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Original Article

Birth weight for gestational age: A reference study in a tertiary referral hospital in the middle region of Turkey

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Abstract

Background: The purpose of this study was to establish a fetal birth weight curve for gestational age for patients who presented to our tertiary referral hospital. The curve can be used for epidemiological analysis and also to develop Turkey's first national nomogram.
Methods: A total of 68,255 live singleton pregnancies delivered during the study period in a tertiary referral hospital were initially reviewed in this study. The data were carefully collected from hospital records and patients' files. Gestational age (weeks) was assessed by either ultrasound examination or according to the patient's last menstrual period, or both. Sex-specific reference tables for fetal birth weight by gestational age were created, and statistical analyses were carried out for descriptive variables using SPSS 15.0 for Windows.
Results: Most newborns weighed between 3000 g and 4000 g. The percentile fetal birth weight curves for gestational age showed that fetal birth weight increased with the increase in gestational age. Typically, male infants were noted to have higher birth weights than female infants. When our results were compared with those of previous studies, it was demonstrated that values for the 10th percentile were higher in our study, whereas values for the 90th percentile were similar to those of previous studies.
Conclusion: To the best of our knowledge, this is the first study evaluating the correlation between gestational age and fetal birth weight with such a large sample size in Turkey. Therefore, the results of this reference study can be helpful in defining normal and abnormal fetal growth in Turkish newborns.

Keywords: birth weight; gestational age; reference growth curves

1. Introduction

Data regarding the significance of birth weight in newborns have been investigated since the 1970s.[1] Over the years, clinicians have created their own reference charts and published important information about their experiences.[2–4] Birth weight for gestational age reference charts provides important data about fetal growth, neonatal morbidity and mortality, and development delay.[5] These charts have different characteristics in terms of data sources (hospital records or population based), population composition, region, geographic differences, and methods of measurement.[3] The birth weight for gestational age reference charts have customarily been used to estimate an infant's growth relative to gestational age. These reference charts have several important purposes, including the evaluation of infants with restricted growth who are at an increased risk of perinatal mortality, the planning of targeted public health programs, and to assess epidemiological data between fetal growth and the possibility of chronic diseases during adulthood.[6,7]

However, there are some difficulties in correctly estimating birth weight for gestational age reference charts, including the difficulties involved in measuring the gestational age and collection of relevant data. Therefore, none of these charts are

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entirely satisfactory,[8] and so should regularly be updated as necessary. In Turkey, there are a few studies that evaluated birth weight for gestational age reference.[9–12] However, most of these studies used small sample sizes and are thus limited in their demonstrated reliability.

In this study, we constructed a sex-specific birth weight for gestational age reference chart using a large sample size from a tertiary reference hospital in the capital city of Turkey. To the best of our knowledge, this is the first study from Turkey with such a large sample size.

2. Methods

This descriptive, hospital-based, and population study was performed according to the standards of the Declaration of Helsinki. The study was approved by the Ethics Committee of Dr. Zekai Tahir Burak Women's Health Education and Research Hospital in Ankara, Turkey, which is a tertiary referral medical center in the country's middle region.

The study included data from 69,742 live births delivered at 24–42 weeks of gestation in our hospital between 2007 and 2013. After excluding extreme birth weight values, a total of 68,255 live births were analyzed. Newborn birth weight is routinely measured in our department by trained nurses or assistant doctors just after delivery using electronic scales accurate to 5 g. The scales are calibrated before each measurement. Gestational age (weeks) was assessed by either ultrasound examination (Logiq 200 PRO Ultrasound Device; GE Medical Systems, Milwaukee, Wisconsin, USA) or according to the patient's last menstrual period, or both. The gestational age was confirmed using the mean gestational sac diameter if the pregnancy was <8 weeks; however, crown rump length was used if the pregnancy period was between 8 weeks and 12 weeks.

Inclusion criteria for our study were live births at 24–44 weeks of gestation, with birth weight reported in ranges that represented ± 2.5 standard deviations from the mean birth weight for gestational age (Table 1). Gestational age distributions were initially examined for cases grouped in the 125-g birth weight interval category. The exclusion criteria for this study were multiple gestations, stillbirths, induced labors for congenital anomalies, and pregnancies for which gestational age could not be assessed accurately. We compared our study results with three published studies, and all of these studies included sufficient number of patients (> 30,000).[13–15] Alexander et al[13] presented data on singleton birth weight percentiles for gestational age by race, Hispanic origin, and sex from 1994 to 1996 in the United States. Wilcox et al[14] produced standard curves of birth weight according to gestational age by including mothers from the Indian subcontinent as well as those of European and Afro-Caribbean origins. Alshimmiri et al[15] developed curves based on eight different ethnic groups.

2.1. Statistical analysis

Sex-specific reference tables for fetal birth weight by gestational age were created. Percentile tables [5th, 10th, 50th (median), 90th, and 95th] and charts [10th, 50th (median), and 90th] at 24–42 weeks of gestation were produced based on the smoothed estimated curves and mean values. Standard deviation was calculated from the empirical distribution of birth weights after correction using the LMS Chart Maker Pro version 2.3 software program (Institute of Child Health, London, UK), which summarizes percentiles at each gestational age based on the power of age-specific Box–Cox power transformations to normalize data. These three quantities depend on gestational age. The final percentile curves are produced using three smooth curves that represent L (lambda, skewness), M (mu, median), and S (sigma, coefficient of variation). The conventional 10th percentile and 90th percentile were used to define small for gestational age (SGA) and large for gestational age (LGA), respectively. Statistical analysis was carried out using SPSS version 15.0 for Windows (SPSS Inc., Chicago, IL, USA).

3. Results

Of all the fetuses evaluated, 36,926 were male (54.1%) and 31,329 were female (45.9%). The birth weights of newborns included in the study after excluding extreme birth weight values, fetal anomalies, and multiple gestations are presented in Table 1. Table 2 depicts the smoothed percentiles [5th, 10th, 50th (median), 90th, and 95th] of birth weight for gestational age, based on the trimmed data of the total population.

Tables 3 and 4 show the percentile tables and charts for the 5th percentile, 10th percentile, 50th (median) percentile, 90th percentile, and 95th percentile for male and female infants after extreme birth weight values were excluded. Fig. 1 shows the smoothed percentile curves [10th, 50th (median), and 90th] of birth weight for gestational age for the male, female, and total population, respectively. From these data it can be seen that the birth weight increases in a nonlinear pattern as the gestational age increases. Birth weights for male infants were

Table 1
Inclusion criteria of birth weights and gestational age at each completed week of gestation.[a]

Gestational age (wk)	Birth weight (g)
22	125–750
23	125–875
24	125–1000
25	250–1500
26	250–1625
27	250–1750
28	250–2000
29	250–2375
30	375–2500
31	375–2750
32	500–3000
33	500–3500
34	625–4000
35	750–4500
36	1000–5000
≥37	1000–5500

[a] Values included in these ranges formed the secondary distribution.

Table 2
Smoothed 5th percentile, 10th percentile, 50th (median) percentile, 90th percentile, and 95th percentile birth weight for 24–42 weeks of gestational age, based on the trimmed data of the total population.

Gestational age (wk)	Smoothed birth weight percentiles (g)				
	5th	10th	50th	90th	95th
24	426	502	704	1080	1272
25	429	530	780	1130	1280
26	500	581	880	1169	1414
27	525	600	970	1280	1530
28	670	730	1170	1578	1728
29	756	880	1300	1700	1887
30	917	1030	1460	1972	2163
31	1030	1223	1680	2110	2430
32	1225	1350	1890	2350	2564
33	1325	1540	2110	2630	2865
34	1519	1730	2280	2861	3080
35	1763	1950	2540	3150	3366
36	2060	2260	2830	3400	3580
37	2302	2500	3060	3610	3780
38	2530	2700	3220	3770	3940
39	2650	2800	3320	3880	4050
40	2740	2890	3400	3960	4140
41	2790	2950	3460	4000	4170
42	2680	2870	3475	4000	4167

Table 4
Smoothed 5th percentile, 10th percentile, 50th (median) percentile, 90th percentile, and 95th percentile birth weight for 24–42 weeks of gestational age for female infants.

Gestational age (wk)	Smoothed birth weight percentiles (g)				
	5th	10th	50th	90th	95th
24	437	486	725	1050	2510
25	594	618	910	1140	1620
26	599	700	920	1178	1360
27	606	694	1000	1280	1404
28	721	770	1180	1551	1692
29	800	888	1290	1692	1823
30	947	1030	1420	1920	2090
31	1036	1220	1660	2058	2266
32	1230	1340	1840	2350	2552
33	1310	1483	2050	2617	2897
34	1482	1660	2200	2820	3075
35	1670	1840	2470	3080	3350
36	1943	2160	2780	3410	3630
37	2160	2400	3040	3650	3840
38	2500	2687	3250	3840	4020
39	2640	2810	3360	3970	4160
40	2700	2880	3490	4130	4310
41	2740	2955	3540	4140	4312
42	2661	2852	3550	4158	4278

greater than those of female infants after 28 weeks of gestation. Before the 28-week gestation threshold, however, female birth weights were greater than male birth weights.

We compared our curves with those generated in three other studies,[14–16] and the comparison is illustrated in Fig. 2. The comparison was made for SGA and LGA birth weights by the 10th percentile and 90th percentile, respectively. The curve of our study was above the curves of the three published studies[13–15] in the 10th percentile as well as having two intersections with the curve reported by Wilcox and co-workers.[14] It was also above the curves of these studies in the 90th percentile.

We also compared our 10th percentile, 50th percentile, and 90th percentile of birth weight of female and male newborns by gestational ages with those reported by Kurtoğlu et al[10] in a cohort of Turkish newborns (Fig. 3). We found that the birth weights of our female newborns were approximately 255 g higher in the 90th percentiles in the 41–42 weeks of gestation, but were 200 g lower in the 10th percentiles between 34 weeks and 38 weeks of gestation. We also found that the birth weights of our male newborns were approximately 400 g higher in the 50th percentile and 90th percentile between 28 weeks and 38 weeks of gestation.

Table 3
Smoothed 5th percentile, 10th percentile, 50th (median) percentile, 90th percentile, and 95th percentile birth weight for 24–42 weeks of gestational age for male infants.

Gestational age (wk)	Smoothed birth weight percentiles (g)				
	5th	10th	50th	90th	95th
24	420	508	700	1002	1252
25	418	510	760	1100	1260
26	420	512	850	1234	1516
27	480	515	905	1520	1797
28	560	670	1110	1720	1910
29	600	834	1300	1850	2094
30	800	1020	1590	2090	2270
31	912	1322	1780	2426	2490
32	1187	1497	1980	2550	2646
33	1484	1636	2230	2656	2850
34	1612	1880	2385	2910	3095
35	2014	2189	2630	3200	3385
36	2220	2380	2850	3400	3550
37	2430	2580	3080	3580	3740
38	2550	2700	3190	3700	3830
39	2660	2800	3290	3800	3950
40	2740	2900	3370	3850	4010
41	2790	2950	3420	3910	4070

4. Discussion

This study provides important information on birth weight for gestational age of all newborns delivered during the study period in a tertiary research hospital in Turkey. This is the largest population study from Turkey describing the association between birth weight and gestational age. The limitations of this study were its cross-sectional nature and that it provides data from a single hospital only. However, this is the largest sample size population study undertaken to date on this topic in Turkey and to the best of our knowledge the first study with this sample size. Because many patients are referred to our hospital from all regions of Turkey, we believe that our study population reflects Turkey's general population.

Usher and McLean[16] developed anthropometric reference curves in 1969 based on a small sample with sex differentiation and means and two standard deviations. One of the important requirements when creating birth weights for gestational age reference curve is the mechanism by which

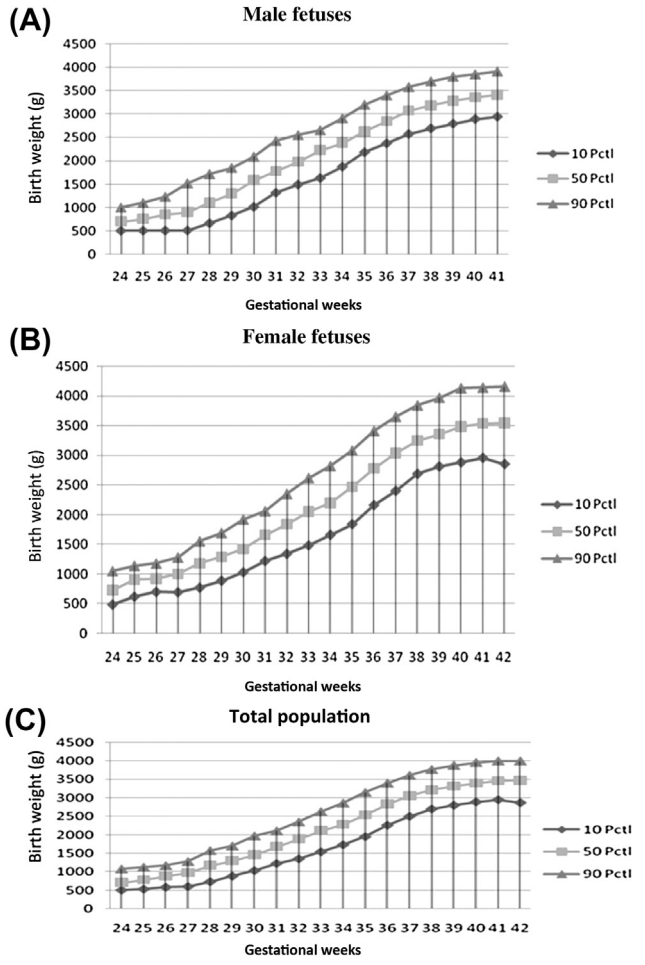

Fig. 1. Smoothed percentiles [10th, 50th (median), and 90th] of birth weight for gestational age for (A) male, (B) female, and (C) total populations. Pctl = percentile.

accurate gestational age is assessed. We assessed the weeks of gestation by either ultrasound examination or according to the last menstrual period, or both. The following factors may lead to errors while calculating the gestational age from the last menstrual period: irregularity of the menses, individual variation of the cycle length, patient's failure to remember the last menstrual period, and oral contraceptive use.[17] In these cases there may be dissonance between birth weights in given gestational ages.

A bias in creating the birth weight for gestational age reference curves is irregularity and even nonmonotonicity in the shape of fetal growth curves, which are caused by using small sample sizes with low gestational ages; however, this problem can be resolved when the curves are smoothed.[8] If SGA is evaluated based on curves obtained from countries other than that of the study population, there is a possibility of misdiagnosis of SGA.[16] Upon comparing our data with other studies (Fig. 2), we also observed that our 10th percentile curve was different, and misdiagnosis is likely if data from other populations are used.

We compared our curve with previously published studies. Alexander et al[13] presented data on singleton birth weight

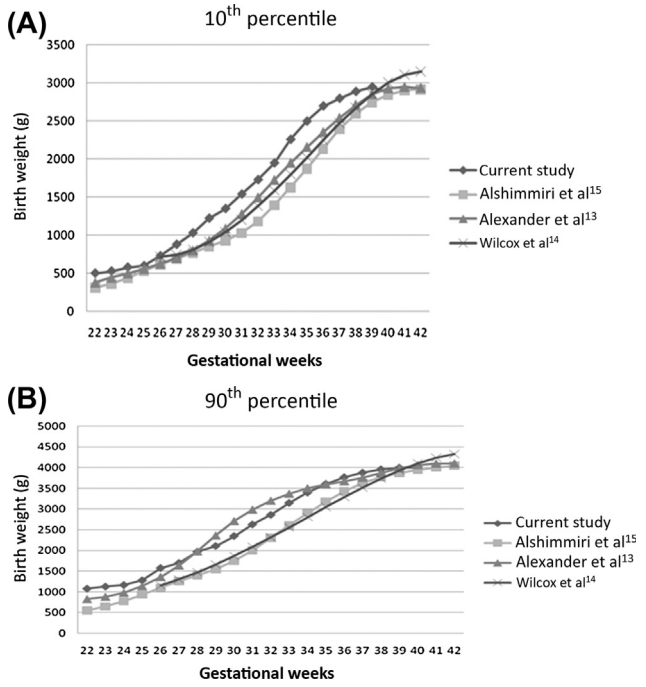

Fig. 2. Comparison of (A) the 10th percentile and (B) the 90th percentile of birth weight for gestational ages calculated in our study with the results of Alexander et al[13] from the United States, Wilcox et al[14] from the United Kingdom, and Alshimmiri et al[15] from Kuwait.

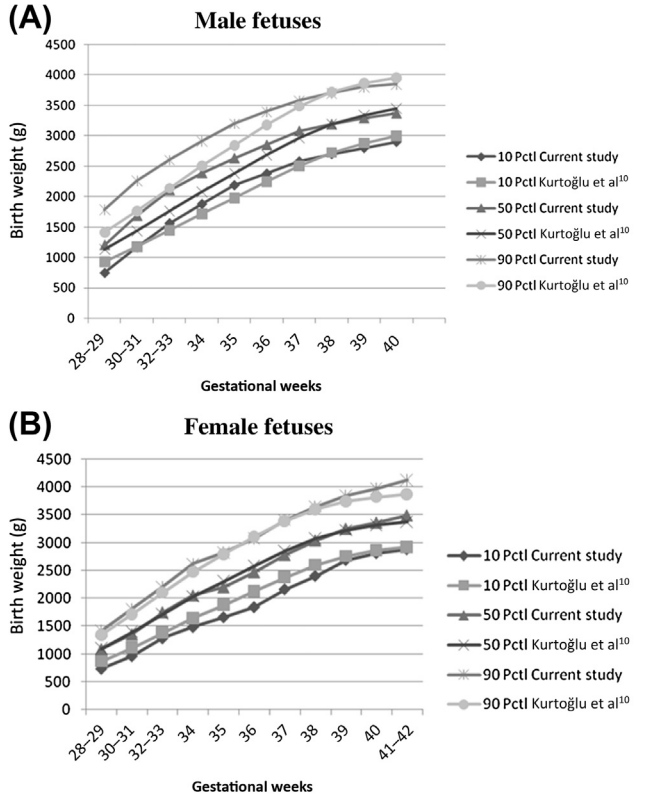

Fig. 3. Comparison of the 10th, 50th, and 90th percentiles of birth weight of (A) male and (B) female newborns by gestational ages with those reported by Kurtoğlu et al[10] in a cohort of Turkish newborns. Pctl = percentile.

percentiles for gestational age by race, Hispanic origin, and sex from 1994 to 1996 in the United States. Wilcox et al[14] produced standard curves of birth weight according to gestational age by including mothers from the Indian subcontinent as well as those of European and Afro-Caribbean origins. Alshimmiri et al[15] developed curves based on eight different ethnic groups. The 90th percentile of our curve was above the curves developed by Wilcox et al[14] and Alshimmiri et al,[15] and had an intersection between 38 weeks and 39 weeks of gestation. Our curve had variable intersections with the curve developed by Alexander and co-workers.[13] All curves were similar during term (between 38 weeks and 42 weeks of gestation) and there was only a slight increase of birth weight.

Kurtoğlu et al[10] reported the birth weights, birth length, and head circumference of 4750 newborns from Turkey. This study had a relatively small sample size and utilized data collected from 11 different hospitals; in addition, they started birth weight data collection from 28 weeks of gestation. Although we collected birth weight data from the 24th week in our study, we used data only from the 28th week in Fig. 3 to compare our results with that of Kurtoğlu et al.[10] Although our 10th percentile birth weight curve was higher than other international studies (Fig. 2),[13−15] we observed that our 10th percentiles curve was lower than a national study between 34 weeks and 38 weeks of gestation for female newborns (Fig. 3). We observed that birth weights of our male newborns were approximately 400 g higher in the 50th percentile and 90th percentile between 28 weeks and 38 weeks of gestation (Fig. 3). These results may be due to socioeconomic differences and the considerably higher number of participants in our study. Given the sample size of our study, we believe that the data and results obtained are more reliable, and are thus of increased value to the medical community.

In conclusion, we think that this study is important because this is the first and the largest population of its kind used to create a reference that describes the association of birth weight with gestational age. In the future, we believe that in order to best evaluate babies delivered in our country, the results of this study will be carefully considered.

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