The Jamaican Fetus – Overview of Various Studies

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ABSTRACT

Objective: *To describe a series of studies conducted which investigated maternal nutrition and its effect on birth outcome.*

Methods: *Seven hundred and twelve women attending their first antenatal clinic visit at the University Hospital of the West Indies were invited to join a prospective study. The women were followed throughout their pregnancies and seen at 14, 17, 20, 25, 30 and 35 weeks gestation. At these visits, the mother's weight, height and triceps skinfold thickness were measured. Abdominal ultrasound was performed to determine placental and fetal growth. Birth and placental weight, head, chest, mid-upper arm and abdominal circumference, crown-rump and crown-heel length were measured. After delivery, mothers and their children were recruited into a longitudinal study of postnatal growth in which blood pressure was measured annually initially and then half yearly from age one year.*

Results: *The interrelationship of first trimester maternal weight, subsequent weight gain in pregnancy, placental weight in early pregnancy and fetal growth were reported. Placental volume was shown to be an earlier predictor of infant size, and placental volume and intrauterine life on birthweight and blood pressure in childhood showed a relationship to blood pressure at two to three years old. The ultrasound derived fetal growth curves for a Jamaican population was created.*

Conclusion: *Maternal nutritional status has an important effect on fetal size and birthweight and fetal size has an effect on blood pressure in childhood, suggesting that the initiating events in programming of blood pressure occur early in pregnancy.*

Keywords: Birthweight, fetal growth, maternal nutrition, placenta weight

El Feto Jamaicano – Panorama de Varios Estudios

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RESUMEN

Objetivo: *Describir una serie de estudios encaminados a investigar la nutrición materna y su efecto en el resultado del embarazo.*

Métodos: *Setecientos doce mujeres que asistían a su primera visita de la clínica prenatal en el Hospital Universitario de West Indies, fueron invitados a sumarse a un estudio prospectivo. Se realizó un seguimiento de las mujeres a lo largo de sus embarazos, con visitas en las semanas 14, 17, 20, 25, 30 y 35 de gestación. En estas visitas, se midió el peso, la altura y el grosor del pliegue cutáneo del tríceps. Se les realizó un ultrasonido abdominal con el fin de determinar el crecimiento placentario y fetal. Se midieron el peso al nacer y el peso de la placenta, la cabeza, el pecho, circunferencia del abdomen y la parte media superior del brazo, las longitudes céfalo-caudal y coronilla-talón. Después del parto, las madres y sus niños fueron reclutados para un estudio longitudinal de crecimiento postnatal en el que la presión sanguínea se mide anualmente, inicialmente y luego a mitad de año desde el primer año de edad.*

Resultados: *Se reportó la interrelación del peso materno en el primer semestre, el subsiguiente aumento de peso en el embarazo, el peso de la placenta al inicio del embarazo, y el crecimiento fetal. El volumen de la placenta resultó ser un predictor temprano del tamaño del infante, y el volumen de la placenta y la vida intrauterina en el peso al nacer, y la presión sanguínea en la infancia mostró una relación con la presión sanguínea a los dos hasta los tres años de edad.*

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Conclusión: *El estado de la nutrición materna tiene un efecto importante en el tamaño del feto y el peso al nacer, y el tamaño del feto tiene un efecto sobre la presión sanguínea en la infancia, lo cual sugiere que los procesos que inician la programación de la presión sanguínea ocurren en una etapa temprana del embarazo.*

Palabras claves: Peso al nacer, crecimiento fetal, nutrición materna, peso de la placenta

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INTRODUCTION

Perinatal morbidity and mortality are related to growth restraint *in utero* and this may manifest itself as low birthweight (BWT < 2500 g). There is good evidence to support the fact that low birthweight infants are at risk at birth, perinatally and in early life. Maternal nutritional status is an important determinant in influencing infant size (1, 2). Poor maternal nutrition is associated with constrained fetal growth and therefore lower birthweight. Infants of mothers who are poorly nourished before and during pregnancy are smaller at birth and mothers who were small at birth in turn give birth to smaller babies leading to intergenerational effects (3).

Numerous studies have shown that the risk of cardiovascular disease in adulthood is inversely related to lower birthweight, even in the normal range (4, 5). Relationships have been shown between different patterns of fetal growth restraint and types of chronic cardiovascular disease in adulthood. Thus, adults who were small babies with reduced birthweight had increased blood pressure, thin babies (low ponderal index) developed high blood pressure and non-insulin dependent diabetes, while the disproportionate babies (short in relation to head circumference) were shown to be at risk as adults for raised blood pressure, increased low density lipoprotein (LDL) cholesterol and fibrinogen (4).

The relationship between impaired fetal growth as measured by birthweight and crown-heel length and risk factors for chronic cardiovascular diseases has also been demonstrated in Jamaican children. Forrester *et al* showed in a group of Jamaican children aged 7–14 years that birthweight was inversely related to blood pressure and crown-heel length at birth was inversely related to glycosolated haemoglobin and total serum cholesterol concentration (6). Forrester *et al* also showed that blood pressure in children was inversely related to maternal haemoglobin concentration which can be used as a measure of nutritional status. An earlier study by Godfrey *et al* on another Jamaican cohort showed that thin maternal triceps skinfolds during pregnancy was a more powerful predictor of blood pressure in childhood than the maternal haemoglobin (7).

The prevalence of hypertension in Jamaica and the Caribbean is high and contributes significantly to morbidity and mortality (8). In Jamaica, diabetes is an important disease with prevalence of 13.4% and it accounts for 10% of total mortality (9). Studies have shown that impaired glucose tolerance and diabetes in adult life are related to growth restraint during fetal life. In the United Kingdom (UK), abnormal glucose tolerance has been described in relation to lower birthweight, ponderal index and growth in early childhood. In Jamaica, the informative phenotype appears to be shortness at birth rather than thinness as in the UK (10). With the incidence of these chronic diseases increasing as infectious diseases were declining, it was important to identify risk factors which may be influenced to attempt to decrease the rising increase.

These earlier studies demonstrated the relationship with birthweight and the risk of increase blood pressure in Jamaican children. Although birthweight may be a proxy of fetal growth, birthweight is only a single point in time and hence cannot give a longitudinal picture of events *in utero*. Hence, as events in intrauterine life were becoming more and more a possible predictor for long term chronic adult disease, it became important to design a study that would capture growth *in utero* and then to investigate the relationships of intrauterine growth, birthweight and events in childhood.

SUBJECTS AND METHODS

Seven hundred and twelve women attending their first antenatal clinic visit at the University Hospital of the West Indies were invited to join a prospective study. Recruitment was restricted to women who were 15–40 years, were sure of the dates of their last menstrual period, which was confirmed by the 14-week ultrasound and did not have any systemic or genetic illness such as sickle cell disease. Each woman was interviewed and a measure of her socio-economic status was derived on the basis of amenities and crowding in the home, her own and father's educational background and occupation. A high score corresponded with a high socio-economic status.

After recruitment, the women were followed throughout their pregnancies when they were seen at 14, 17, 20, 25, 30 and 35 weeks gestation. At these visits, the mother's weight was measured to the nearest 0.01 kg by use of a Weylux beam balance, height to the nearest 0.1 cm by use of a stadiometer, triceps skinfold thickness to the nearest 0.2 mm with a Harpenden skinfold caliper and blood pressure with a dinamap. Haemoglobin levels were determined at the first antenatal visit (8–10 weeks), 25 and 35 weeks gestation.

Abdominal ultrasound was performed on the women to determine placental and fetal growth. Placental volume was measured at the first three visits and fetal biparietal diameter, femoral length, head and abdominal circumferences were measured at all six visits. The average of three measurements was used in the analyses.

Placental volume was determined by identifying and recording on videotape the long axis of the placenta. A continuous recording of the image of the placenta orthogonal to the axis was made by sweeping the probe along the axis at constant velocity. This axis was divided into six sections of equal length; the five interior cross-sectional areas were measured and integrated to estimate the placental volume. This method was developed and validated by Howe *et al* (11).

Birth and placental weight were measured with an electronic balance; head, chest, mid-upper arm and abdominal circumference were measured with a fibreglass measuring tape; crown-rump and crown-heel lengths were measured with an infantometer and gestational age was determined by the last menstrual period, which was validated by ultrasound scan at 14 weeks of gestation.

After delivery, mothers and their children were recruited into a longitudinal study of postnatal growth in which blood pressure was measured annually initially and then half yearly from age one year, weight was measured on an electronic scale and length was measured up to age two years on an infantometer and thereafter on a stadiometer.

This study allowed investigation of various aspects:

1. The interrelationship of first trimester maternal weight, subsequent weight gain in pregnancy, placental weight in early pregnancy and fetal growth
2. The importance of placental volume and its effect on infant size
3. Placental volume and intrauterine life on birthweight and blood pressure in childhood hence demonstrating a link with intrauterine life and the development of higher blood pressures in childhood
4. The creation of ultrasound derived fetal growth curves for a Jamaican population

RESULTS

As expected, fetal and placental measurements gradually increased throughout pregnancy. Maternal and newborn characteristics are shown in Table 1 and feto-placental measurements from 14 to 35 weeks gestation are shown in Table 2.

The interrelationship of first trimester maternal weight, weight gain in pregnancy, placental volume in early pregnancy and fetal growth was investigated. In order to explore the relationships between maternal weight and placental volume, the women were stratified into groups of maternal weight, beginning at ≤ 55kg and increasing by 10 kg, based on maternal weight at the first antenatal visit. Women with lower maternal weight had a significantly smaller placental volume at 17 and 20 weeks gestation ($p < 0.002$ and $p < 0.0001$, respectively) compared to women with higher maternal weights (Table 3). Similarly, there was a direct relationship between maternal body mass index (BMI) and placental volume at 14, 17 and 20 weeks gestation. Hence, a 1 kg/m^2 increment in the mother's BMI at booking was associated with a 0.08 unit increase in the square root of the placental volume at 14 weeks gestation ($p = 0.02$); with a 0.07 unit increase at 17 weeks ($p = 0.026$) and with a 0.1 unit increase at 20 weeks ($p = 0.001$).

Table 1: Maternal and newborn measurements

Variable	Mean	±	SD	Minimum	Maximum
Maternal measurements					
Age, years	26.4	±	5	16	40
Weight, kg	66.3	±	13.8	32.9	122.3
Weight gain: 1st visit to 35 weeks, kg	9	±	4.3	-3.9	23.8
Height, cm	163.5	±	6.1	144.4	182.9
Body mass index, kg/m^2	24.8	±	4.9	14.8	44.3
Triceps skinfold thickness, mm	19.2	±	8.2	5	50
Haemoglobin, g/dL	12.2	±	1.1	8.8	15.5
Systolic blood pressure, mm Hg	109.5	±	10.4	85	144
Diastolic blood pressure, mm Hg	62.6	±	8.1	41	95
Newborn measurements					
Birth weight, kg	3.15	±	0.51	1.23	4.69
Crown heel length, cm	49.5	±	2.9	36	57
Crown rump length, cm	33.1	±	2.3	23.5	48.5
Head circumference, cm	34.3	±	1.6	27	38.8
Mid upper arm circumference, cm	10.4	±	1	5.3	13.5
Chest circumference, cm	32.5	±	2.2	23.5	41.5
Abdominal circumference, cm	30.8	±	2.3	21.5	37.5
Placental weight, g	577	±	133	226	1200
Ponderal index, kg/m^3	25.9	±	3.5	16	41.3
Gestational age, d	276	±	13	193	299

Measurements are for 428 mothers and babies (216 primigravida [51%] and 190 males [44%])

Table 2: Feto-placental measurements from 14 to 35 weeks gestation

	Gestation (weeks)											
	14		17		20		25		30		35	
Variable	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
BPD (mm)	28.8 (371)	3.2	38.9 (373)	3.3	48.6 (372)	3.3	64.1 (321)	3.6	77.7 (318)	3.6	87.2 (309)	3.4
HC (mm)	98.5 (371)	12.2	137.2 (372)	11.8	173.6 (373)	12.1	229.7 (321)	12.4	276.9 (318)	12.4	309.4 (309)	11.7
AC (mm)	85.9 (366)	11.4	120.0 (372)	11.1	152.6 (373)	11.9	206.9 (322)	14.4	262.8 (318)	16.8	314.6 (309)	18.6
FL (mm)	15.0	3 (369)	24.6	3.1 (372)	33.6	2.9 (372)	46.7	3.1 (322)	58.4	3 (318)	68.9	3.2 (308)
PV (mm)	116.5 (374)	52.3	242.9 (374)	73.4	359.8 (374)	84.5						

Number of subjects shown within the brackets.
BPD = biparietal diameter; HC = head circumference; AC = abdominal circumference; FL = femoral length; PV = placental volume

Table 3: The effect of maternal weight at the first antenatal visit on placental volume at 14, 17 and 20 weeks gestation

	Placental volume (ml)						
Weight (kg)	**14 week**	**SD**	**17 week**	**SD**	**20 week**	**SD**	**n**
≤ 55	118	46.9	227.6	70.7	330.7	80.9	79
55.1 – 65.0	110.2	52.3	236.9	72	353.5	83.4	118
65.1 – 75.0	115.9	54.1	247.7	76.2	374	94.3	89
> 75.1	124.4	54.7	259.9	71.9	380	70.4	88
Total	116.5	52.3	242.9	73.4	359.8	84.5	374
p	0.17		0.002		0.0001		

The simultaneous contribution of maternal weight and weight gain to fetal growth were also explored. Both maternal weight and maternal weight gain was stratified into groups and were directly related to fetal abdominal circumference at 35 weeks gestation. Thus women whose fetuses had the largest abdominal circumference were those who were heaviest at the first antenatal visit and gained the greatest amount of weight in early pregnancy. This analysis was repeated for the other fetal measurements, biparietal diameter, head circumference, and femoral length and similar results were obtained.

Table 4 shows the effects of maternal weight, weight gain, placental volume and rate of placental growth on fetal measurements (biparietal diameter, femoral length, abdominal and head circumference). A multiple regression analysis was performed controlling for gender and gestational age. Placental volume at 14, 17 and 20 weeks gestation were highly correlated hence placental volume at 14 weeks was used. It was found that placental volume at 14 weeks and the rate of growth of the placenta between 17 and 20 weeks gestation were significantly related to all fetal measurements. Abdominal circumference was the only fetal measurement that was associated with maternal weight at the first antenatal visit and maternal weight gain in pregnancy was associated with all fetal measurements except femoral length.

This work showed the interrelationship of first trimester maternal weight, subsequent weight gain in pregnancy, placental volumes in early pregnancy and fetal growth. This work demonstrated evidence of a significant influence of both placental volume and the rate of placental growth in determining fetal size (12). It appears as if these effects are mediated through maternal weight and weight gain in preg-

Table 4: Maternal weight at the first antenatal visit, early weight gain, placental volume, rate of placental growth and fetal measurements at 35 weeks gestation: multiple regression analysis. Outcome variables are fetal measurements at 35 weeks gestation (mm).

	Abdominal circumference		**Femoral length**		**Head circumference**		**Biparietal diameter**	
Variable	**B**	**SEB**	**B**	**SEB**	**B**	**SEB**	**B**	**SEB**
Gender (male =1, female =2)	-2.09	1.77	0.08	0.32	-4.14	1.26†	-0.83	0.35*
Gestational age at 35 weeks gestation (days)	1.11	0.16‡	0.23	0.03‡	0.43	0.11‡	0.18	0.03‡
Placental volume at 14 weeks (SD)(mls)	8.34	1.15‡	1.09	0.21‡	3.33	0.82‡	1.10	0.23‡
Rate of placental growth between 14–17 weeks gestation (ml/day)	102.80	22.65‡	11.82	4.10†	27.69	16.17	7.56	4.44
Rate of placental growth between 17–20 weeks gestation (ml/day)	98.35	21.79‡	14.58	3.95‡	36.52	15.56*	13.52	4.28†
Maternal weight (kg) at the first antenatal visit	0.19	0.07†	0.01	0.01	0.04	0.05	0.02	0.01
Early maternal weight gain (first antenatal visit – 20 weeks gestation) (kg/4 weeks)	4.35	0.99‡	0.19	0.18	1.61	0.70*	0.52	0.19†
Constant	27.8	39.00	10.55	7.03	204.51	27.84	43.76	7.66
Adjusted R^2	33.4		25.0		14.9		21.2	

B is the regression coefficient
**p* <0.05; †*p* <0.01; ‡*p* < 0.001

nancy and suggest that these events determining fetal size operate early in pregnancy.

The next study explored the ability of second trimester placental volume measured sonographically to predict infant size. The placenta is not seen on the ultrasound until 8–10 weeks of gestation when it can usually be identified as an area of increased thickness and echogenicity. The chorionic plate of the placenta is formed by the fusion of the amniotic and chorionic mesoderm at approximately 12 weeks gestation and this chorionic plate produces a strong acoustic interface between the amniotic cavity and the fetal surface of the placenta. Before this, the placenta is not well defined and therefore difficult to measure. The technique used in the study requires that the entire placenta be visualized on the screen; hence beyond 20 weeks gestation, it is difficult to visualize the entire placenta in one field which makes this technique unsuitable for the late second or third trimesters.

Low birthweight and macrosomia have specific problems in which anticipatory management becomes important. Size and shape of the neonate has become more relevant to health throughout the life cycle than previously thought and the risk of hypertension, coronary heart disease and diabetes are inversely related to birthweight and newborn anthropometry. With this, it has become important to identify infants' size at birth from intrauterine life, and it was hypothesized that placental volume in the early second trimester may be a more reliable predictor of size at birth than fetal measurements, and this may be useful in early identification of the fetus at risk in the perinatal period. If early placental volume improves the ability to predict birth size, then it may enable early identification of the fetus at risk, and thus facilitate preparation for management at least in the neonatal period.

This part of the study was therefore designed to investigate, in women of African origin, the relative ability of placental volume and fetal measurements to predict birthweight. In addition, it also sought to identify the earliest point in pregnancy when placental volume proved predictive of birthweight and newborn anthropometry.

Regression models were restricted to subjects with a complete set of fetal and placental measurements. The number of subjects used at each stage in the second trimester was 370 (14 weeks), 423 (17 weeks) and 411 (20 weeks). The study showed that placental volumes at each of the three gestational ages were positively associated with all birth measurements. The placental volume at 20 weeks gestation was most often the strongest predictor.

All fetal measurements were statistically significant predictors of birthweight (data not shown, $p < 0.001$ in each case). Analyses showed that the four fetal measurements taken together predicted birthweight, with head circumference being the most powerful predictor at 14 and 17 weeks, and abdominal circumference at 20 weeks. These analyses were extended to include placental volume. At each of the three gestational ages, placental volume was a strongly significant predictor of birthweight, more so than any of the fetal measurements,

These analyses were repeated for other anthropometric measures at birth (length, head, chest and abdominal circumferences and placental weight) with similar results seen. None of the anthropometric measurements at birth was associated with socio-economic status of the mother.

Further analyses were performed to assess the determinants of poor outcome. Hence low birthweight (bwt < 2500 g) and macrosomia (bwt > 4500 g), were used as the dependent variables in multiple logistic regression analyses with the standard set of control variables. The odds ratio (OR) for low birthweight increased by 1.68 for every standard deviation decrease in placental volume at 14 weeks gestation (p = 0.03). Fourteen of the 27 cases of LBW occurred in those whose placental volumes were in the lowest fifth of the distribution at 20 weeks gestation. There were only three cases of macrosomia and these occurred in babies whose placental volumes at 20 weeks gestation were in the first, second and fourth fifths of the distribution.

This section of the study therefore showed clearly that placental volume as early as 14 weeks gestation predicted birthweight and proportions more accurately than fetal measurements made at the same time (13). Placental volume early in the second trimester was also able to detect intrauterine growth retardation that went on to be a low birthweight infant, in comparison to Goldenberg *et al* who reported that fetal growth retardation was not detectable from fetal measurements until the third trimester (14). This raises the possibility that an easier and more convenient method of measuring placental volume could prove useful in the early diagnosis of the fetus at risk of intrauterine growth retardation.

The next arm of the study investigated the relation between maternal anthropometry, fetal size, placental volume and childhood blood pressure. This became important as there is a growing body of evidence that birthweight and body proportions at birth are important risk factors for hypertension, diabetes and coronary heart disease. Most studies investigated birthweight with this phenomenon but this was the first time that a study was going to report on intrauterine life (fetal growth and placental volume) and postnatal life.

Findings of this arm of the study showed that abdominal circumference at 20 weeks gestation was the fetal measurement most strongly associated with childhood blood pressure in that systolic blood pressure fell by 0.85 mm Hg for every 10 mm increase in abdominal circumference (p = 0.001). Abdominal circumference was also the fetal measurement most strongly associated with placental volume. Fetal head circumference, biparietal diameter and femoral length were not associated with childhood blood pressure.

Table 5 shows the influence of birthweight on systolic blood pressure by age, controlling for gender and current weight. These results show systolic blood pressure was negatively associated with birthweight at ages 2.5 and 3 years but not at other ages. Pooling the data across ages, blood pressure decreased by 1.4 mmHg for every 1 kg of birthweight (p = 0.04).

Table 5: The influence of birthweight on systolic blood pressure by age, controlling for gender and current weight

	Mean systolic blood pressure (mmHg) at age					
Birthweight (kg)	**1**	**2**	**2.5**	**3**	**3.5**	**All ages**
≤ 2.5	92.6_{24}	92.7_{26}	93.1_{16}	95.0_{20}	90.8_{12}	92.9_{35}
≤ 2.75	96.1_{30}	94.5_{32}	92.7_{20}	91.3_{30}	90.8_{17}	93.7_{50}
≤ 3.0	92.1_{50}	91.8_{49}	92.6_{29}	90.5_{36}	93.1_{16}	92.0_{72}
≤ 3.25	94.5_{70}	92.8_{66}	92.9_{42}	92.0_{57}	91.9_{31}	92.5_{96}
≤ 3.5	91.5_{57}	94.7_{50}	90.9_{30}	91.3_{45}	90.6_{25}	91.5_{85}
≤ 3.75	90.3_{29}	94.4_{28}	91.6_{12}	91.7_{27}	92.9_{15}	91.6_{43}
> 3.75	91.6_{28}	92.3_{30}	87.9_{17}	88.8_{35}	89.7_{22}	90.1_{47}
All	92.8_{288}	93.2_{281}	91.9_{166}	91.3_{250}	91.3_{138}	92.0_{428}
B (± SE) Birthweight (kg)	1.7 ± 1.2	0.5 ± 1.2	2.8 ± 1.1*	2.6 ± 0.8**	0.4 ± 0.9	1.4 ± 0.6
B (± SE) Gender (0 = m, 1 = f)	-0.09 ± 1.2	0.7 ± 1.3	1.0 ± 1.0	-0.3 ± 0.8	-1.5 ± 1.0	
B (± SE) Current weight (kg)	2.0 ± 0.5***	1.5 ± 0.4***	1.5 ± 0.3***	1.5 ± 0.2***	1.1 ± 0.2***	
Adjusted R^2	0.05	0.05	0.13	0.18	0.20	

B is the regression coefficient. For example, at age 2 ½ years, systolic blood pressure decreased by 2.8 mmHg for every 1 kg increase in birthweight. Subscripts give number of subjects. *p < 0.05, **p < 0.01, ***p < 0.001.

Childhood blood pressure was also analysed in relation to placental volume at 20 weeks of gestation. Systolic blood pressure was also negatively associated with placental volume, an association that was significant at ages 1, 2 and 3.5 years. Pooling of the data across the ages showed that blood pressure fell by 1.2 mmHg for every 100 ml increase in placental volume ($p = 0.004$). A similar association was found with placental volume at 17 weeks gestation [$p = 0.004$] (15).

Finally, ultrasound derived fetal growth curves and percentile growth charts for a Jamaican population were created (16). It is known that birthweight varies with ethnic groups. The mean birthweight of a Jamaican newborn is 3.11 kg, which is approximately 200 g lower than Caucasian babies in the United States of America and the UK and approximately 200 g greater than that of Asian babies. Ninety-seven per cent of the population of Jamaica is of West African descent; hence, the pattern of fetal growth may also vary from the standard of a Caucasian population which is routinely used.

A total of 2574 ultrasound scans were made on 499 women (mean 5.2 per woman). Figures 1–4 show the observed data and fitted growth curves for biparietal, head and abdominal circumferences, and femoral length, respectively.

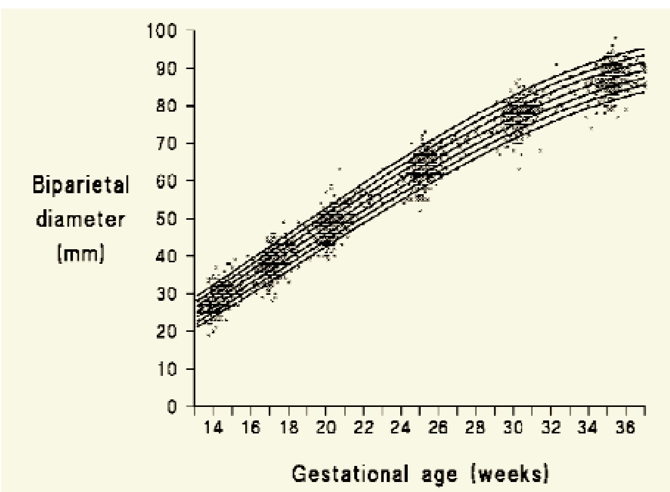

Fig. 1: Fetal growth curve of biparietal diameter.

Values obtained were similar but there were differences seen between the two reference groups and more importantly, the body proportions were different. Variations in body proportions have been shown to be important, as disproportionate infants are thought to be at a higher risk of disease in adult life. These curves will also give the obstetricians reference values for the Jamaican population and have the potential to improve obstetric care.

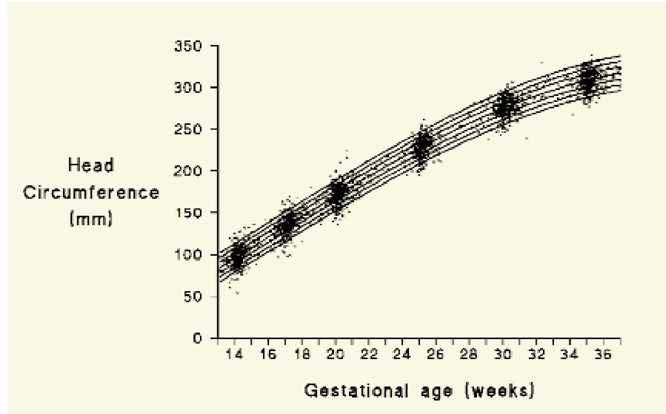

Fig. 2: Fetal growth curve of head circumference.

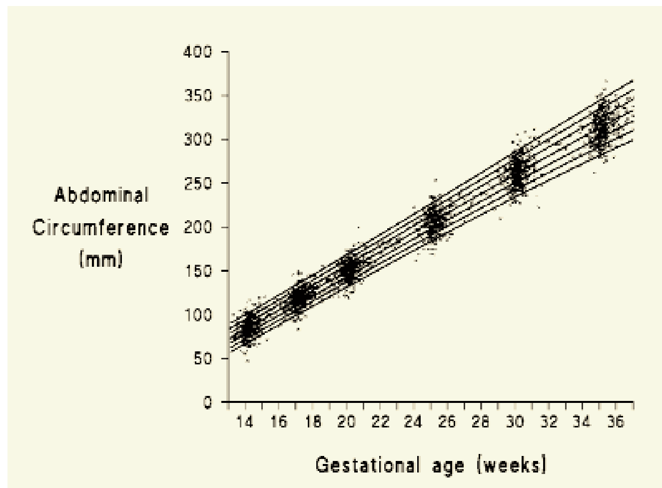

Fig. 3: Fetal growth curve of abdominal circumference.

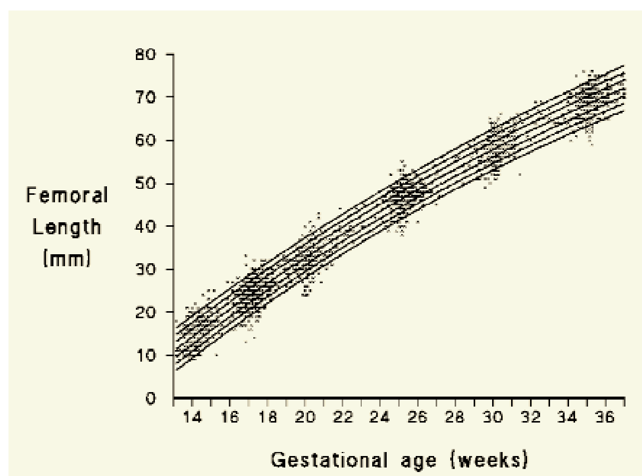

Fig. 4: Fetal growth curve of femoral length.

CONCLUSION

This work has demonstrated the relationship between maternal nutrition and the effect on placental and fetal growth. The work has also shown the relationship of placental growth to fetal size. The importance of fetal size and the association with blood pressure in childhood is a very important finding. These associations between blood pressure and measurements made in the second trimester suggest that the initiating events in programming of blood pressure occur early in pregnancy and are associated with placental growth and that fetal abdominal circumference may be the most sensitive of the fetal measurements as an indicator of the programming process.

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