RESEARCH PAPER

RELATIONSHIP BETWEEN MATERNAL ANTHROPOMETRY AND BIRTH WEIGHT IN A SRI LANKAN COHORT OF TERM NEONATES

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Abstract

Background: Birth weight (BW) of new born babies is the main proxy measure used by the healthcare providers and planners to measure foetal wellbeing. Further, it is strongly associated with the babies' risk of mortality, and health later in life. Among many other factors, maternal anthropometry plays a crucial role in determining the neonatal BW.

Objectives: The aim of this study was to assess the relationship of maternal pre-pregnancy weight, height, Body Mass Index (BMI), Gestational Weight Gain (GWG) and neonatal BW in a cohort of Sri Lankan term neonates.

Methods: This is a correlation study based on the data reported in a prospective study done at Teaching Hospital (TH) Kandy, to explore the neonatal outcomes at term. The study included 688 mother-newborn pairs with term neonates delivered at TH Kandy between February and May 2017.

Results: In the correlation testing between maternal anthropometric measurements and neonatal BW, all maternal anthropometric measurements considered in the study had significant positive correlation with neonatal birth weight (P<0.001). The strength of association between maternal anthropometry and birth weight was higher in baby girls compared to baby boys. In multiple linear regression, maternal prepregnancy weight, maternal height and GWG had significant associations with neonatal birth weight (p<0.001). According to the standardized regression coefficients, pre-pregnancy weight had the greatest impact on BW of term neonates, followed by the GWG.

Conclusion: Maternal prepregnancy weight, maternal height, maternal BMI and GWG were significantly associated with neonatal birth weight at term. However, maternal prepregnancy weight was the best predictor of term neonatal BW in Sri Lanka.

Key Words: Maternal anthropometry, Birth weight, Term neonate, Relationship

Introduction

Birth Weight (BW) of newborn babies is the main proxy measure used by the healthcare providers and planners to measure foetal wellbeing. Further, it is strongly associated with the babies' risk of mortality, and health in later in life[1]. Among many other factors, maternal anthropometry plays a crucial role in determining the neonatal BW[1-6]. Many studies done in this aspect focused on most commonly used maternal anthropometric measures, such as pre-pregnancy weight, height, Body Mass Index (BMI) and Gestational weight gain, due to their significant association with intrauterine growth [2, 5, 7-10]. Different degrees of associations between maternal anthropometric measures and newborn birth weight were reported in those studies [2-7, 11]. Differences in relationships could be due to variations in growth potentials among different communities. A Study[12] done to explore the worldwide variance in human growth, by using data from 55 countries or ethnic groups showed that height, weight and head circumference somewhat varied among different nationalities and ethnic groups. Due to the same reason, it is important for healthcare providers to have local evidence about the state of the maternal and neonatal anthropometry as a proxy to their nutritional status, in order to plan counselling and behavioural interventions for pregnant women. But unfortunately, even though midwives usually performed the measurements of basic maternal and neonatal anthropometry parameters for years,thisdata has not been properly stored as a database in Sri Lanka. Further, very few studies [13, 14] were done on the relationship between maternal anthropometric measures and newborn birth weight in Sri Lanka. Therefore, the aim of this study was to assess the relationship of maternal pre-pregnancy weight, height, BMI, gestational weight gain (GWG) and neonatal BW in a Sri Lankan cohort of term neonates.

Methods

Data reported in this investigation are from a prospective study done at Teaching Hospital Kandy (THK), to explore the neonatal outcomes at term. The study included 1105 women who delivered at term between February to May 2017 at THK. The study was approved by the ethics review committee of the Faculty of Medicine, University of Colombo.

Term delivery was defined as a delivery that occurred during the period of gestation from 37 completed weeks (259days) up to and including 41 completed weeks and 6 days (293days), based on the gestational age at delivery. In this prospective study, following term neonates were excluded; neonates of mothers with uncertain Last Menstrual Period (LMP), neonates of mothers who did not have an ultrasound scan (USS) before the completion of 24 weeks of gestation and neonates of mothers whose USS Expected Date of Delivery (EDD) was different from EDD calculated by the LMP more than 14 days.

For the present analysis, only single birth pregnancies were considered to control the effect of newborn weight differences arising from multiple births. Mothers with diabetes or gestational diabetes, hypertension, intrauterine growth restriction and anaemia too were excluded from the present study. The analysed data set was further limited to mother-newborn couples with complete anthropometric measurements (21 pairs were excluded due to incomplete anthropometric data). Consequently, the present analysis was performed on 688 mother-newborn pairs.
In the data collection process the maternal anthropometric measurements and neonatal birth weights were extracted from the

maternal pregnancy record (H 512A) and neonatal examination format (H 1162).

Descriptive statistics; mean, standard deviation and key percentiles were calculated for all anthropometric measurements and percentages with counts were calculated for all categorical variables. Pearson's correlation test was used to assess the correlation between maternal anthropometric measurements and neonatal birth weight. The correlations were repeated with boys, girls and combined sample.

To further quantify the relationships between various maternal anthropometric measurements and neonatal body weight, simple and multiple linear regression with standard coefficients were used. Variables with a significance level less than 0.1 in simple linear regression were considered for the multiple regression analysis. Apart from significant variables ethnicity, maternal education, occupation, monthly family income, parity, period of amenorrhoea (POA) and maternal age was used as covariates in the multiple linear regression analysis with backward elimination to evaluate the confounding effects of these covariates on the relationship between maternal anthropometric measurements and neonatal BW.

All analysis was done by using STATA version 12.1 except multiple linear regression. Minitab (17.0) software was used to perform the multiple logistic regression since it automatically generates dummy variables for categorical variables in the regression analysis. Statistical significance was set at p<0.05.

Results

The final study sample was 688 women and their term newborns. Exactly half of term neonates were baby boys (n=344). Slightly less than half (n=300, 43.6%) of the births were the mothers first child. The average age of women was 28.47 years and only 3.4% were teenage mothers. The majority (80%) were, Sinhalese mothers, while nearly 80% were not having any occupational engagement. Nearly one-third (32.7%) had a monthly income less than SRL 25000 (Table 01).

The descriptive statistics of the maternal and newborn anthropometric measurements are given in Table 02. The average pre-pregnancy weight was 51.91kg and the average pre-pregnancy BMI was 21.88 kg/m^2, which falls under the normal BMI weight range. In the sample 23.3% (n=160) of mothers were underweight (BMI <18.5), 55.5% (N=382) were normal weight (18.5< BMI < 24.9), 17.7 %(n=122) were overweight (25<BMI<29,9) and 3.5% (n=24) were obese (BMI > 30). The mean BW was 2941.64 g (SD 424.04 g). Six newborns (0.9%) were macrocosmic (BW>4000 g) and 83 newborns (12%) were low birth weight (BW<2500 g).

In the correlation testing between maternal anthropometric measurements and neonatal BW, all maternal anthropometric measurements considered in the study had significant positive correlation with neonatal birth weight (P<0.001). But the strength of association between maternal anthropometry and birth weight was higher in baby girls compared to baby boys (Table 03).

Table 04 shows the values of the coefficient of univariate linear regression, that estimates the BW based on maternal anthropometric measures at the individual level. All 4 measures; maternal pre pregnancy weight, height, BMI, GWG had statistically significant (p<0.001) relationship with BW of the neonate in univariate analysis.

Multiple regression with backward elimination method was used to analyse the

relationship between neonatal BW (as the dependent variable) and maternal weight, height, BMI and GWG, adjusted for the following potential confounding variables; ethnicity, maternal education, occupation, monthly family income, parity, POA and maternal age. One insignificant (p-value greater than 0.05) predictor was removed at a time in the order of the highest p-value and run the model again. This was repeated until all the predictors in the model were statistically significant. In the final model, all the maternal anthropometric measures were becoming significant with two covariates; POA and Maternal age (none of the other confounding variables tested became significant). But very high multicollinearity (Variance Inflation Factor (VIF) - >100) was noted between maternal pre-pregnancy weight and BMI. Since BMI, also has relationship with height it was removed from the final model (BW= -1615 + 9.48 Pre-pregnancy weight+ 5.4 maternal height + 11.92 GWG + 10.64 POA + 6.41 Maternal age). No considerable multicollinearity was noted in the final model (VIF - <1.15). The detailed output of multiple linear regression analysis is given in Table 05.

In summary, the multiple regression models had R square value of 15.03 and adjusted R squared value of 14.40, meaning 14.4% variability in BW could be explained by this model. The p-value for the F test for the total model was < 0.001 (F-24.08), indicating that the model has a strong prediction power within the variability of the dependent variable, explained by the model. Unstandardized coefficient (B) predicts how much BW will change for every unit change in the corresponding independent variable. For instance, for the maternal pre-pregnancy weight with B-9.48, each unit increase (by 1kg) in the mother's pre-pregnancy weight, will result in 9.48 g increase in the neonatal BW.

The magnitude of an unadjusted coefficient is affected by the nature of the measurement scale for the variable itself. Therefore, we have calculated the standardised regression coefficient to examine the effects of each independent variable on the dependent variable (BW). According to the standardized regression coefficients, pre-pregnancy weight had the greatest impact on BW of term neonates, followed by the GWG. It appears that if we increase the pre-pregnancy weight by 1 standard deviation, BW of term neonates will increase by 0.222 standard deviations.

Discussion

In the present study, we report the factors affecting the BW of full-term neonates of apparently healthy pregnant women. Our findings are consistent with another study[15] conducted to determine the growth parameters at birth for a cohort of Sri Lankan children. Our mean BW of 2.94kg (SD − 0.042) was pretty much similar to, that reported by Perera et.al.[15] (2.93 ± 0.40 kg). When compared with the mean BW reported by in India[6] (2.93kg), Nepal[16] (3.03kg), Iran[5] (3.23kg), and the United States[4] (3.27kg), Sri Lankan newborns are much closer to the figures from the neighbouring countries. These findings also raise the concern about the misclassifications, which can be occur due to use of one growth standard for different ethnic and community groups.

In the correlation assessment, all maternal anthropometric measures assessed in the present study were correlated with the neonatal BW. Despite the statistical significance (p<0.001) all correlations were weak and ranged from 0.115 to 0.25. These findings are consistent with few other studies done in different geographical areas[4, 7, 11]. Similarly to a cross-sectional study[11] done in Egypt, these associations were more evident in baby girls than the baby boys. In contrast to these findings some studies[2, 3, 5, 6, 17] did not report significant relationships between neonatal

Table 01 - **Distribution of maternal sociodemographic and obstetric characteristics**

Characteristic	Number	Percentage
Age (Years)		
<20 Years	23	3.4%
20-35 Years	579	87.6%
>35 Years	85	9%
Parity		
Primiparous	300	43.6%
Multiparous	388	56.4%
Ethnicity		
Sinhala	554	80.5%
Tamil	65	9.4%
Muslim	69	10.0%
Level of education		
Degree or above	53	7.7%
Passed GCE O/L	219	31.8%
Passed GCE A/L	289	42.0%
Other	125	18.2%
No schooling	2	0.3%
Occupation		
Working	136	19.8%
Nonworking	552	80.2%
Monthly family income (LRK)		
<25000	225	32.7%
25000-50000	336	48.8%
>50000	127	18.5%

Table 02 - Anthropometric values of mothers and birth weight of full-term newborns

	Mean	SD	Percentiles						
			3rd	10th	25th	50th	75th	90th	97th
Maternal anthropometric measures									
Pre-pregnancy weight (kg)	51.91	9.95	36.8	40	45	50	58	65	73
Height	1.54	0.6	143	146	150	154	158	162	165.3
Body Mass Index (kg/m^2)	21.88	4.06	15.8	16.9	18.7	21.4	24.2	27.4	30.5
Gestational weight gain (kg)	9.78	5.83	2	4.5	7	10	13	16	20
Newborn birth weight (g)									
Entire Sample(n=688)	2941.64	424.04	2140	2419	2652	2930	3227	3500	3750
Males(n=344)	2991.02	432.16	2150	2450	2700	3000	3288	3540	3800
Females(n=344)	2892.25	410.47	2080	2400	2600	2875	3150	3450	3700

Table 03 - Correlation between maternal anthropometry and neonatal birth weight

Maternal parameter	Neonatal Birthweight (g)	
For All	r	P value (2-tailed)
Pre-pregnancy weight (kg)	0.25	< 0.001
Height (cm)	0.17	< 0.001
Body Mass Index(kg/m2)	0.19	< 0.001
Pregnancy weight gain(kg)	0.17	< 0.001
Boys		
Pre-pregnancy weight (kg)	0.235	< 0.001
Height(cm)	0.115	0.0331
Body Mass Index(kg/m2)	0.196	0.0003
Pregnancy weight gain(kg)	0.1544	0.0041
Girls		
Pre-pregnancy weight (kg)	0.2441	< 0.001
Height(cm)	0.2358	< 0.001
Body Mass Index(kg/m2)	0.1571	0.0035
Pregnancy weight gain(kg)	0.2041	0.0001

Table 04 - Simple linear regression analysis showing the effect of maternal anthropometric characteristics on neonatal birth weight

Independent variable	Coefficient	95% CI	P value	Adj. R
Pre Pregnancy Weight (kg)	10.5677	7.474-13.66	0.001	0.0602
Height (cm)	11.7379	6.60-16.86	0.001	0.0272
BMI (kg/m2)	19.66	11.99-27.33	0.001	0.0342
GWG (kg)	12.30	6.93-17.67	0.001	0.0282

BMI – Body Mass Index
GWG – Gestational Weight Gain

Table 05 - Multiple linear regression analysis showing the effect of maternal anthropometric characteristics on neonatal birth weight (Final model).

Multivariate	Coefficient	95% CI	P value	VIF	Contribution	Standardized coefficients
Constant	-1615	-2884--346	0.013		15.03	
Pre Pregnancy Weight (kg)	9.48	6.30-12.65	0.000	1.15	6.2	0.2222
Height (cm)	5.40	0.30-10.50	0.038	1.12	1.14	0.0776
GWG (kg)	11.92	6.72-17.13	0.000	1.07	3.51	0.16399
POA (days)	10.64	6.95-14.33	0.000	1.07	3.55	0.2070
Maternal Age (Yrs)	6.41	0.75-12.06	0.026	1.08	0.62	0.0817

R Sq - 15.03 Adjusted R - 14.40   F- 24.08   P – 0.001
BW (g) = -1615+9.48Prepregnancy Weight+5.4Height+11.92GWG+10.64POA+6.41Maternal age
BW – Birth Weight
GWG – Gestational Weight Gain
POA – Period of Amenorrhoea

BW and all four maternal anthropometric measures included in the present analysis. Again these different findings may be due to different sampling approaches, for example, some studies include non-full term neonates and women with maternal conditions such as diabetes, hypertension and anaemia. Nevertheless, our study contributes to the existing literature by further supporting the hypothesis that several maternal anthropometric variables are associated with BW of newborn.

Our data indicated that, of all the maternal measurements evaluated in this study, pre-pregnancy maternal weight was the strongest predictor of neonatal BW. This is in complete agreement with studies done in Bangladesh[18] and USA[4]. Based on the standardized regression coefficient, increase in the pre-pregnancy weight by 1 standard deviation, will increase by 0.222 standard deviations of neonatal BW. According to the regression equation (after adjusting for covariates) 1 kg increase in pre-pregnancy weight was associated with a 9.48 g (95% CI 6.3g – 12.65g) increase in neonatal BW. Unfortunately, it was not possible to investigate the relationship between maternal BMI and neonatal BW, because of high correlation (0.91) between maternal BMI and Pre-pregnancy weight. In the multiple linear regression analysis, due to very high multicollinearity, we had to keep either Pre-pregnancy weight or maternal BMI (even though both had significant p values < 0.01) in the final model. We kept the maternal BMI out of the final model since it shared both maternal weight and height components within it.

Even though maternal anthropometry (pre-pregnant Weight, maternal Height and GWG) was significantly associated with the neonatal BW in the multiple linear regression models, maternal anthropometry only explained nearly 11% of the variability in the neonatal BW. This fits well with the findings of Elshibly et al[7] study done in Sudan.

This study had several limitations. First, the anthropometric measurements used in this analysis was taken by the field and hospital midwives and those were not supervised or verified for accuracy, which could lead to systematic errors. Similarly, we cannot extrapolate our regression equation outside the range of maternal variable used to build the model, since values outside of this range may not follow the same patterns of estimating neonatal BW.

In conclusion, maternal prepregnancy weight, maternal height, maternal BMI and GWG were significantly associated with neonatal birth weight at term. However, maternal prepregnancy weight was the best predictor of term neonatal BW in Sri Lanka.

Acknowledgment

Conflict of interest
None

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