PRACE ORYGINALNE
położnictwo

Fetal biometry between 20-42 weeks of gestation for Polish population

Biometria płodowa dla przedziału od 20 do 42 tygodnia ciąży w polskiej populacji

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Abstract

Objective: *Ultrasound estimating of fetal weight is one of the most frequent examinations during pregnancy. Hitherto, foreign fetometry curves have mostly been used in Poland as there are no national available reference charts that are based on ultrasound fetal biometry. The aim of the present study was to construct new charts based on ultrasound fetometry reference for Polish population.*

Study design: *A group of 959 healthy volunteers with uncomplicated singleton pregnancy joined in a cross-sectional study. The study was designed prospectively to evaluate normal reference charts for fetal ultrasound measurements and estimated fetal weight. Four biometric parameters were studied: biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC) and femur length (FL). Estimated fetal weight (EFW) was calculated using Hadlock et al. formula from 1985.*

Results: *In the course of normal pregnancy an acceleration of growth rate was seen, but with a slight decline at the end of pregnancy. Reference curves for mean, 90th and 95th percentile were constructed for BPD, HC, AC and FL. Estimated fetal weight curves were outlined for both boys and girls.*

Conclusion: *Reference charts for Polish population are similar to foreign curves. Less variation was seen in comparison with national charts based on postnatal weight. Ultrasound method seems to be better than birthweight curves especially in preterm pregnancies. This will improve the diagnosis of a small for gestational age newborn.*

Key words: **fetal biometry** / **fetal weight** / **ultrasonography** / **pregnancy** /

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Otrzymano: **15.09.2008**
Zaakceptowano do druku: **15.10.1008**

Streszczenie:

Ultrasonograficzna ocena biometrii płodu jest jednym z najczęściej wykonywanych badań w perinatologii. Ocena wielkości płodu oraz szacunkowej masy płodowej ma duży wpływ na większość decyzji położniczych. W Polsce ze względu na ograniczony dostęp do krzywych referencyjnych opartych na polskiej populacji, ocena fetometryczna bazuje na siatkach centylowych zagranicznych.

Cel pracy: *Celem przedstawionej pracy było opracowanie nowych krzywych referencyjnych biometrii płodowej dla polskiej populacji.*

Materiał i metody: *Bazę danych utworzono w oparciu o 959 zdrowych ciężarnych z niepowikłanym przebiegiem ciąży. Badania wykonano metodą cross-sectional, czyli każda pacjentka miała wykonane badanie ultrasonograficzne jednorazowo. Krzywe referencyjne utworzono dla następujących czterech parametrów: wymiar dwuciemieniowy (BPD), obwód głowy (HC), obwód brzucha (AC), długość kości udowej (FL). W dalszej części pracy opracowano prospektywne krzywe referencyjne dla szacunkowej masy płodowej (EFW), oddzielnie dla płci żeńskiej i męskiej. Szacunkowa masa płodowa była obliczona w oparciu o formułę Hadlocka z 1985 r.*

Wyniki: *Uzyskane krzywe biometryczne charakteryzowały się stopniowym przyspieszeniem dynamiki wzrostu płodów z niewielkim zwolnieniem trendu wzrostowego pod koniec ciąży. Krzywe dotyczące szacunkowej masy płodów męskich różniły się od krzywych opracowanych dla płodów żeńskich.*

Wnioski: *W trakcie analizy porównawczej wykazano, że kształt krzywych referencyjnych zagranicznych jest zbliżony do uzyskanych w przedstawionej pracy.*

Wydaje się, że prospektywne siatki centylowe powstałe na bazie ultrasonografii mogą dokładniej oceniać prawidłowy wzrost płodu w porównaniu do krzywych referencyjnych opartych na ocenie masy noworodków z porodów przedwczesnych.

Przedstawione nowe krzywe referencyjne mogą być przydatne w ocenie prawidłowego lub nieprawidłowego wzrostu płodu. Każde odchylenie wielkości płodu od wzrostu optymalnego dla danej populacji powinno być wskazaniem do rozszerzenia diagnostyki.

Słowa kluczowe: **płód** / **biometria** / **ciąża** / **masa płodu** / **ultrasonografia** /

Introduction

Fetal biometry is one of the most common examinations in perinatal diagnosis. It allows estimating of gestational age, growth and approximate fetal weight. In obstetrical practice, many decisions are dependent on estimated fetal weight, which reflects fetal growth and development. Accurate estimating of fetal weight is very important. Appropriate diagnosis of intra-uterine growth restriction (IUGR) or macrosomia enables supervision of these high-risk pregnancies, which often influences the mode of delivery.

Several publications have appeared on fetal biometry presenting growth and estimated fetal weight curves, appropriate for the populations on which they were constructed [1-5]. Many factors influence the normal growth such as socioeconomic status, race and geographic climate. Gestational age related curves are therefore needed for different geographic populations.

Hitherto, foreign fetometry curves have been used in Poland [1, 4, 6], as there were no available national reference charts based on ultrasound fetal biometry. Due to differences between populations, it is necessary to provide new growth curves, which will reflect current fetal growth and estimated fetal weight in the Polish population. The Polish curves presently used are based on postnatal growth curves [7], which obviously would be inappropriate for premature delivery [5]. These birthweight curves were gathered on pregnancies where gestational age was based on last menstrual period and not on early ultrasound dating. Ultrasound fetometry is better indicator of weight deviation than birthweight curves as has been shown by Marsal et al. [5].

The aim of the present study was to evaluate new reference charts based on ultrasound fetometry for biparietal diameter (BPD), head circumference (HC), femur length (FL), abdominal circumference (AC), and to estimate fetal weight (EFW) for the Polish population. Furthermore, to compared the results with the foreign reference curves and the birthweight curves that are presently in use in Poland.

Material and methods

A group of 1133 healthy volunteers with uncomplicated singleton pregnancy joined the cross-sectional study in a rural population. The study was designed prospectively to evaluate normal reference charts for fetal ultrasound measurements and estimate fetal weight. All pregnancies had an uneventful course of pregnancy and labour. All patients gave informed consent and the study protocol has been approved by the Hospitals Ethics Committees. To select the patients for the study group, the following criteria had to be fulfilled:

1. Uncomplicated course of pregnancy.
2. Singleton pregnancy.
3. Delivery after 37 weeks' of gestation.
4. No chromosomal or anatomical malformations.
5. Non-smokers.
6. Caucasian race and Polish habitants and nationals.

Based on these criteria, 174 cases had to be excluded. A total of 959 pregnancies were thus included in the study. Gestational age was established by crown-rump-length measurement performed in the first trimester in all pregnancies.

All ultrasound measurements were obtained by one experienced examiner (MK) using commercially available ultrasound unit with 2-5 MHz abdominal probe (LOGIQ 200, GE Health Care, USA). In the beginning of the study, an interobserver variability study was performed between authors MK and MD. The outcome was excellent. The pregnancies were recruited equally distributed from 20 to 41 weeks of gestation. There were only 5 pregnancies at 42 weeks of gestation. A part from that the median number of cases for each gestational week was 44 (range 34-48).

Four biometric parameters were studied according to the standards: biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC) and femur length (FL). Each measurement was obtained three times and the mean was used for analysis. Fetal head measurements were taken in a horizontal plane showing a central mid-line echo and the anterior and posterior horns of the lateral ventricles at the level of cavum septi pellucidi and the thalamus.

BPD was measured by placing the calipers in the outer to inner surface of the parietal bones on opposite sides. HC was measured using an ellipse, which surrounded the scull on the same level as BPD was taken [8].

The AC was obtained in a transverse plane perpendicular to the fetal spine at the level of bifurcation of the main portal vein into left and right branches and the stomach, using an ellipse, which included outer borders of the skin [9]. FL was measured from the great trochanter to the lateral epicondyle [10].

Estimated fetal weight (EFW) was calculated using Hadlock et al. formula from 1985 [1].
log10 = 1.3596 - 0.00386 x AC x FL + 0.0064 x HC + 0.00061 x BPD x AC + 0.0424 x AC + 0.174 x FL .

The gestation age formulas were obtained by quadratic polynomial regression analysis using the computer software SPSS (SPSS Inc.). Statistica version 5.0 (StatSoft, Inc.) was used to construct the graphs based on the formulas. Curves for all measured parameters were calculated for gestational age median, 5th, 10th, 90th and 95th percentiles. Curves for ±2SD were also calculated. Estimated fetal weight curves were also calculated separately for the male and female subgroups.

Results

Figures 1, 2, 3 and 4 show diameters of BPD, HC, FL, AC against gestational age gives as median, 5th, 10th, 90th and 95th. The ±2SD curves were nearly the same as the 5th and 95th percentile. The polynomial regression formulas and SD are given in Table I.

Table II-V give gestational age related figures for the median, 5th, 10th, 90th and 95th percentiles for BPD, HC, FL and AC in our study population.

Figure 5 and 6 give male and female estimated fetal weights (EFW) plotted against gestational age also presents the mean and the 5th, 10th, 90th and 95th. The Hadlock formula from 1985 was used to calculate fetal weight from ultrasound biometric parameters for BPD, HC, FL and AC.

Table I. Calculated regression slopes of ultrasound measured parameters related to gestational age for the study population.

Parameter	Polynomnial regression slope	SD
BPD	LOG 10 = 1,885627 + 0,017795*GA - 0,000190*GA^2	0,00877
HC	LOG 10 = 1,925127 + 0,033314*GA - 0,000386*GA^2	0,01280
AC	LOG 10 = 1,888435 + 0,031625*GA - 0,000313*GA^2	0,01641
FL	FL = -0,747357 + 0,400971*GA - 0,004082*GA^2	0,17646

BPD – biparietal diameter
HC – head circumference
AC – abdominal circumference
FL – femur length
GA – gestational age
SD – standard deviation

Table VI-VIII give gestational age related figures for the median, 5th, 10th, 90th and 95th percentiles for estimated birthweight for boys, girls and the mean of both sexes. In the course of normal pregnancy the acceleration of growth rate is seen, but with a slight decline at the end of pregnancy.

Three phases are seen in increasing EBW: first slow phase, second acceleration phase, and third phase of slowing down. With advancing gestational age the standard deviation (SD) and variation of EFW increased. The boys are slightly smaller in the beginning of the study period, but weigh 2.5% more at term. (Table VI-VII).

Figure 7 shows estimated median fetal weight from the current study with comparison to prospective birthweight estimation from newborns by Malewski et al. in 19957. It seems that scattering is less in the ultrasound estimated data in the present study. Fetal weight was slightly lower in the beginning of the period and higher in term pregnancies as compare with data from 1995.

Discussion

The present results suggest that intrauterine ultrasound estimated fetal weight is different to weight curves designed from newborn birthweight. Fetal weight was lower in preterm pregnancies as compared with the postnatal curves for weight. (Figure 7).

This was unexpected as curves based on postnatal weight might be lower in preterm newborns, which often are complicated pregnancies [5]. The postnatal curves [7] were based on gestational age estimation from the last menstrual period, which might be one reason for the difference. Weight was also lower at term in the old curves. There was also less scattering in the ultrasound estimated data. (Figure 7).

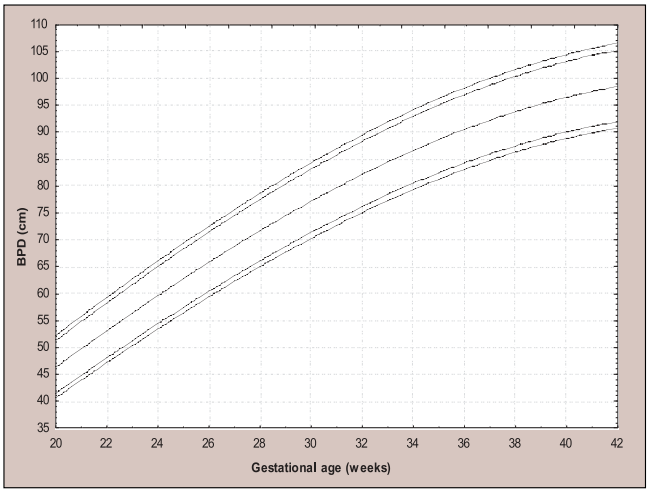

Figure 1. Biparietal diameters (BPD) plotted against gestational age; median, 5th, 10th, 90th and 95th percentile in the course of normal pregnancy.

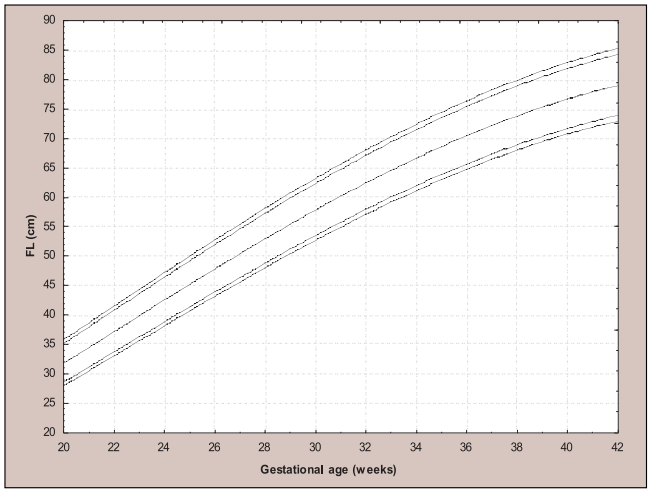

Figure 2. Femur length (FL) plotted against gestational age; median, 5th, 10th, 90th and 95th percentile in the course of normal pregnancy.

Table II. Reference ranges for fetal biparietal diameter (BPD) in mm. Median, 5th, 10th, 90th and 95th percentiles are given for the study population.

Gest. age	5th	10th	median	90th	95th
20	41	42	46	51	52
21	44	45	50	55	56
22	47	48	53	58	59
23	50	51	56	62	63
24	53	54	60	65	66
25	56	57	63	68	69
26	59	60	66	71	73
27	62	63	69	75	76
28	65	66	72	78	79
29	68	69	75	80	82
30	70	71	77	83	84
31	73	74	80	86	87
32	75	76	82	88	90
33	77	78	84	91	92
34	79	80	87	93	94
35	81	82	89	95	96
36	83	84	90	97	98
37	85	86	92	99	100
38	86	87	94	100	102
39	88	89	95	102	103
40	89	90	96	103	104
41	90	91	98	104	106
42	91	92	98	105	107

Table III. Reference ranges for fetal femur length (FL) in mm for gestational age in weeks. Median, 5th, 10th, 90th and 95th percentiles are given for the study population.

Gest. age	5th	10th	median	90th	95th
20	28	29	32	35	36
21	31	31	34	38	39
22	33	34	37	41	42
23	36	36	40	44	44
24	38	39	43	46	47
25	41	41	45	49	50
26	43	44	48	52	53
27	46	46	50	55	55
28	48	49	53	57	58
29	50	51	55	60	61
30	53	54	58	62	63
31	55	56	60	65	66
32	57	58	62	67	68
33	59	60	65	69	70
34	61	62	67	72	72
35	63	64	69	74	75
36	65	66	71	75	76
37	66	67	72	77	78
38	68	69	74	79	80
39	69	70	75	81	82
40	71	72	77	82	83
41	72	73	78	83	84
42	73	74	79	84	85

Fetal biometry between 20-42 weeks of gestation for Polish population.

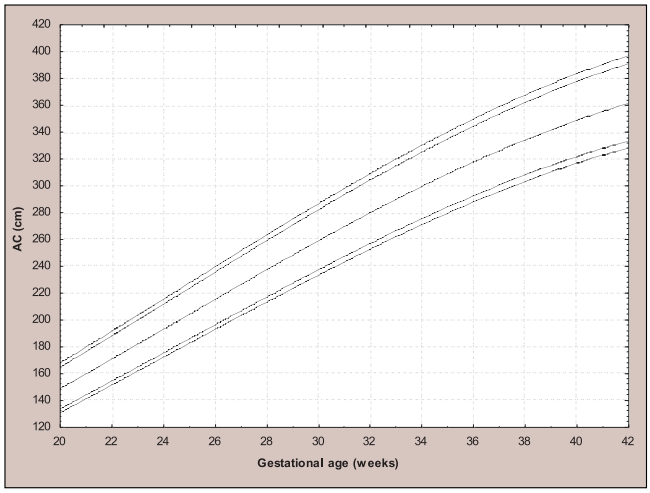

Figure 3. Abdominal circumference (AC) plotted against gestational age; median, 5th, 10th, 90th and 95th percentile in the course of normal pregnancy.

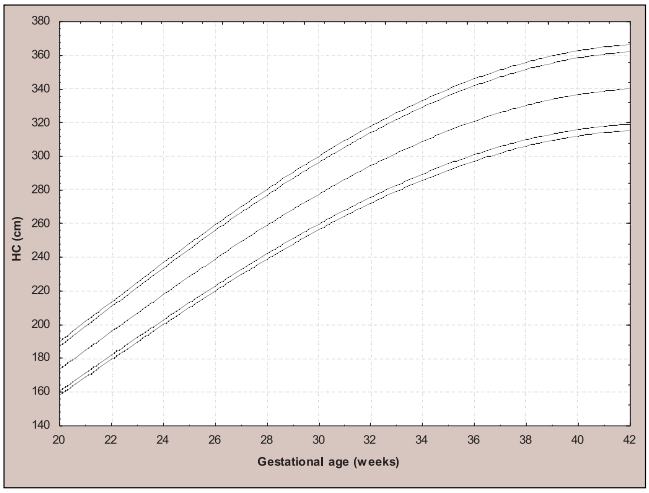

Figure 4. Head circumference (HC) plotted against gestational age; median, 5th, 10th, 90th and 95th percentile in the course of normal pregnancy.

Table IV. Reference ranges for fetal abdominal circumference (AC) in mm for gestational age in weeks. Median, 5th, 10th, 90th and 95th percentiles are given for the study population.

Gest. age	5th	10th	median	90th	95th
20	131	134	149	165	167
21	141	144	160	176	179
22	151	154	171	188	191
23	162	165	182	200	203
24	172	175	193	212	215
25	183	186	204	224	227
26	193	196	215	236	239
27	203	207	227	248	252
28	213	217	238	259	264
29	224	227	248	271	275
30	233	237	259	282	287
31	243	247	270	293	298
32	253	257	280	304	309
33	262	266	290	315	320
34	271	275	300	325	330
35	280	284	309	335	340
36	288	293	318	345	350
37	296	301	326	354	359
38	303	308	334	362	368
39	310	315	342	370	376
40	317	322	349	378	384
41	323	328	356	385	391
42	328	334	362	391	397

Table V. Reference ranges for fetal head circumference (HC) in mm. Median, 5th, 10th, 90th and 95th percentiles are given for the study population.

Gest. age	5th	10th	median	90th	95th
20	158	161	174	187	190
21	169	171	185	199	202
22	179	182	196	211	214
23	190	193	207	222	225
24	200	203	218	234	237
25	210	213	229	245	248
26	220	223	239	256	259
27	230	233	249	267	270
28	239	242	259	277	281
29	248	251	269	287	291
30	257	260	278	297	300
31	265	268	286	306	309
32	272	276	295	314	318
33	279	283	302	322	326
34	286	290	309	329	333
35	292	296	315	336	340
36	297	301	321	342	346
37	302	306	326	347	352
38	306	310	330	352	356
39	310	313	334	356	360
40	312	316	337	359	363
41	314	318	339	361	365
42	315	319	340	362	367

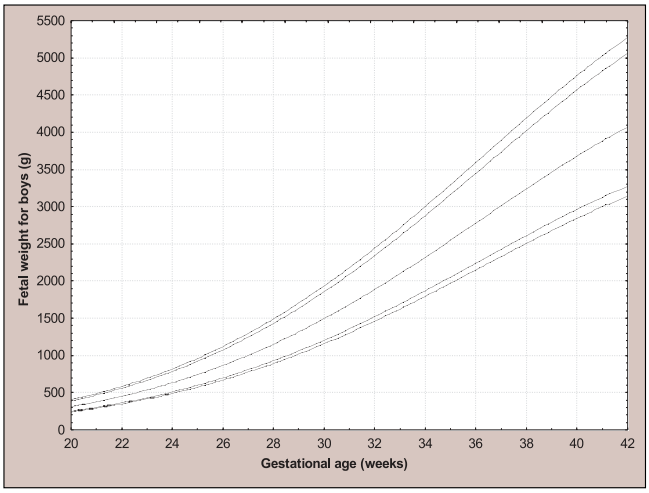

Figure 5. Male estimated fetal weight (g) plotted against gestational age; median, 5th, 10th, 90th and 95th percentile in the course of normal pregnancy.

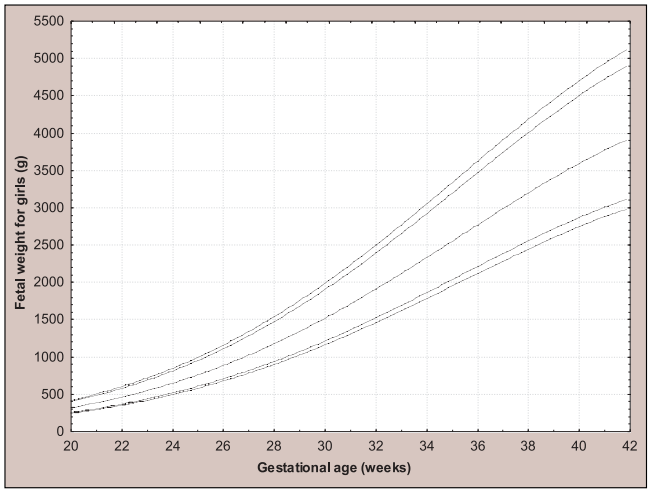

Figure 6. Female estimated fetal weight (g) plotted against gestational age; median, 5th, 10th, 90th and 95th percentile the course of normal pregnancy.

Table VI. Reference ranges for fetal boys weight in gram for gestational age in weeks. Median, 5th, 10th, 90th and 95th percentiles are given.

Gest. age	5th	10th	median	90th	95th
20	241	251	312	388	404
21	290	303	376	467	487
22	348	363	450	559	582
23	414	431	535	664	692
24	500	521	647	803	837
25	574	598	742	920	959
26	669	697	865	1073	1118
27	784	819	1025	1284	1326
28	890	928	1152	1429	1489
29	1017	1060	1316	1633	1702
30	1175	1225	1520	1886	1966
31	1307	1364	1708	2137	2227
32	1458	1520	1886	2341	2440
33	1623	1691	2099	2604	2715
34	1794	1870	2320	2878	3000
35	1969	2053	2547	3160	3294
36	2148	2239	2778	3447	3593
37	2327	2426	3010	3735	3893
38	2505	2611	3240	4020	4191
39	2677	2791	3464	4299	4482
40	2842	2963	3679	4568	4762
41	2997	3125	3882	4822	5027
42	3139	3273	4068	5057	5273

Table VII. Reference ranges for fetal weight for girls in gram. Median, 5th, 10th, 90th and 95th percentiles are given.

Gest. age	5th	10th	median	90th	95th
20	245	256	321	402	420
21	303	317	397	497	519
22	354	370	463	580	606
23	421	440	551	690	720
24	497	519	650	814	850
25	583	609	762	955	997
26	679	709	888	1112	1161
27	785	820	1027	1286	1342
28	902	941	1179	1476	1541
29	1028	1073	1344	1683	1758
30	1164	1216	1522	1906	1991
31	1309	1367	1712	2144	2239
32	1462	1526	1912	2394	2500
33	1621	1693	2120	2655	2772
34	1785	1864	2334	2923	3053
35	1952	2039	2553	3197	3338
36	2120	2214	2772	3472	3625
37	2286	2387	2990	3744	3909
38	2448	2556	3202	4010	4187
39	2624	2740	3433	4300	4490
40	2748	2869	3595	4505	4705
41	2880	3008	3770	4727	4937
42	3056	3192	4006	5028	5252

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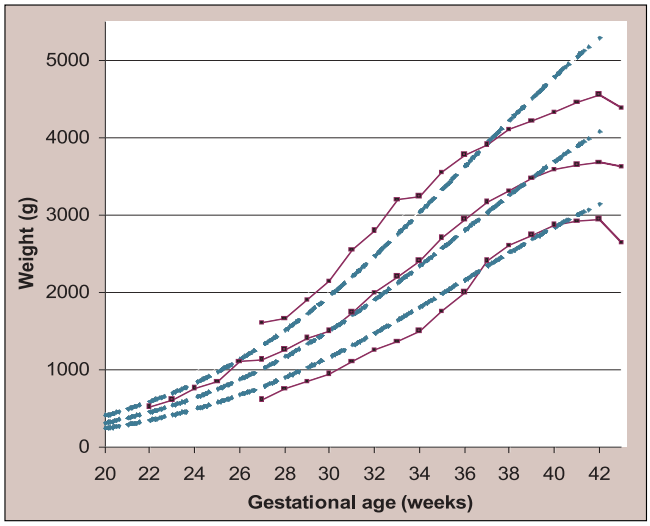

Figure 7. Boy's fetal weight estimation from present study (bold lines) compared to previous prospective Polish chart based on newborn boy's weight (dotted line). Median, 5th and 95th percentiles are given.

Table VIII. Reference ranges for fetal weight in gram for gestational age in weeks (mean of both sexes). Median, 5th, 10th, 90th and 95th percentiles are given.

Gest. age	5th	10th	median	90th	95th
20	243	253	316	395	412
21	297	310	386	482	503
22	351	366	457	569	594
23	417	435	543	677	706
24	499	520	649	809	844
25	578	603	752	938	978
26	674	703	876	1092	1140
27	785	820	1026	1285	1334
28	896	935	1165	1453	1515
29	1023	1067	1330	1658	1730
30	1170	1220	1521	1896	1978
31	1308	1365	1710	2140	2233
32	1460	1523	1899	2367	2470
33	1622	1692	2109	2630	2743
34	1789	1867	2327	2901	3027
35	1961	2046	2550	3179	3316
36	2134	2226	2775	3459	3609
37	2307	2407	3000	3739	3901
38	2476	2584	3221	4015	4189
39	2651	2766	3448	4300	4486
40	2795	2916	3637	4536	4733
41	2939	3066	3826	4774	4982
42	3097	3233	4037	5042	5263

During the years there have been many attempts to estimate fetal intrauterine growth based on ultrasound. Numerous authors were searching for proper formulas that would be able to estimate fetal weight by means of ultrasound dimensions. The first formulas used only the abdominal perimeter to estimate fetal growth, but as abdominal perimeter did not reflect the whole growth of fetus, a need to use more dimensions arose. Numerous publications have since then appeared on fetal biometry and many dimensions have been studied *ie.* biparietal diameter (BPD), occipital diameter (OFD), head circumference (HC), femur length (FL), abdominal circumference (AC), transverse cerebellum diameter (TCD) and cisterna magna diameter (CM) [6, 14, 15, 16, 17].

We choose the Hadlock formula published in 1985, which is based on BPD, HC, AC and FL as it has been widely used in Poland for intrauterine weight estimation [1].

The estimated fetal weight from the present study was compared with some of the previously published curves [11, 19, 20, 21, 22]. Differences were seen emphasizing the need for national reference curves. Curves presented by Higginbottom et al. [19] showed lower fetal weight throughout gestation. Jeanty et al. [11] and Thurnau et al. [20] showed lower fetal weight after 36 weeks of gestation. Thurnau et al. [20] show also higher values in the first part of the study period. These publications were the earliest in that comparison. The results might therefore be biased by old ultrasound equipment.

Presented study was designed as a prospective cross-sectional instead of a longitudinal study. Longitudinal charts have also been used for serial examinations [3, 5, 11, 12, 13], but some of these publications were based on a small study group [12, 13], which might not reflect the real variations in population and thus be less accurate. Only longitudinal studies with large study groups reflect the real variation in the population and may be considered as appropriate [3].

Poland has homogenous population. In other countries, which have multicultural society the use of a single fetal weight standards is more questionable. Many factors can influence fetal growth. These include parity, maternal weight and height, length of gestation, smoking during pregnancy, gender and ethnic origin. There is a need for normal fetal growth charts taking into account especially ethnicity in countries with a multiethnic population. This is available on the internet at: *http://www.hutchon.net/CESDIcalc.htm* which is based on data by Gardosi et al. [18].

This paper describes changes in major fetal biometric dimensions in the course of normal pregnancy. We have analyzed five parameters HC, BPD, AC, FL and EFW and constructed new normal reference charts for the Polish population based on ultrasound measurements. Such charts can be used to estimate fetal weight and growth, and seem to be more convincing than curves based on newborn birthweight.

Many obstetrical decisions depend on reference charts. The new reference curves will therefore improve diagnosis of weight deviation both intrauterine and postnatally.

ACKNOWLEDGEMENT

We acknowledge funding by Malmö University Hospital and Region Skane, Nicolaus Copernicus University, Torun, Poland and University of Medical Sciences, Poznan, Poland. The statistician Zoran Milosevic is acknowledged for constructing the graphs.

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