class.11

We studied national figures to develop current Canadian standards for live singleton and twin births and live male and female births. We examined the data for 1972 and 1986 to detect any changes in the standards over time.

Methods

Information relating to all live births in Canada in 1972 and 1986 was gathered from tapes provided by Statistics Canada. Records were separated by type of birth and by length of gestation. Records with missing information on birth weight, gestational age, sex or type of birth were excluded. Because birth weights of 500 g or less and of 5000 g or more had been put into two separate groups by Statistics Canada to ensure individual confidentiality, records of infants with these weights were not used. The percentiles and mean birth weights at 20 to 24 weeks' gestation and at 43 or more weeks' gestation were not reported, because more than 10% of these infants had birth weights of either 500 g or less or 5000 g or more. Because of their small numbers, births before 20 weeks' gestation were also excluded.

Birth weights for 1972 were converted to grams; for 1986 the weights were rounded to the nearest 10 g by Statistics Canada, again to ensure confidentiality. No births were included from Newfoundland, because this province does not provide birth weights to Statistics Canada.

The 10th, 50th and 90th percentiles of birth weight by gestational age for male and female infants were calculated for singleton and twin births.

Results

The total numbers of live births in Canada in 1972 and 1986 were 347 319 and 367 077 respectively. After records of multiple births other than twin, incomplete records, those of births before 20 weeks' gestation and those of birth weights of 500 g or less or 5000 g or more were excluded, the figures for 1972 and 1986 were 327 483 (96.0%) and 355 334 (98.6%) respectively (Table 1).

Table 1 -- Number of live births in Canada in 1972 and 1986 by sex and type of birth*

	Year; no. (and %) of births	
Type of birth	1972	1986
Singleton		
Total	341 082	357 797
Complete†	327 483 (96.0)	355 334 (99.3)
Male	168 582	182 017
Female	158 901	173 317
Twin		
Total	6 158	6 855
Complete†	5 898 (95.8)	6 767 (98.7)
Male	2 968	3 360
Female	2 930	3 407

*Excludes births in Newfoundland, because they are not reported to Statistics Canada.

†Excludes infants with incomplete records for gestational age, birth weight, sex or type of birth, those born before 20 weeks gestation and those with birth weights of 500 g or less or 5000 g or more.

Table II -- Mean birth weights of singleton and twin infants

Type of birth	Year; mean weight (and standard deviation), g 1972	1986
Singleton		
Male	3 325 (549.4)	3 457 (558.9)
Female	3 199 (519.4)	3 334 (523.6)
Twin		
Male	2 376 (625.8)	2 519 (640.4)
Female	2 304 (584.5)	2 425 (601.2)

The mean birth weight of singleton infants increased by 4.1% from 1972 to 1986; the increase for twins was 5.7% (Table II). The male:female ratio for singletons was 1.06 for 1972 and 1.05 for 1986; these figures agree with those of other reports.12 For twins the male:female ratio was 1.01 in 1972 and 0.99 in 1986.

Birth-weight-gestational-age standards based on the 10th and 90th percentiles for singleton and twin births are given in Tables III to VI.

The percentage of singleton births that were premature (before 37 weeks' gestation) was 8.3% in 1972 and 5.3% in 1986; the corresponding figures for twin births were 33.8% and 41.0%. Of the singleton births 6.9% of the infants weighed 2500 g or less in 1972; the figure decreased to 4.8% in 1986. The corresponding figures for twin births were 58.8% and 49.4%.

Discussion

Any classification scheme that uses birth weight and gestational age is prone to errors in measurement. Errors in determining gestational age include variation in length of menstrual cycle and time of ovulation, mistakes in calculating or recording the dab, interpretation of vaginal bleeding during the early stage of pregnant as a menstrual period and poor recall of menstrual information. Errors in the measurement of birth weight can occur because of faulty or careless use of scales, poor recording and, because some weight loss occurs immediately after birth, inaccurate recording of the precise age of the baby when first weighed.

Table **III**—Percentiles of birth weight for live singleton births In 1972 (GA=gest age))

GA	Males				Females			
	Total	Percentile; weight, g			Total	Percentile; weight, g		
wk	no.	10	50	90	no.	10	50	90
25	*57*	588	**840**	1 506	*54*	588	**784**	1 288
26	*138*	644	**952**	1 512	*108*	616	**896**	1 350
27	*87*	672	**1 008**	1 680	*79*	672	**1 036**	1 652
28	*270*	840	**1 288**	1 932	*282*	840	**1 204**	1 848
29	*134*	966	**1 372**	2 030	*91*	952	**1 344**	1 977
30	*369*	1 120	**1 596**	2 212	*338*	1 064	**1 540**	2 184
31	*219*	1 344	**1 708**	2 464	*160*	1 260	**1 708**	2 324
32	*781*	1 372	**1 932**	2 772	*657*	1 366	**1 932**	2 610
33	*460*	1 568	**2 128**	2 968	*395*	1 568	**2 128**	2 923
34	*1 129*	1 736	**2 352**	3 304	*909*	1 708	**2 240**	3 108
35	*1 291*	1 960	**2 548**	3 360	*1 126*	1 876	**2 464**	3 276
36	*9 052*	2 324	**3 052**	3 752	*8 403*	2 240	**2 940**	3 584
37	*5 354*	2 408	**2 996**	3 640	*4 704*	2 296	**2 884**	3 556
38	*14 050*	2 576	**3 164**	3 780	*12 920*	2 464	**3 024**	3 612
39	*18 362*	2 744	**3 304**	3 864	*17 137*	2 632	**3 164**	3 724
40	*92 988*	2 828	**3 388**	4 004	*88 544*	2 716	**3 248**	3 836
41	*13 221*	2 968	**3 556**	4 144	*13 004*	2 828	**3 388**	3 976
42	*8 791*	2 968	**3 584**	4 200	*8 353*	2 856	**3 416**	4 032

Table **IV**—Percentiles of birth weight for live twin births in 1972 (GA=Gest age)

GA	Males				Females			
	Total	Percentile; weight, g			Total	Percentile; weight, g		
wk	no.	10	50	90	no.	10	50	90
25	*8*	532	**938**	1 120	*4*	700	**756**	1 064
26	*18*	644	**896**	1 375	*16*	672	**994**	1 436
27	*14*	588	**1 022**	1 246	*11*	605	**924**	1 742
28	*28*	932	**1 218**	1 767	*36*	672	**1 008**	1 590
29	*29*	616	**1 204**	1 736	*21*	633	**1 092**	1 529
30	*68*	1 008	**1 414**	1 907	*64*	896	**1 512**	2 016
31	*37*	1 120	**1 596**	2 397	*28*	1 341	**1 680**	2 187
32	*96*	1 260	**1 736**	2 338	*86*	952	**1 736**	2 164
33	*73*	1 288	**1 792**	2 374	*64*	1 190	**1 638**	2 394
34	*133*	1 456	**1 932**	2 352	*97*	1 394	**1 904**	2 408
35	*99*	1 624	**2 100**	2 632	*117*	1 523	**2 016**	2 554
36	*359*	1 680	**2 296**	2 800	*382*	1 680	**2 184**	2 716
37	*294*	1 904	**2 464**	3 038	*277*	1 876	**2 324**	2 856
38	*386*	2 044	**2 590**	3 136	*384*	1 876	**2 436**	3 024
39	*249*	2 100	**2 716**	3 192	*283*	2 044	**2 576**	3 136
40	*931*	2 072	**2 688**	3 276	*937*	1 932	**2 548**	3 136
41	*63*	2 240	**2 772**	3 405	*53*	2 022	**2 828**	3 545
42	*30*	1 837	**2 758**	3 441	*37*	2 134	**2 632**	3 394

Because the proportion of infants born very prematurely is small, particularily among singleton births, the figures reported here are subject to some statistical instability and should be interpreted with this in mind. However, the use of national birth totals minimized statistical variation relative to smaller populations.

A comparison of the percentiles of birth weight by gestational age revealed that there had been some change in the standards from 1972 to 1986. The number of term deliveries was slightly higher in 1986; this indicates some improvement in the rate of intrauterine growth and the need for revising these standards every decade or so. Furthermore, it is encouraging that the strong digit preference for even numbers between 25 and 33 weeks' gestation among singleton births had decreased by 1986 (Tables III and V).

Few of the birth-weight-gestational-age standards previously reported were according to sex

Table V—Percentile of birth weight for live singleton births in 1986 by sex and gestational age (GA)

	Males				Females			
		Percentile; weight, g				Percentile; weight. g		
GA wk	Total no.	10	50	90	Total no.	10	50	90
25	*100*	651	**810**	950	*73*	604	**750**	924
26	*113*	714	**950**	1 170	*109*	700	**880**	1 130
27	*138*	827	**1 010**	1 331	*105*	738	**1 000**	1 300
28	*219*	900	**1 190**	1 550	*140*	833	**1 100**	1 517
29	*179*	990	**1 320**	1 610	*127*	942	**1 280**	1 624
30	*257*	1 156	**1 530**	2214	*216*	1 040	**1 485**	2 001
31	*294*	1 230	**1 680**	2 105	*244*	1 220	**1 605**	2 205
32	*578*	1 459	**1 915**	2 400	*428*	1 359	**1 800**	2 430
33	*648*	1 610	**2 100**	2 601	*472*	1 543	**2 040**	2 571
34	*1 181*	1 880	**2 350**	2 940	*894*	1 750	**2 235**	2 830
35	*1 840*	2 060	**2 570**	3 140	*1 454*	1 950	**2 460**	3 040
36	*4 654*	2 280	**2 820**	3 490	*3 870*	2 210	**2 740**	3 370
37	*8 576*	2 530	**3 050**	3 640	*7 604*	2 410	**2 940**	3 520
38	*22 898*	2 740	**3 280**	3 850	*20 814*	2 630	**3 140**	3 710
39	*35 909*	2 900	**3 430**	4 000	*33 931*	2 780	**3 290**	3 850
40	*68 102*	3 020	**3 570**	4 160	*67 149*	2 900	**3 430**	4 000
41	*25 048*	3 140	**3 700**	4 300	*25 294*	3 000	**3 540**	4 120
42	*10 309*	3 200	**3 770**	4 390	*9 636*	3 060	**3 610**	4 190

Table VI -- Percentiles of birth weight for live twin births in 1986 by sex and gestational age (GA)

	Males				Females			
		Percentile; weight, g				Percentile; weight, g		
GA wk	Total no.	10	50	90	Total no.	10	50	90
25	*14*	560	**720**	1 415	*13*	530	**700**	872
26	*10*	714	**860**	1 102	*32*	606	**800**	1 000
27	*20*	597	**1 000**	1 293	*13*	704	**950**	1 078
28	*36*	859	**1 140**	1 389	*40*	858	**1 105**	1 355
29	*39*	1 110	**1 280**	1 640	*36*	947	**1 275**	1 543
30	*56*	1 277	**1 475**	1 846	*38*	1 139	**1 355**	1 642
31	*66*	1 287	**1 630**	1 965	*42*	1 139	**1 515**	1 931
32	*88*	1 309	**1 710**	2 071	*93*	1 360	**1 720**	1 992
33	*133*	1 580	**1 970**	2 336	*128*	1 469	**1 850**	2 253
34	*226*	1 720	**2 110**	2 533	*191*	1 724	**2 070**	2 360
35	*253*	1 914	**2 350**	2 796	*274*	1 800	**2 230**	2 655
36	*430*	2 030	**2 460**	2 930	*423*	1 858	**2 340**	2 800
37	*519*	2 120	**2 660**	3 180	*514*	2 075	**2 510**	3 000
38	*666*	2 300	**2 830**	3 370	*743*	2 154	**2 680**	3 216
39	*463*	2 444	**2 940**	3 540	*440*	2 320	**2 840**	3 319
40	*254*	2 395	**3 000**	3 590	*310*	2 272	**2 940**	3 489
41	*47*	2 440	**3 140**	3 902	*41*	2 540	**3 100**	3 518
42	*7*	2 560	**2 940**	3 640	*15*	2 384	**2 870**	3 514

and even fewer according to the type of birth. In addition, the standards were often presented in a graph without accompanying tables, and thus extraction of the specific numbers was difficult.

Identification of infants who are small or large for gestational age often implies an increased maternal risk of disordered glucose homeostasis and the need for special monitoring.l3 The use of stable population-based standards should enhance the clinician's ability to verify true cases of retardation or acceleration of intrauterine growth.

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Regression *M&M §2.3 and §10*

Uses

- Curve fitting
- Summarization ('model')
- Description
- Prediction
- Explanation
- Adjustment for 'confounding' variables

Technical Meaning

- [originally] simply a line of 'best fit' to data points
- [nowadays] Regression line is the LINE that connects the CENTRES of the distributions of Y's at each X value.
- not necessarily a straight line; could be curved, as with growth charts
- not necessarily $\mu_{Y|X}$'s used as CENTRES ; could use medians etc.
- strictly speaking, haven't completed description unless we characterize the variation around the centres of the Y distributions at each X
- inference not restricted to the distributions of Y's for which we make some observations; it applies to distributions of Y's at all unobserved X values in between.

Examples (with appropriate caveats)

- Birth weight (Y) in relation to gestational age (X)
- Blood pressure (Y) in relation to age (X)
- Cardiovascular mortality (Y) in relation to water hardness (X) ?
- Cancer incidence (Y) in relation to some exposure (X) ?
- Scholastic performance (Y) vis a vis amount of TV watched (X)

Caveat: No guarantee that simple straight line relationship will be adequate. Also, in some instances the relationship might change with the type of X and Y variables used to measure the two phenomena being studied; also the relationship may be more artifact than real - see later for inference.)

	MALES				FEMALES			
Age.	*Tot.*	%-ile; weight,g			*Tot.*	%-ile; weight,g		
wk	*N.*	10th	50th	90th	*No.*	10th	50th	90th
25	*100*	651	810	950	*73*	604	750	924
30	*257*	1 156	1 530	2 214	*216*	1 040	1 485	2 001
31								
32								
33								
34								
35	*1 840*	2 060	2 570	3 140	*1 454*	1 950	2 460	3 040
36								
37								
38								
39								
40	*68 102*	3 020	3 570	4 160	*67 149*	2 900	3 430	4 000
41								
42	*10 309*	3 200	3 770	4 390	*9 636*	3 060	3 610	4 190