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A Customized Birth Weight Standard for a Multi-Ethnic Asian Population

KH Tan, X Wei, MJ Ng

ABSTRACT

Introduction: Being an essential parameter in evaluating fetal growth and antenatal care, birth weight is influenced by many factors such as race, parity, maternal stature and weight, infant sex and gestation. Previous studies have investigated the influence of maternal characteristics on birth weight, establishing a customized birth weight standard in Caucasian populations. Since a relevant study in Singapore based on local data was lacking, the aim of this study was to establish a customized birth weight standard for a multi-ethnic Asian population.

Methods: Data collected from the Obstetric Information System (OIS) of Labour Wards of KK Women's and Children's Hospital (KKH), Singapore was used in this study. The database relating to 14,642 consecutive deliveries between 1994 and 1995 was extracted. After excluding multiple pregnancies and stillbirths, the data was analyzed with respect to gestation, parity, maternal weight, maternal height, race and infant sex. With 498 cases having missing or inconsistent values, the final analysis included 14,144 cases.

Results: A multiple regression model was fitted. Expected birth weight can be calculated using the formula: Birth weight = (55.8202657 + 0.0530928 × (Maternal height - 155) + 0.0864225 × (Maternal weight - 59.5) - 0.0007236 × (Maternal weight - 59.5)^2 - 0.4005178 × Indian - 0.0957305 × Malay + 0.6421114 × Para 1 + 0.9764204 × Para 2 + 1.0967433 × Para 3 + 1.6766895 × Para > 3 + 0.7255601 × (Gestational age - 40) - 0.1965524 × (Gestational age - 40)^2 - 0.0117546 × (Gestational age - 40)^3 + 0.9384311 × Male)^2 where Indian, Malay, Para 1, Para 2, Para 3, Para > 3 and Male are indicator variables that take value 1 if true, and 0 otherwise.

Conclusion: The development and use of a population customized standard may ensure a more reliable definition and judgment of growth-related disorders. This is very useful in Singapore given its multi-ethnic population.

Keywords : Birth weight, customized standard, growth-related disorders, multi-ethnic

Authors:
Mr Wei Xing
Research Coordinator
Department of Obstetrics and Gynaecology
(Academic Clinical Program)
KK Women's and Children's Hospital, Singapore

Mr Ng Mor Jack
Senior Executive
Department of Obstetrics and Gynaecology
(Academic Clinical Program)
KK Women's and Children's Hospital, Singapore

Corresponding Author:
Prof Tan Kok Hian
MBBS, M.Med, FRCOG, FAMS
Chairman and Senior Consultant
Division of Obstetrics and Gynaecology
KK Women's and Children's Hospital, Singapore
Email: Tan.Kok.Hian@kkh.com.sg
Telephone: +65-6394 1319

INTRODUCTION

Birth weight is an important parameter in assessing fetal growth and antenatal care. In relation to the gestation, birth weight gives extremely useful information with regard to the possibility of intra-uterine growth restriction or hyper-growth. It is also a powerful predictor of obstetric performance, infant morbidity and survival, childhood growth and adult height [1,2]. Birth weight is influenced by many factors including race, parity, maternal stature and weight, infant sex and gestation. Prior studies have investigated the influence of maternal characteristics on birth weight [3,4,5], and some aimed at establishing a customized birth weight standard in Caucasian populations [6,7]. However, a relevant study in Singapore based on local data is lacking. The availability of optimal birth weight adjusted for different maternal, epidemiological, obstetric and anthropometric

characteristics will be useful for obstetricians and neonatologists in their perinatal practice in Singapore and Malaysia.

METHODS

Data collected from the OIS of Labour Wards of KKH was used. The OIS was a Clipper-5 based computer database program installed in the labour wards of KKH to capture all clinical and obstetric information of patients delivering in KKH. The data were collected and entered into the computer network by house officers, midwives and labour ward clinical assistants at the time of delivery. The database relating to 14,642 consecutive deliveries between 1994 and 1995 were extracted from OIS and analyzed with respect to the gestation, parity, maternal weight, maternal height, race and infant sex, after excluding multiple pregnancies and stillbirths. In addition, 498 cases were excluded because of missing or inconsistent values, leaving 14,144 cases for the final analysis.

A multiple linear regression model was fitted. In deriving the term optimal weight, the model was centered at 40 weeks of gestational age for a nulliparous Chinese woman with median height (155 cm) and weight (59.4 kg), and assuming the baby was female. Square root transformation on the main outcome variable, birth weight, was applied to improve the normality of residual distribution and goodness of fit. Standard deviation of birth weights at any given gestation was estimated by regressing scaled absolute residuals of the previous birth weight regression model on the same set of covariates, as described previously [8]. The percentile of any given birth weight can then be approximated using the cumulative normal distribution function or by looking up a normal table.

RESULTS

Tables 1 and 2 show the general characteristics and pregnancy outcomes of the study population. The results of the multiple regression analysis are presented in Table 3. The overall R^2 of the model was 0.276. Maternal weight, height, ethnicity, parity, gestational age as well as sex of the baby were all significant determinants of birth weight.

The formula for calculating the expected birth weight is therefore:
Birth weight = (55.8202657 + 0.0530928 × (Maternal height - 155) + 0.0864225 × (Maternal weight - 59.5) - 0.0007236 × (Maternal weight - 59.5)^2 - 0.4005178 × Indian - 0.0957305 × Malay + 0.6421114 × Para 1 + 0.9764204 × Para 2 + 1.0967433 × Para 3 + 1.6766895 × Para > 3 + 0.7255601 × (Gestational age - 40) - 0.1965524 × (Gestational age - 40)^2 - 0.0117546 × (Gestational age - 40)^3 + 0.9384311 × Male)^2.

The estimated standard deviation of the square root of birth weight given gestational age is: SD = $\sqrt{(\pi/2)}$ × (2.5418805 - 0.0082398 × (Maternal height - 155) + 0.0105474 × (Maternal weight - 59.5) + 0.0002981 × (Maternal weight - 59.5)^2 - 0.1936227 × (Gestational age - 40)), where Indian, Malay, Para 1, Para 2, Para 3, Para > 3 and Male are indicator variables that take value 1 if true, and 0 otherwise.

DISCUSSION

We have previously published multiple fetal weight charts representing gestational age-specific fetal weight distribution based on different ethnic groups, parity, sex of baby and maternal characteristics [9]. These charts, while useful, become increasingly complicated as more variables are being considered simultaneously. Hence, a regression-based model is needed to account for multiple factors that are related to birth weight.

Our analysis showed that in the Singaporean population, birth weight is influenced by similar physiological factors to those found in maternity populations elsewhere, including maternal height, weight, parity, ethnic origin as well as gestational age and sex of the baby. However, maternal BMI was not found be associated with birth weight, after maternal weight and height have been accounted for.

Gardosi et al. first described the concept of customized growth chart in 1992 [10] and they subsequently published several reports using data from United Kingdom [11], Australia [7], New Zealand [12] and United States [6], all based on the same methodology. It is of interest to see that results from the regression models are mostly comparable, except for the constant term, which represents a mother of the largest ethnic group, average height and weight, at a standard gestational age (40 weeks) and first pregnancy (para 0). As we expected, on average, babies born in United Kingdom (3455.6 g), Australia (3463.6 g), New Zealand (3464.4 g) and United States (3453.4 g) are larger than those in Singapore (55.82^2 = 3115.9 g). This further adds to the evidence that it is not appropriate to adopt a universal standard in assessing fetal growth. Moreover, we observed that Indians and Malays tend to have smaller babies than the Chinese, and subsequent-born babies tend to weigh more than the first born. In addition, male babies are on average heavier than female babies, if other variables are held constant.

The development and use of a population customized standard which takes into account factors that significantly affect birth weight distribution, such as in this study, will allow more reliable definition and judgment of growth-related disorders such as macrosomia, intra-uterine growth restriction, small- and large-for-gestation. This is particularly useful in a

multi-ethnic population such as Singapore. An Excel format customized birth weight centile calculator developed for our Singaporean multi-ethnic Asian population based on the above formula has been created. This is available on request.

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Table 1. Distribution of maternal weight, height, BMI, gestation and birth weight of the study population (total number of subjects = 14,144)

Variable	Mean	SD	Median	Range
Maternal weight (kg)	60.6	11.1	59.5	30.7-112.1
Maternal height (cm)	155.1	5.6	155	115-186
BMI (kg/m^2)	25.2	4.5	24.7	11.6-40.0
Gestation at delivery (weeks)	39.3	1.59	39.6	32-43
Birth weight (g)	3127.5	458.4	3130	510-5680

Table 2. Distribution of maternal parity, ethnicity and gender of newborns (total number of subjects = 14,144)

Variable		*n*	%
Parity	0	5416	38.3
	1	4679	33.1
	2	2835	20.0
	3	933	6.6
	≥ 4	281	2.0
Ethnicity	Chinese	7325	51.8
	Malay	5319	37.6
	Indian	1500	10.6
Sex	Male	7269	51.4
	Female	6875	48.6

Table 3. Coefficients from multiple regression model. Note that square root transformation is applied on the dependent variable (birth weight).

Variable	Coefficient	Standard error	*p* value
Constant	55.8202657	0.0707248	< 0.0001
Maternal height	0.0530928	0.0057127	< 0.0001
Maternal weight	0.0864225	0.0033152	< 0.0001
Maternal weight^2	-0.0007236	0.0001699	< 0.0001
Indian	-0.4005178	0.1019052	< 0.0001
Malay	-0.0957305	0.0683225	NS
Gestational age	0.7255601	0.0272789	< 0.0001
Gestational age^2	-0.1965524	0.0153009	< 0.0001
Gestational age^3	-0.0117546	0.0023559	< 0.0001
Male baby	0.9384311	0.0601846	< 0.0001
Para 1	0.6421114	0.0717589	< 0.0001
Para 2	0.9764204	0.0842724	< 0.0001
Para 3	1.0967433	0.1294974	< 0.0001
Para ≥ 4	1.6766895	0.2214784	< 0.0001

NS: non - significant

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