MEDICAL SCIENCES (2000), 2, 97–104

Evaluation of applicability of standard growth curves to healthy native Omani women by fetal biometry at selected gestational ages

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تقييم إمكانية تطبيق منحنيات معايرية للنمو على الحوامل العمانيات بواسطة القياسات الحيوية للجنين

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الملخص: الهدف: التحقق من إمكانية تطبيق المنحنيات القياسية لنمو الجنين المقترحة للشعوب الغربية على العمانيات. **الطريقة:** تم مسح ١٦٥ حامل عمانية طبيعية على مراحل مختلفة من الحمل، بالموجات فوق الصوتية لقياس نمو الجنين بحساب محيط جداري الرأس، محيط الرأس، منسب الرأس، محيط البطن وطول عظم الفخذ. قورنت النتائج مع معايير موصى بها.**النتائج:** لم تتفق نتائجنا مع أي من المعايير ما عدا معايير صباغا ووكسلر لمحيط الجداريين وقياس جيني لطول عظم الفخذ. **الخلاصة:** بسبب عدم التطابق مع غالبية المنحنيات الغربية ، من الضروري تطوير منحنيات خاصة لنمو الأجنة في عُمان تجنبا للتشخيص المفرط لقصر النمو داخل الرحم.

ABSTRACT: ***Objective*** – To verify the applicability of standard fetal growth curves proposed for Western populations to an Omani population. ***Method*** – Ultrasound scans were performed at selected stages of gestation on 165 healthy Omani pregnant women to measure fetal growth parameters of biparietal diameter, head circumference, cephalic index, abdominal circumference and femur length. The data were compared with the commonly recommended standards of Hadlock, Campbell, Sabbagha, Wexler, Jeanty and others. ***Results*** – None of the standard charts agreed with the data in the present study except those of Sabbagha and Wexler for biparietal diameter and of Jeanty for femur length. ***Conclusion*** – Since most parameters of the standard growth curves developed in the West are not applicable for assessing the intra-uterine growth of Omani babies, it is necessary to develop growth curves for the Omani population to prevent over-diagnosis of intrauterine growth retardation.

KEY WORDS: ultrasonography, bi-parietal diameter, head circumference, abdominal circumference, femur length, fetal growth

Proper assessment of fetal well-being requires an accurate knowledge of the gestational age of the fetus.[1] From among the abundant charts and growth curves in the literature relating various ultrasonic fetal parameters to gestational age, only a few have been recommended as standard.[2] Queries have been raised regarding the applicability of these standard curves to a racially mixed population due to ethnic variations.[3,4,5] There might be a risk of over-diagnosing intra-uterine growth retardation in the Omani population. This study evaluates the validity of the standard growth curves proposed for Western populations to an Omani population.

METHOD

This prospective longitudinal cohort study was performed at the Sultan Qaboos University Hospital, a tertiary referral centre, from June 1995 to July 1997. Only those women who fulfilled the following criteria were included in the study.

1. Healthy Omani primigravidas, aged 20–30 years, with singleton pregnancies and cephalic presentation.
2. Certain last menstrual periods (LMP's), with regular menstrual cycles of 28 to 30 days. In each woman, gestational age was confirmed by an early scan prior to 20 weeks of gestation.
3. No history of oral contraceptive use in the 3 months prior to conception.
4. Women who had spontaneous onset of labour at term and delivered healthy live infants weighing greater than 2,500 g with no congenital anomalies.
5. Women who did not develop maternal or fetal complications during the pregnancies.
6. Fetal gestational age confirmed by senior neonatologist within the first two hours of delivery.

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The same patient was scanned serially on three occasions, between the following completed weeks of gestation: 17 and 20; 27 and 30; 35 and 37. Out of a total of 200 healthy pregnant Omani women originally included in the study, 35 were excluded due to maternal or fetal complications. While 165 women underwent their first scan, only 164 and 114 respectively attended the second and third scans.

The ultrasound machine used for the study was a Toshiba Sonolayer SSA–270A with a 3.75 MHz linear array transducer. To avoid inter-operator error, all the ultrasound examinations in this study were performed by the same senior ultrasonologist. The parameters measured on each examination were the bi-parietal diameter (BPD), head circumference (HC), cephalic index, femur length (FL) and abdominal circumference (AC). All parameters were measured following the guidelines of the British Medical Ultrasound Society – Fetal Measurements Working Party Report[2] (hereinafter referred to as BMUS guidelines). Measurements were repeated until three successive readings agreed to within 1 mm. and the average was taken.

Bi-parietal Diameter (BPD). This was measured from the leading edge of the echo from the proximal skull surface to the leading edge of the echo from the distal skull surface – 'outer to inner' diameter, as per the BMUS guidelines. The BMUS has recommended only four papers relating BPD to gestational age that meet the required statistical criteria: Levi and Smets,[6] Hadlock,[7] Shepard and Filly[8] and Campbell.[1]

Head Circumference (HC). Measured on the same section of the fetal head used for BPD. The occipito-frontal diameter was measured at this plane and the HC calculated using the formula: HC = (BPD + OFD) × 1.62. The BMUS has recommended the use of the data of Hadlock[9], Ott[19] and Deter[10] for this parameter.

Abdominal Circumference (AC). Measured on a transverse image of the fetus at the level of the umbilical vein. The circumference was measured by tracing around the outer edge of the image. The BMUS has recommended the papers of Deter,[10] Hadlock[11] and Jeanty.[1]

Femur Length (FL). Measured using a straight-line measurement between the two ends of the femoral diaphysis. The BMUS has recommended the papers of Hadlock,[13] Issel[14] and Warda.[15]

The gestational age in this study has been expressed as completed weeks of gestation and all measurements are in millimetres. Since nomograms for the various parameters of all the various recommended authors by BMUS were not available, we have, in addition, used nomograms of other authors.

STATISTICS

For each fetal parameter measured, the mean ±2SD was calculated for each of the studied weeks of gestation. These means were compared with the means of the published standards for each parameter.

Based on the data obtained from published standards, graphs were generated to show the relationship between gestational age and the means of the measured parameters. The data obtained in this study were superimposed as scatterplots for comparison.

For each parameter studied at a given gestational age, one-sample t-tests were performed, to compare the means we obtained against those calculated using the published standards. The equation used was

$t = (y - \mu) / S_Y$, where

y = the mean of the parameter calculated in the present study

S_Y = the standard error of the above mean

μ = the mean of the published standard

The null hypothesis (H_0) for the above test states that the mean of the parameters calculated for the Omani women is not significantly different from that of the published standard at 5% level ($p \leq 0.05$).

To assess the reliability of using published standards, an index of reliability was calculated as follows:

$$\text{Index of reliability} = \frac{\text{Number of means not significantly different}}{\text{Total number of weeks compared}} \times 100$$

The values calculated by this Index range from 0 to 100%. As a rule of thumb, ≥ 50% reliability is suggested as an acceptable limit for using the published standards.

Table 9 analyses the results of the one-sample t-test comparing the means calculated in the present study for various indices, against the published standards. For this, the standard error was calculated at each week of gestation and the means obtained were compared with the means or the50th percentiles of the published standards using the one-sample t-test.

All graphics and basic statistical calculations were obtained using Microsoft Excel 7 for Windows. All statistical procedures were adopted from Zar.[16]

RESULTS AND DISCUSSION

BIPARIETAL DIAMETER (BPD)

Table 1 shows the BPD measurements in mm for the Omani women studied. For each specified week of gestation, the number of women and the minimum and maximum measurements obtained are shown along with the mean ± 2SD.

Table 2 compares the BPD means ± 2SD obtained in the present study against the published standards of Hadlock,[7] Campbell,[1] Sabbagha[17] and Wexler.[18] In the present study, the values are expressed as mean ± 2SD while Sabbagha and Wexler expressed theirs as percentiles. All the data sets are comparable. The table shows

that all the means in the present study are higher than those presented by Hadlock and lower than those by Campbell. The means published by Sabbagha and Wexler are, however, in close agreement with the present study.

HEAD CIRCUMFERENCE (HC)

The minimum and maximum measurements along with the mean ± 2SD for the HC at each specified week of gestation are shown in Table 3.

Table 4 compares the mean ± 2SD against the standards of Hadlock[9] Ott [19] and Deter.[10] Hadlock and Ott have presented their data as mean ± 2SD. Deter has given the lower limit (LL), predicted value(PV) and upper limit(UL). All the data sets are comparable. Most of Hadlock's means are different from those in the present study. The means of Ott et al are all lower than the means in the present study, while most of Deter's means are higher.

ABDOMINAL CIRCUMFERENCE

Table 5 shows the minimum, maximum and mean ± 2SD for the abdominal circumference in the Omani population. A comparison of the obtained mean ± 2SD against the standards of Hadlock,[11] Deter [10] and Tamura[20] are presented in Table 6. Hadlock's data are presented as mean ± 2SD, Deter as lower limit (LL), predicted value (PV) and upper limit (UL) and Tamura as 5th, 50th and 95th percentile. The data sets are comparable. The reported means of all the three authors are higher than those obtained for the Omani women.

FEMUR LENGTH

The minimum and maximum measurements along with the mean ± 2SD are shown in Table 7. A comparison of the mean ± 2SD in the present study against the standards of Jeanty,[21] O'Brien[22] and Warda[15] are presented in Table 8. Jeanty has expressed the data as percentiles, O'Brien as mean ± 2SD and Warda as lower limit (LL), predicted value (PV) and upper limit (UL). Jeanty's data is in close agreement with the present study. The means of O'Brien are for the most part higher and Warda lower.

The gist of the index of reliability results is presented in Table 9. It can be seen that for Biparietal Diameter, only the data of Sabbagha and Wexler have a sufficient index of reliability (73%) to be relevant for Omani population. The data of Hadlock and Campbell have low reliability at 36.4% ($p \leq 0.05$) and cannot be used. Regarding Head Circumference, the indices of reliabilities of all the standard data are too low (36.4% 27.3% to 9.1%) to be useful. Similar low reliability is seen for the standard data on Abdominal Circumference. Here, the

TABLE 1

Biparietal Diameter measurements for Omani population in present study (All measurements in mm from outer to inner diameter)

GA	n	Min	Max	Mean 2± SD
17	7	35	43	40 ± 5
18	88	37	50	42 ± 5
19	44	36	51	44 ± 5
20	26	42	52	47 ± 6
27	7	64	73	70 ± 6
28	114	65	85	72 ± 6
29	29	66	81	74 ± 6
30	14	71	84	77 ± 8
35	6	86	96	89 ± 7
36	95	82	94	89 ± 5
37	13	83	94	90 ± 7

GA = Gestational age
n = Number of individuals studied

TABLE 2

Comparison of Biparietal Diameter for the Omani population studied against the standards of Hadlock[7], Campbell[1], Sabbagha[17] and Wexler[18] (All measurements in mm from outer to inner diameter)

	Hadlock			Campbell			Sabbagha			Wexler			Present Study		
GA	×2SD	×	×+2SD	×2SD	×	×+2SD	5%	50%	95%	5%	50%	95%	× 2SD	×	×+2SD
17	33	36	40	33.9	38.7	43.5	34	40	47	34	38	43	35	40	45
18	37	40	43	35.7	41.5	47.3	37	43	49	37	42	47	37	42	47
19	38	43	48	39.8	46.0	52.2	39	45	51	40	45	50	39	44	49
20	41	46	50	41.8	48.2	54.6	42	47	53	44	48	53	41	47	53
27	63	67	71	60.5	70.9	81.3	64	69	76	64	69	73	64	70	76
28	67	70	73	69.4	75.8	82.2	66	72	79	66	71	76	66	72	78
29	69	72	75	71.9	78.7	85.5	68	75	83	69	73	78	68	74	80
30	70	75	80	71.7	80.3	88.9	71	78	86	71	76	81	69	77	85
35	83	87	91	85.6	91.6	97.6	82	88	96	81	86	91	82	89	96
36	85	88	91	83.0	91.4	99.8	83	90	97	83	88	93	84	89	94
37	84	89	94	85.7	93.5	101.3	84	92	98	85	90	94	83	90	97

TABLE 3

Head Circumference (mm) in the present study

GA	n	Mini-mum	Maxi-mum	Mean ± 2SD
17	7	141	160	150 ± 15
18	88	138	189	154 ± 18
19	44	144	183	164 ± 18
20	26	158	191	175 ± 18
27	7	238	274	258 ± 24
28	114	234	303	264 ± 20
29	29	225	296	268 ± 25
30	14	254	298	276 ± 27
35	6	310	335	320 ± 17
36	95	290	337	318 ± 23
37	13	295	337	321 ± 23

GA = Gestational age
n = Number of individuals studied

TABLE 4

Comparison of Head Circumference (mm) for the Omani population studied against the standards of Hadlock9, Ott19 and Deter10

	Hadlock			Ott			Deter			Present study		
GA	x-2SD	x	x 2SD	x-2SD	x	x +2SD	LL	PV	UL	x-2SD	x	x+2SD
17	120	134	148	112	130	148	126	141	156	131	150	169
18	135	148	161	113	141	169	139	154	169	136	154	172
19	137	160	183	123	153	183	152	167	182	146	164	182
20	154	177	200	142	168	194	164	179	194	157	175	193
27	235	256	277	218	242	266	244	259	274	228	258	288
28	241	271	301	231	257	283	244	269	294	245	264	283
29	250	273	296	234	258	282	254	279	304	243	268	293
30	261	277	293	243	269	295	263	288	313	247	276	305
35	292	317	342	272	300	328	304	329	354	298	320	342
36	303	322	341	277	305	333	311	336	361	295	318	341
37	307	330	353	279	309	339	317	342	367	296	321	346

TABLE 5

Abdominal Circumference (mm) in the present study

GA	N	Mini mum	Maxi mum	Mean ± 2SD
17	113	129	121 ± 12	113
18	110	159	126 ± 16	110
19	113	151	135 ± 16	113
20	129	160	144 ± 17	129
27	210	232	221 ± 18	210
28	206	284	232 ± 25	206
29	214	262	240 ± 24	214
30	228	267	247 ± 25	228
35	294	320	308 ± 22	294
36	256	338	308 ± 32	256
37	304	339	321 ± 23	304

GA = Gestational age
n = Number of individuals studied

TABLE 6

Comparison of Abdominal Circumference (mm) for the Omani population studied against the results of Hadlock [11], Deter[10] and Tamura[20]

	Hadock			Deter			Tamura			Present study		
GA	x-2SD	x	x 2SD	LL	PV	UL	5%	50%	95%	X-2SD	x	x+2SD
17	96	114	131	102	117	133				109	121	133
18	111	128	144	112	128	145	103	131	159	110	126	142
19	107	136	164	121	139	157	116	144	172	119	135	151
20	129	155	181	131	150	170	126	154	182	127	144	161
27	212	231	250	198	227	257	209	237	265	203	221	239
28	216	247	278	207	238	269	225	253	281	207	232	257
29	228	250	272	217	249	282	241	269	297	216	240	264
30	226	252	279	226	260	294	246	274	302	222	247	272
35	280	305	329	274	315	356	294	322	350	286	308	330
36	289	312	335	284	326	369	305	333	361	276	308	340
37	300	330	359	293	337	381	316	344	372	298	321	344

TABLE 7

Femur length (mm) in the present study

GA	N	Mini-mum	Maxi-mum	Mean ± 2SD
17	7	25	28	26 ± 2
18	88	23	35	28 ± 4
19	44	26	40	31 ± 5
20	26	29	37	33 ± 4
27	7	51	55	52 ± 3
28	114	48	62	54 ± 4
29	29	51	60	56 ± 5
30	14	55	61	58 ± 3
35	6	65	72	68 ± 6
36	95	64	72	69 ± 3
37	13	64	73	70 ± 5

GA = Gestational age
n = Number of individuals studied

TABLE 8

Comparison of Femur Length (mm) for the Omani population studied against Jeanty[21], O' Brien[22] and Warda[15]

	Jeanty			O'Brien			Warda			Present study		
GA	x-2SD	x	x 2SD	LL	PV	UL	5%	50%	95%	X-2SD	x	x+2SD
17	20	25	29	22	25	28	20	23	26	24	26	28
18	19	28	31	27	30	33	22	26	30	24	28	32
19	23	31	38	29	32	36	25	29	33	26	31	36
20	22	33	39	32	35	37	27	31	35	29	33	37
27	45	51	57	50	53	56	42	49	56	49	52	55
28	45	53	57	50	54	59	45	52	59	50	54	58
29	49	56	62	53	57	62	46	54	62	51	56	61
30	49	58	62	55	59	63	48	56	64	55	58	61
35	61	67	73	63	68	73	57	66	75	62	68	74
36	61	69	74	65	70	74	58	68	78	66	69	72
37	64	71	77	67	71	75	59	69	79	65	70	75

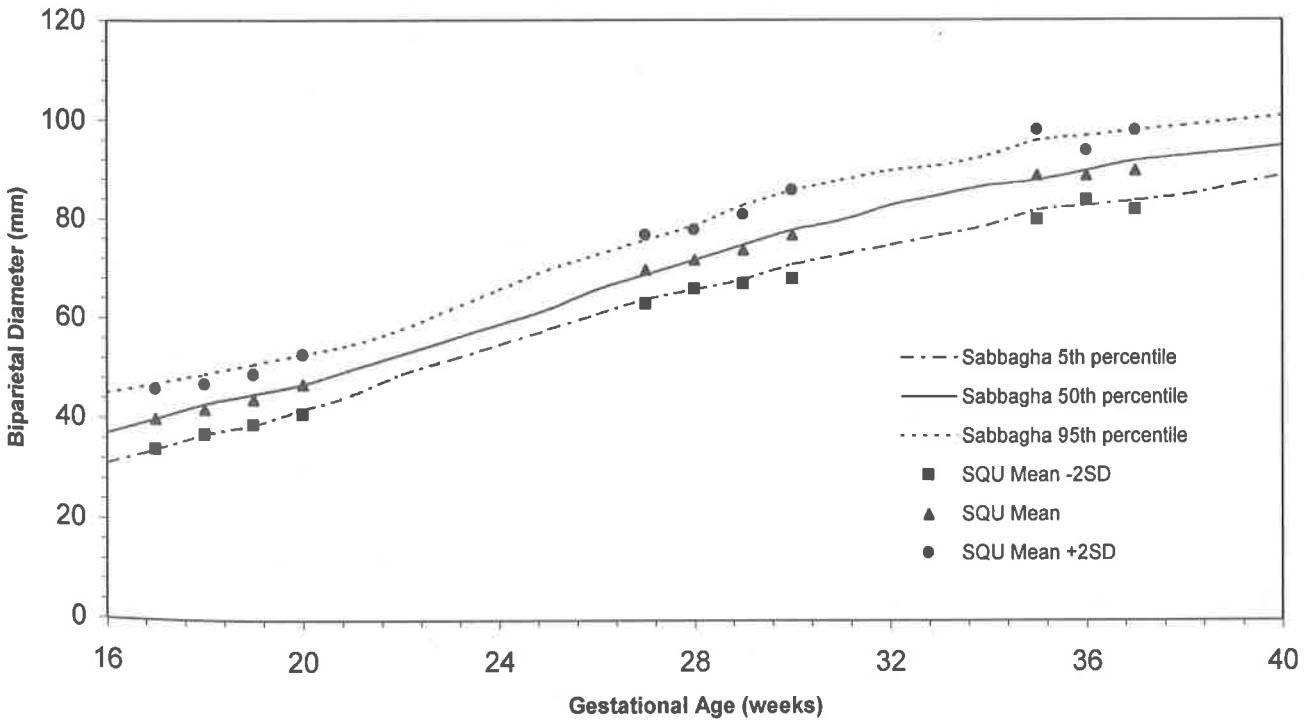

FIGURE 1 *Comparison of Biparietal Diameter (mm) for the Omani population studied against the results by Sabbagha*

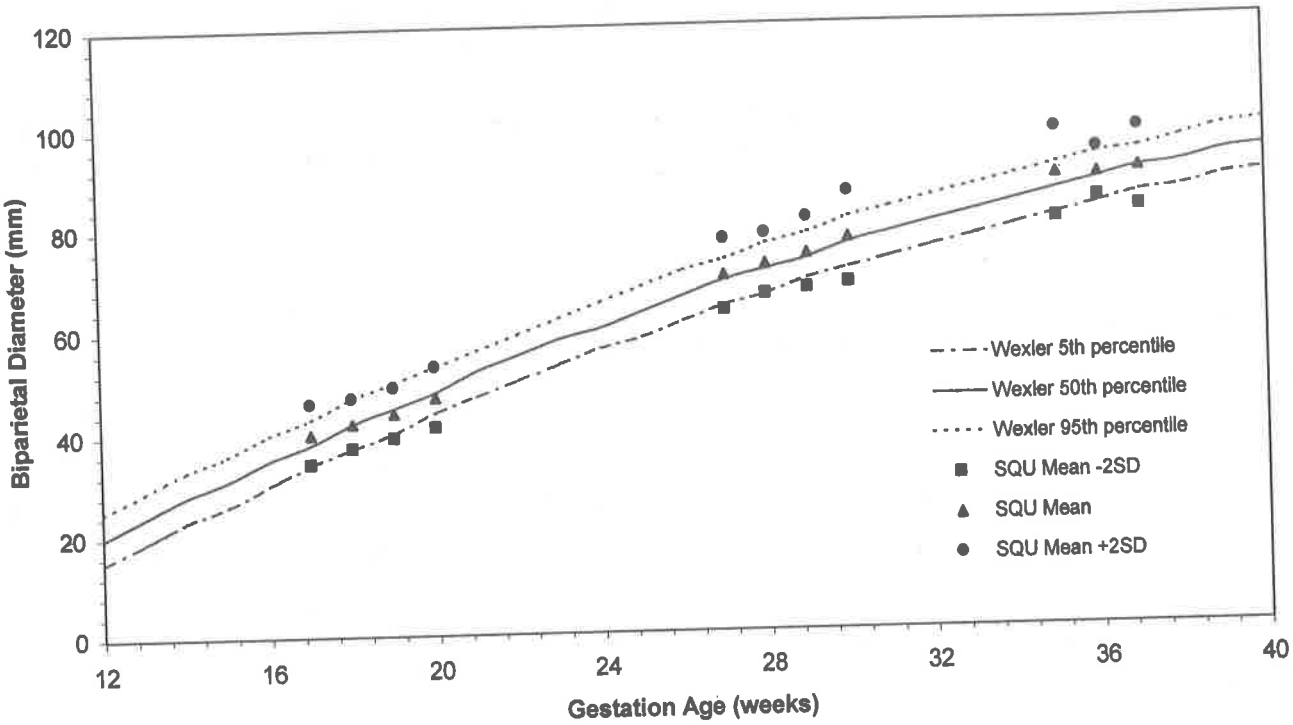

FIGURE 2 *Comparison of Biparietal Diameter (mm) for the Omani population studied against the results by Wexler*

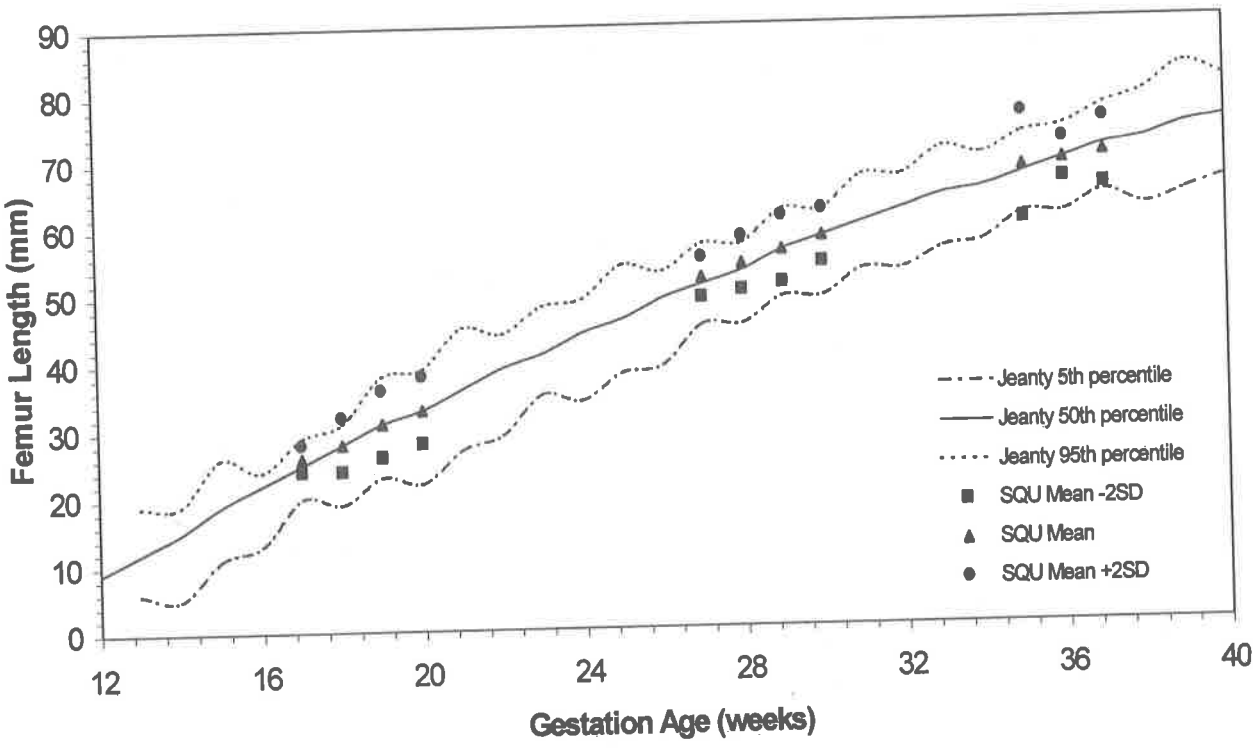

FIGURE 3. *Comparison of Femur Length (mm) for the Omani population studied against the results by Jeanty*

TABLE 9

Index of reliability for the studied parameters

Biparietal diameter	
Hadlock	36.4%
Campbell	36.4%
Sabbagha	73.0%
Wexler	73.0%
Head circumference	
Hadlock	36.4%
Ott	9.1%
Deter	27.3%
Abdominal circumference	
Hadlock	27.3%
Deter	27.3%
Tamura	0.0%
Femur length	
Jeanty	81.8%
O'Brien	36.4%
Warda	18.2%

reliability index for both Hadlock's and Deter's data is only 27.3%, while Tamura's data begins only at 18 weeks of gestation and are not applicable to this population. For Femur Length, however, Jeanty's data agree significantly (81.8%) with the present study, while those of O'Brien and Warda have low reliability at 36.4% and 18.2% respectively.

Data from the three studies (Sabbagha, Wexler and Jeanty) that correlate well with ours are shown graphically in Figures 1 to 3.

The idea to study the applicability of standard fetal biometric growth curves to an ethnic Omani population stemmed from the fact that there exist population differences with regard to height, weight, body mass index.[23,24,25] Population differences apply to birth weight as well. As per the 1996 Oman census,[23] the mean birth weight was 3,130 grams (± 0.46). For Indian babies, the mean birth weight is 2892 grams.[25] Applying the standard Western curves would lead to an overdiagnosis of intrauterine growth retardation in this population. Though there are several studies on fetal biometry for different ethnic groups living in the same country, there is none yet on the Arab population. This study is a pioneering one.

CONCLUSION

This study shows that only a minority of the standard charts, viz., those of Sabbagha and Wexler for biparietal diameter and Jeanty for the femur length, have sufficient reliability to be used for serial assessment of the intrauterine growth of Omani babies. None of the standard curves for head circumference and abdominal circumference is applicable. As such, it is necessary to develop growth curves for the Omani population, especially for the Head Circumference and Abdominal Circumference, to be able to diagnose abnormalities of growth in utero.

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