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Sonographic Fetal Estimated Weight Significantly Differs from Neonatal Weight in the Same Population

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Abstract

Background: Fetal biometric sonographic measurements are an important tool in prenatal assessment.

Objectives: To establish reliable growth charts for fetal ultrasound biometry and estimated fetal weight in a large population and to assess the difference between fetal estimated weight and actual birth weight in the same population at the same week of gestation.

Methods: Data were collected retrospectively from fetal biometric measurements performed in the ultrasound unit of the Department of Obstetrics and Gynecology at the Sheba Medical Center over a period of 9 years (n = 82,725). Data were used to calculate percentiles and nomograms for each parameter and for calculated estimated fetal weight (EFW). The 50th percentile of the calculated EFW was compared to the 50^{th} percentile of the neonatal birth weight according to the most common Israeli growth plot charts.

Results: Reference charts were built for calculated EFW and additionally reference tables were created for biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC) and femur length (FL) for singleton fetuses in the Israeli population. The estimated median weight per gestational week was significantly larger in our curves compared to the most commonly used Israeli growth plot chart ($P<0.0001$). The mean absolute difference was 230.6±84.8 g. The mean relative difference was 14.7 ± 7.3%.

Conclusion: We demonstrated a statistically significant difference between sonographic estimated fetal weight and neonatal birth weight through all weeks of gestation, This variance is of clinical importance in prenatal counseling, since the actual fetal weight is larger than previously expected in this population.

Keywords: Fetal biometry; Estimated fetal weight (EFW); Growth charts; Ultrasound; Israeli population

Abbreviations: HC: Head Circumference; BPD: Biparietal Diameter; FL: Femur Length; AC: Abdominal Circumference

Introduction

Fetal biometric sonographic measurements are an accepted method for predicting fetal weight and for assessing potential fetal anomalies during the second and third trimesters of pregnancy [1,2]. Measurements include head circumference (HC), biparietal diameter (BPD), abdominal circumference (AC) and femur length (FL). They are performed routinely in Israel, almost invariably among both Jewish and Arab women [3].

In 2005, Dollberg & Colleagues [4] published new standards of birth weight of singletons and multiple births based on data of birth weight by gestational age of live infants born in Israel. Since then most centers in Israel have been using these growth curves as a percentile reference of the fetal calculated estimated fetal weight (EFW). Hence, EFW, a derivation of sonographic biometric measurements, is referenced to charts based on liveborn infant weight.

Importantly, fetal biometrical measurements also serve to detect fetal anomalies. Each of the four parameters measured has a discrete growth pattern, and any deviation from the expected pattern can imply a possible placental, anatomic, genetic or chromosomal anomaly. Although there are many nomograms published in the literature [5-9], most are based on small-numbered prospective cross-sectional studies. There lies a major drawback of this methodology. Since different charts are used by different physicians, the definition of abnormal measurement may vary according to the selected reference chart. It has been shown that the assessment of fetal biometry is largely dependent on the choice of reference charts [10].

During the last few years there has been growing interest in creating population-specific fetal growth charts [11-14]. Prior comparisons to global charts used routinely in clinical practice have yielded inconclusive results. In 2005 Romano et al. [15]

published new Israeli fetal weight curves that were based on 857 ultrasound examinations compared to those adopted from the American population [15]. They found differences between their new curves and the American-based curves. This was especially true in cases where fetal weight was close to, or below, the 3rd percentile of the American curve in weeks 27-35, and when fetal weight was close to or above the 97th percentile of the American curve in weeks 14-22 and 25-37.

Therefore, the aim of this study was to establish reliable growth charts for fetal ultrasound biometry and to compare the calculated growth charts to the neonatal birth weight charts in order to assess whether a significant difference exist between the two.

Patients and Methods

The study data were obtained from fetal biometric measurements performed in the ultrasound unit of the Department of Obstetrics and Gynecology at Sheba Medical Center over a period of nearly 9 years, from October 2004 to March 2013. Ultrasound examinations were performed by different operators, including specialized sonographic technicians, residents and expert sonographers, and were recorded in the hospital computerized database.

Data were collected between weeks 20 and 43 of gestation. Inclusion criteria were known gestational age by last menstruation date or corrected early ultrasound dating. In order to create a representative sample of all fetus population no exclusion criteria, such as maternal disease or fetal malformations, were applied.

Fetal measurements were all made in accordance with the guidelines outlined in Ultrasonography in Obstetrics and Gynecology [16]. Biparietal diameter (BPD) was measured from the outer border of the skull to the inner border of the skull (outer-inner). Head circumference (HC) was measured at the plane of the third ventricle with the thalami in the central portion and the cavum septi pellucidi visible in the anterior portion. Abdominal circumference (AC) was measured through the transverse section of the fetal abdomen at the level of the stomach and bifurcation of the main portal vein. Femur length (FL) was measured from the greater trochanter to the lateral condyle. Estimated fetal weight (EFW) was calculated according to the model of Hadlock et al. [1], which was shown to be the most accurate in comparison with birth weights in the Israeli population [17].

Our data was compared to the study by Dolberg et al. [4] who established standardized birth weight data from 754,713 singleton.

Several different ultrasound systems were used over the years: GE LOGIQ 7 ultrasound, Voluson 730 Expert, Voluson E6 and E8 (GE Healthcare, Milwaukee, WI, USA). The study was approved by the Institutional Helsinki Review Board of the Sheba Medical Center.

Statistical Methods

Crude data were first used to calculate percentiles 1, 5, 10, 25, 50, 75, 90, 95 and 99 for each parameter (AC, FL, HC, BPD and EFW). Due to limited observations before week 20 and after 41 weeks of gestation, analysis was done only within this interval.

Exploring the plots of these quintiles by day revealed that the dependence of the quintiles on day is not linear (but rather close to linear); the dependence is not smooth and has some substantial fluctuations. The extreme quintiles (1 and 99) are much less stable than the other quartiles and the median.

We compared the crude plots (not smoothed) with non-parametric (LOWESS) smoothing of raw quintiles [18], fractional polynomial quintile regression [19] and cubic polynomial quintile [20]. We revealed that both polynomial quartile regressions failed to express important features of the crude plot. Fractional polynomial failed to demonstrate the decreasing rate of growth at the end of pregnancy, and cubic regression added an artificial elevation of 95 and 99 quartiles at the beginning of the time interval. Therefore, we applied non-parametric (LOWESS) smoothing of raw quintiles to produce nomograms for each parameter. All calculations were done using STATA 12© software.

The 50th percentile of our calculated EFW was compared to the 50th percentile of the most common plot used in Israel Dollberg et al. [4] for singleton infants. The median weight per week (for weeks 22 to 41 where both methods presented the data) were compared using the paired t-test and the Wilcoxon rank test. The relative difference in each week was defined as the difference (ours-Dollberg) divided by the average weight in this week (ours+Dollberg)/2.

Results

Table 1: Number of examinations at different gestational weeks.

Week of Gestation	No. of Examinations
20+0 - 20+6	812
21+0 - 21+6	849
22+0 - 22+6	1172
23+0 - 23+6	1240
24+0 - 24+6	1369
25+0 - 25+6	1605

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26+0 - 26+6	1755
27+0 - 27+6	1912
28+0 - 28+6	2129
29+0 - 29+6	2268
30+0 - 30+6	2645
31+0 - 31+6	2836
32+0 - 32+6	3128
33+0 - 33+6	3319
34+0 - 34+6	3721
35+0 - 35+6	4602
36+0 - 36+6	5522
37+0 - 37+6	6978
38+0 - 38+6	9411
39+0 - 39+6	9415
40+0 - 40+6	12,388
41+0 - 41+6	3607
Total	82,683

During the 9 year period, 82,725 reports of routine examinations were recorded in our institute. Of these, 82,683 were included in the analysis. Table 1 summarizes the number of observations per week of gestation. We included all reports that produced calculated EFW in the liberal range of 100 to 5000g for week 20 and 1000 to 10,000g for week 40. Examinations missing either one of the four biometrical parameters (AC, HC, FL, BPD) were also excluded. Multiple examinations of the same fetus were included at different weeks of gestation.

Figure 1 show the raw data for calculated EFW. Table 2 summarizes the mean and fitted centiles for calculated EFW.

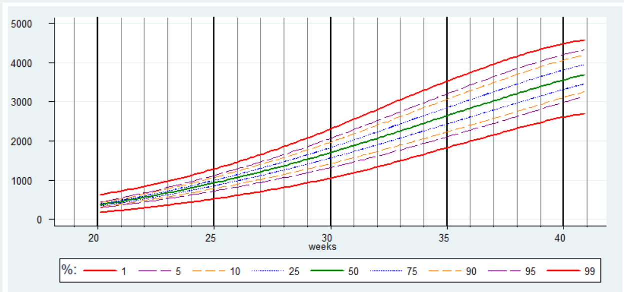

Figure 1: Percentiles of calculated estimated fetal weight.

Table 2: Predicted EFW for the 1, 5, 10, 25, 50, 75, 90, 95, 99 percentile for each week of gestation.

Gestational Age (wk)	p01	p05	p10	p25	p50	p75	p90	p95	p99
20	178	303	326	351	377	403	430	447	635
21	229	365	395	427	458	491	525	547	723
22	294	443	482	523	562	604	647	675	840
23	364	530	577	628	676	725	778	813	973
24	440	624	679	740	798	857	919	962	1121
25	523	725	788	861	928	998	1070	1121	1285
26	613	831	903	988	1067	1147	1230	1290	1463
27	710	944	1024	1122	1213	1305	1400	1468	1654
28	814	1062	1151	1264	1367	1472	1579	1656	1857
29	927	1188	1284	1413	1531	1649	1769	1855	2076
30	1052	1321	1426	1569	1703	1835	1970	2066	2309
31	1189	1464	1575	1734	1883	2031	2182	2288	2553
32	1338	1615	1732	1904	2070	2234	2402	2517	2803

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33	1499	1774	1895	2080	2261	2441	2625	2748	3050
34	1664	1938	2062	2257	2452	2647	2846	2977	3290
35	1829	2105	2232	2436	2644	2853	3065	3202	3523
36	1994	2276	2404	2614	2834	3056	3281	3423	3747
37	2158	2451	2579	2793	3023	3257	3492	3638	3961
38	2320	2629	2755	2971	3208	3454	3697	3845	4161
39	2475	2810	2933	3146	3387	3642	3891	4037	4338
40	2610	2988	3108	3316	3556	3815	4062	4203	4483
41	2689	3132	3250	3452	3689	3947	4184	4316	4575

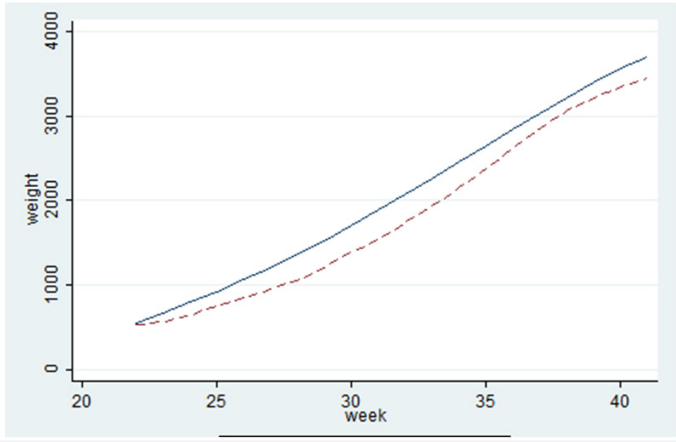

Figure 2: Comparison of our EFW 50th percentile with those of Dollberg et al. [4].

Comparison of our results of the median EFW to the Dollberg percentiles commonly used in our department is shown in Figure 2. The estimated median weight per week was larger in our curves compared to that of Dollberg et al. [4] (P<0.0001). The mean absolute difference was 230.6±84.8 g (range 32-343g). The mean relative difference was 14.7 ± 7.3% (range 4.7-25.3%).

Table 3-6 show the predicted head circumference biparietal diameter, abdominal circumference and femoral length respectively for each gestational week. These were added given the importance of customized chart use in this population.

Table 3: The predicted HC for the 1, 5, 10, 25, 50, 75, 90, 95, 99 percentile for each week of gestation

Gestational week	p01	p05	p10	p25	p50	p75	p90	p95	p99
20	127	170	175	181	186	192	196	199	215
21	141	179	184	190	195	201	206	209	223
22	157	189	194	200	206	212	217	220	233
23	172	200	205	211	217	223	228	231	244
24	185	210	215	221	227	233	238	242	254
25	197	219	225	231	237	243	249	253	263
26	209	229	234	241	247	253	259	263	273
27	220	238	243	250	256	263	269	273	282
28	230	247	252	259	265	272	278	282	292
29	240	255	261	267	274	281	287	291	300
30	248	263	268	275	282	289	295	300	309
31	256	271	276	283	290	297	303	307	317
32	264	278	283	290	297	304	311	315	324
33	271	284	289	296	303	310	317	322	331
34	278	290	295	302	309	316	323	328	337
35	284	295	300	308	315	322	329	333	343
36	290	301	305	313	320	327	334	338	348

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37	295	306	310	317	324	332	339	343	352
38	300	310	315	322	329	336	343	347	356
39	305	314	319	325	332	340	346	351	360
40	309	318	322	329	336	343	349	353	363
41	312	321	325	331	338	346	352	355	364

Table 4: The predicted BPD for the 1, 5, 10, 25, 50, 75, 90, 95, 99 percentile for each week of gestation.

Gestational week	p01	p05	p10	p25	p50	p75	p90	p95	p99
20	36	45	46	48	50	52	53	54	61
21	39	47	49	51	53	54	56	57	63
22	43	50	52	54	56	57	59	60	65
23	47	53	55	57	59	60	62	63	68
24	50	56	58	60	62	63	65	66	70
25	53	59	60	62	64	66	68	69	73
26	56	61	63	65	67	69	71	72	76
27	59	64	66	68	70	72	74	75	78
28	62	67	68	70	73	75	76	78	81
29	64	69	71	73	75	77	79	80	83
30	67	71	73	75	77	80	82	83	86
31	69	73	75	78	80	82	84	85	88
32	71	76	77	80	82	84	86	87	90
33	74	78	79	82	84	86	88	89	92
34	76	79	81	83	86	88	90	91	94
35	78	81	83	85	87	90	92	93	96
36	80	83	85	87	89	91	93	95	97
37	82	85	86	88	91	93	95	96	98
38	83	86	88	90	92	94	96	97	99
39	85	88	89	91	93	95	97	98	100
40	87	89	90	92	94	96	98	99	101
41	88	90	91	93	95	97	99	100	102

Table 5: The predicted AC for the 1, 5, 10, 25, 50, 75, 90, 95, 99 percentile for each week of gestation.

Gestation Week	p01	p05	p10	p25	p50	p75	p90	p95	p99
20	113	146	151	156	162	168	174	178	197
21	124	154	159	165	171	177	183	187	206
22	135	164	169	175	182	188	194	198	216
23	147	173	179	186	192	199	205	210	227
24	158	183	189	196	203	210	217	221	237
25	168	192	199	206	213	220	228	233	248
26	178	201	208	216	224	231	239	244	259
27	189	211	218	226	234	242	250	255	270
28	198	220	227	236	244	252	261	266	280
29	208	229	236	246	254	263	271	277	291
30	217	237	245	255	264	273	282	288	302
31	227	246	254	264	274	283	292	299	313
32	236	255	263	274	284	293	303	309	324
33	246	263	271	282	293	303	313	319	334

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34	255	272	280	291	302	312	322	329	344
35	263	280	288	299	310	321	332	338	353
36	271	289	296	307	319	330	340	347	361
37	278	297	304	315	327	338	349	356	369
38	285	305	312	323	334	346	357	364	377
39	290	313	319	330	341	353	364	371	384
40	293	321	327	337	348	360	371	377	389
41	292	327	333	342	353	365	375	381	393

Table 6: The predicted FL for the 1, 5, 10, 25, 50, 75, 90, 95, 99 percentile for each week of gestation.

Gestational week	p01	p05	p10	p25	p50	p50	p50	p95	p99
20	24	32	33	34	36	37	38	39	44
21	26	34	35	37	38	39	41	41	46
22	29	36	38	39	40	42	43	44	48
23	32	39	40	42	43	44	46	47	50
24	34	41	42	44	45	47	48	49	52
25	37	43	45	46	48	49	51	52	54
26	40	46	47	49	50	52	53	54	56
27	42	48	49	51	52	54	56	56	59
28	44	50	51	53	55	56	58	59	61
29	47	52	54	55	57	59	60	61	63
30	49	54	56	57	59	61	62	63	65
31	52	56	58	59	61	63	64	65	67
32	54	58	60	61	63	65	66	67	69
33	56	60	61	63	65	67	68	69	71
34	58	62	63	65	67	69	70	71	73
35	60	64	65	67	69	70	72	73	75
36	62	65	67	68	70	72	74	75	77
37	64	67	68	70	72	74	75	76	78
38	66	69	70	71	73	75	77	78	80
39	68	70	71	73	75	77	78	79	81
40	70	72	73	74	76	78	79	80	83
41	71	73	74	75	77	79	80	81	84

Discussion

In this study we compared new growth charts for the common fetal biometric variables in order to compare them to the actual neonatal birth weight, for the Israeli population, based on a large and minimally selected sample size. We used over 82,000 ultrasound examinations of singleton fetuses distributed from 20 to 41 weeks of pregnancy. Only examinations of fetuses with known gestational age and complete biometry were included. The data were collected by many professionals using the same methodology for fetal biometry accepted in our institute, and with numerous ultrasound devices, which is relevant for building a referral practical clinical tool. Our data include a relatively large number of examinations in the early stages of pregnancy. This enables wide data distribution, leading to better statistical analysis especially at the extreme percentiles.

The use of cross-sectional growth charts is the first-line screening tool for assessing fetal growth, and the customization of fetal growth charts improves the ability to detect high risk fetuses [10]. It has been demonstrated that in a genetically heterogeneous population, the need exists for constructing national charts of fetal biometry based on large cohorts of the local population.

The importance of tailored charts for the population studied is extremely important in prenatal consultations. For example, one of the main factors associated with differences in head growth measurement is ethnicity [21]. An Israeli study presented four women referred to a neuro-fetal clinic for isolated fetal microcephaly. Striking differences in percentiles were found between different professionals using different charts. In all children, measured head circumference after birth/termination was within normal limits [22].

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Currently in customary clinical practice, most centers in Israel use either American or European charts to assess biometric parameters. These studies are based on a relatively small number of examinations and on selective populations. For example, in our institute we use the Altman and Chitty charts published in 2002 to assess femur length percentiles. These charts are based on 663 ultrasound scans and they include only western European and Afro-Caribbean racial groups [23]. Abdominal circumference and head circumference are referred to the Hadlock charts which are based on 361 fetuses and were published in 1984 [24].

When comparing our EFW chart to the commonly used Israeli infant birth weight chart created by Dollberg et al. [4]. We demonstrated a statistically significant difference through all weeks of gestation, with larger EFW observed for each week when compared to neonatal birth weight. This variance is of clinical importance in prenatal counseling, for the actual fetal weight is larger than previously expected in this population. This discrepancy may be explained by the fact that fetal birth weight is calculated by mathematic formulas and not by the actual weight at birth. Additionally, during the early half of the pregnancy it is possible that neonates delivered at that early stage were small for gestational age due to maternal disease which necessitates early delivery.

In conclusion, we constructed new Growth plot charts for fetal biometric variables suitable for the Israeli population, based on a large number of observations. The significant differences between our prenatal sonographic based growth plot charts and neonatal actual birth weight plot charts justify the use of our charts for prenatal assessment of fetal growth.

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