Adverse Maternal Nutritional Status Affects Birth Weight among Rural Mothers of Maharashtra

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Summary Maternal anthropometry and its influence on the birth weight has been studied widely, but effects of maternal undernutrition in-utero depicted by surrogate measures of sitting height and head circumference are largely unknown. We have studied the maternal sitting height along with other conventional nutritional status indicators at registration in predicting the risk of low birth weight (LBW) among 204 young rural women. Information on socio-demographic and economic profile, anthropometric measurements at registration and neonatal birth weight after delivery was recorded. Mothers were thin (mean weight: 46.4 ± 6.1 kg), had short stature (mean height: 153.3 ± 5.7 cm) and 33.8% were undernourished (body mass index (BMI) <18.5 kg/m²). Prevalence of LBW was 27.5%. Maternal weight, height, BMI, head circumference, sitting height and %body fat at registration were significantly (p<0.05) associated with birth weight. Significant risks for LBW were observed for low (<42.26 kg) weight (OR=3.69; CI: 1.6–8.1), short (<150 cm) height (OR=2.3; CI: 1–5.1), low (<18.5 kg/m²) BMI (OR=3.27; CI: 1.4–7.3), low (<70 cm) sitting height (OR=2.3; CI: 1.0–5.1), small (<52 cm) head circumference (OR=3.3; CI: 1.6–7.1), and low (<22.7%) %body fat (OR=4.98; CI: 2.2–11.2). Interestingly, these risks remained significant for sitting height (OR=3.4; CI: 1.5–7.6, OR=2.5; CI: 1.1–5.8) and head circumference (OR=2.4; CI: 1.1–5.6, OR=2.2; CI: 0.9–5.03) even after adjusting for BMI and %body fat respectively indicating their independent influence. Our findings highlight that in addition to the current maternal undernourishment, maternal undernourishment in-utero (small head circumference and short sitting height) imposes risk for LBW.

Key Words low birth weight, maternal anthropometry, sitting height, rural mothers

Low birth weight (LBW) is a major concern worldwide especially in a developing country like India. It is of public health importance as well as the measure of quality of life and survival of the future generation (1). The relationship between maternal malnutrition and its effect on birth outcome has been highlighted in several studies. Maternal anthropometry is one such influential avenue that determines birth outcome. In particular, previous studies have highlighted the significance of maternal height, weight, gestational weight gain, pre-pregnancy body mass index and maternal arm circumferences as measures of current and past nutritional status of the mother as the predictors of birth weight (2–5). However other measures like maternal head circumference and sitting height are less reported despite the fact that they are known indicators of maternal undernutrition. For example, maternal head circumference is reported to be surrogate measure of maternal undernourishment in-utero (6). Similarly, leg length is known to be an indicator of malnutrition but sitting height as its complement has not been explored (4).

Hence the present study attempts to highlight the importance of maternal sitting height and head circumference along with other conventional anthropometric indicators used for defining maternal nutritional status at registration to the risk for LBW.

MATERIALS AND METHODS

The study was in accordance with the Declaration of Helsinki and was approved by Institutional Ethics Committee of Symbiosis International Deemed University. A written informed consent was obtained from participants voluntarily. In the present study, 204 pregnant women were recruited from 3 primary health centres located in Mulshi Taluka, Pune, Maharashtra, age <25 y with a gestational age of <13 wk. The women were followed up until delivery.

Multiple pregnancies and cases with congenital anomalies or chronic illness were excluded from the study. The sample size was determined considering prevalence of LBW of 30% and an allowable error of 6%. An interview was conducted using a structured questionnaire based on National Family Health Survey-2015 for obtaining the socio demographic and economic information. At the time of enrollment maternal anthropometry was measured in duplicate using stan-
standard tools and calibrated instruments.

Weight was measured using digital weighing balance (HBF 210 Omron Corporation) to the nearest 100 g while standing height was measured using a stadiometer to the nearest 0.1 cm. The pregnant woman was asked to sit on a table with feet off the floor comfortably placed on a stool, using a non stretchable tape sitting height was measured as the distance between the vertex and the base to the nearest 0.1 cm while being seated. The head circumference was measured using a non stretchable tape to nearest 0.1 cm. The tape was placed on the widest part of the forehead and around the widest part of the back of the head while measuring. The %body fat was measured using an analyser HBF 210 Omron Corporation. The birth weight of neonates was measured with a digital weighing scale within 24 h of birth. Birth weight was categorized clinically based on WHO guidelines: LBW (<2,500 g) and normal birth weight (2,500–3,999 g). Gestational age was determined from the self-reported date of last menstrual period (LMP) and was confirmed using the USG reports from the primary health centre. Preterm birth was defined as gestational age <37 completed weeks at delivery.

**Statistical Analysis.** The measured variables were expressed in terms of mean ± standard deviation or percentages. Means of groups were compared using t test and linear trend was tested using oneway ANOVA. Logistic regression was used to estimate risk (Odds

| Variable | N (%) |
|----------|-------|
| Weight (kg) | 46.46±6.1 |
| Height (cm) | 153.39±5.79 |
| BMI (kg/m²) | 19.74±2.41 |
| Head Circumference (cm) | 52.56±1.62 |
| Sitting Height (cm) | 74.64±2.8 |
| Body fat (%) | 25.34±4.71 |

**Table 1.** Maternal socio-economic and demographic characteristics.

| Variable       | N (%) |
|----------------|-------|
| Family size    |       |
| <5             | 57 (27.9) |
| 4–5            | 33 (16.2) |
| >5             | 114 (55.9) |
| Maternal education |       |
| 12th grade     | 46 (22.6) |
| 10th grade     | 88 (43.1) |
| 7th grade      | 39 (19.1) |
| 5th grade      | 31 (15.2) |
| Maternal occupation |       |
| Laborer/farming | 86 (42.2) |
| Housewife      | 118 (57.8) |
| Husband education |       |
| Laborer/farming | 41 (20.1) |
| Service        | 163 (79.9) |
| Monthly Family Income (INR) |       |
| <8,000         | 58 (28.4) |
| 8,000–10,000   | 83 (40.7) |
| >10,000        | 63 (30.9) |
| Age at registration (y) |       |
| <20            | 37 (18.1) |
| 20–24          | 124 (60.8) |
| >24            | 43 (21.1) |
| Age at Menarche (y) |       |
| <12            | 38 (18.6) |
| 13–15          | 121 (59.3) |
| >15            | 45 (22.1) |
| Age at Marriage (y) |       |
| <18            | 87 (42.6) |
| 19–20          | 57 (27.9) |
| >20            | 60 (29.4) |

**Table 2.** Mean (±SD) maternal anthropometric profile.

| Variable       | Mean Birth weight (g) | % LBW |
|----------------|-----------------------|-------|
| Weight (kg)    | 2.391                 | 44.6  |
| Height (cm)    | 2.706                 | 20.8  |
| BMI (kg/m²)    | 2.855                 | 17.9  |
| Head Circumference (cm) | 0.000 | 0.001 |
| Sitting height (cm) | 2.777 | 18.6  |
| Body Fat (%)   | 2.849                 | 16.4  |

| Variable | n | Mean Birth weight (g) | % LBW |
|----------|---|-----------------------|-------|
| Weight (kg) | 65 | 2.391 | 44.6  |
| Height (cm) | 72 | 2.706 | 20.8  |
| BMI (kg/m²) | 67 | 2.855 | 17.9  |
| Head Circumference (cm) | 68 | 2.506 | 34.8  |
| Sitting height (cm) | 66 | 2.674 | 29.4  |
| Body Fat (%) | 70 | 2.777 | 18.6  |

**Table 3.** Mean (±SD) birth weight and prevalence of LBW by tertiles of maternal nutritional status at registration.

| Maternal Anthropometry | n | Mean Birth weight (g) | % LBW |
|------------------------|---|-----------------------|-------|
| Weight (kg) | 69 | 2.466 | 39.1  |
| Height (cm) | 68 | 2.655 | 26.5  |
| BMI (kg/m²) | 67 | 2.849 | 16.4  |
| Head Circumference (cm) | 71 | 2.410 | 43.7  |
| Sitting height (cm) | 58 | 2.719 | 19    |
| Body Fat (%) | 75 | 2.837 | 18    |

| Maternal Anthropometry | n | Mean Birth weight (g) | % LBW |
|------------------------|---|-----------------------|-------|
| Weight (kg) | 64 | 2.522 | 42.2  |
| Height (cm) | 68 | 2.700 | 23.5  |
| BMI (kg/m²) | 74 | 2.730 | 18.1  |
| Head Circumference (cm) | 67 | 2.671 | 19.7  |
| Sitting height (cm) | 71 | 2.876 | 15.5  |
| Body Fat (%) | 66 | 2.414 | 47.8  |

| Maternal Anthropometry | n | Mean Birth weight (g) | % LBW |
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| Weight (kg) | 67 | 2.671 | 19.7  |
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Adverse Maternal Nutritional Status and Low Birth Weight

Statistical analysis of the data was done using SPSS v. 23 and p value of <0.05 was considered to be significant.

RESULTS

The socio-economic and demographic characteristics of mothers are described in Table 1. The family size was >5 for 28.5% mothers. Very few (22.6%) mothers had school education above 10th grade while sizeable (42.2%) proportion of husbands were educated above 10th grade. Mothers were occupied as housewife (57.8%) or as farming labourer (42.2%). On the other hand, 79.9% of their husbands were engaged in service employment. Monthly income was low (<10,000 INR or <142$) in majority of the families (69.1%). The demographic data indicates a delayed age at menarche (around 14 y) for 59.3% mothers. But, early age at marriage (<20 y) was prevalent (66.5%). Consequently, most of mothers (77.5%) were young (<24 y) at conception.

Maternal anthropometry revealed that mothers were thin (mean±sd weight 46.4 kg) and short (mean±sd height 153.3±5.7 cm) as shown in Table 2. Their mean BMI was also low (19.7 kg/m²) but, reasonable %body fat (25.34%). Mean sitting height was 74.6 cm, while mean head circumference was 52.5 cm. Of the mothers, 5% had body weight <38 kg, 4.4% had body weight <150 cm, and 33.8% had BMI <18.5 kg/m².

The overall prevalence of LBW was 28.7%. The mean birth weight by tertiles of maternal nutritional status indicators are shown in Table 3. It shows that the mean birth weight of the neonate increases significantly with increase in maternal weight (p=0.000), height (p=0.002), body mass index (p=0.000), head circumference (p=0.000), sitting height (p=0.018) and %body fat (p=0.000). We also examined the prevalence of LBW and found an inverse association with maternal anthropometric parameters of weight (p=0.001), body mass index (p=0.012), head circumference (p=0.001), sitting height (p=0.005) and body fat percentage (p=0.000) but not with maternal height. Overall it was observed that the prevalence of LBW was highest in the lowest tertile of each of these indicators.

The risk of LBW by maternal nutritional status indicators using odds ratio is shown in Table 4. Low maternal weight (<42.26 kg), short height (<150 cm), low BMI (<18.5 kg), small head circumference (<52.16 cm), short sitting height (<70 cm) and low %body fat (<22.73%) imposed a significantly higher risk for LBW. In order to examine the independent influence of each of the maternal nutritional status indicators, the ORs were adjusted for BMI and% body fat. The maternal weight and height became non significant after adjustment, but maternal BMI (OR: 2.27; CI: 1.5–8.3) and %body fat (OR: 3.9; CI: 1.3–11.9) remained significant after adjustment.

The risk of LBW by maternal nutritional status indicators using odds ratio is shown in Table 4. Low maternal weight (<42.26 kg), short height (<150 cm), low BMI (<18.5 kg), small head circumference (<52.16 cm), short sitting height (<70 cm) and low %body fat (<22.73%) imposed a significantly higher risk for LBW. In order to examine the independent influence of each of the maternal nutritional status indicators, the ORs were adjusted for BMI and% body fat. The maternal weight and height became non significant after adjustment, but maternal BMI (OR: 2.27; CI: 1.5–8.3) and %body fat (OR: 3.9; CI: 1.3–11.9) remained significant after adjustment.

Finally, short sitting height of <70 cm (OR=3.4; CI: 1.5–7.6, OR=2.5; CI: 1.1–5.8) and smaller head cir-
cummence $< 52.2$ cm (OR = 2.4; CI: 1.1–5.6, OR = 2.2; CI: 0.9–5.03) showed significant risk for LBW even after adjusting for BMI and %body fat respectively.

**DISCUSSION**

Maternal nutritional status has been considered to be the most important factor influencing birth outcomes. LBW due to poor pre-pregnancy weight (8), poor gestational weight gain (9), short stature (10) and poor arm circumferences (5) have been studied globally. On the other hand, maternal head circumference (11) has been reported by only one study, while maternal sitting height as a risk factor has been reported by none. We observed that smaller head circumference and shorter sitting height have independent influence on risk of LBW.

Before discussing the major findings, it is worthwhile to point out that we are exclusively analyzing maternal anthropometry and it cannot be denied that other maternal variables such as diet, physical activity, use of tobacco etc. are not considered. Secondly, being a prospective follow-up study, the sample size was moderate. Inspite of those, the significant associations observed for maternal anthropometry with risk of LBW cannot be overlooked.

The prevalence of LBW in the present study was 27.5%, which was similar to that reported for South Asia (UNICEF global database 2014) and was closer to the region specific western rural population 24.7% of India (12). Mean birth weight was significantly associated with mean maternal nutritional status indicators such as weight, height, BMI, head circumference, sitting height and %body fat. Thus, the difference in mean birth weight for mothers in higher tertile vs. lower tertile was maximum for weight (464 g), %body fat (462 g) and head circumference (427 g). Similarly, the prevalence of low birth weight was minimum (around 18%) for mothers in the highest category of each of the nutritional status indicators and was maximum for those in lower tertile (above 40%). Similar associations have been reported for weight and height (13), BMI (14) and body fat (15), but are not reported for maternal sitting height or maternal head circumference.

Our observation that low maternal weight and low maternal height show significant risk for LBW are in confirmation with past studies (13, 14). However, it is worthwhile to note that these risks became non significant after adjustment for BMI and %body fat have not been reported by others. Mothers with low %body fat (22.73%) showed the highest risk (OR: 4.9; CI: 2.2–11.12) for LBW indicating the importance of maternal body energy stores during pregnancy. We also reported significant risk for LBW in association with smaller head circumference and smaller sitting height. It is known that smaller maternal head circumference is a surrogate measure of maternal undernutrition in-utero (11) and indicates intergenerational influence on birth outcome. It is reported that during fetal undernutrition the blood flow is prioritized towards protection of vital organs such as brain and heart situated in the upper part of the body affecting skeletal growth of epiphysis (16) probably resulting in a shorter sitting height. Thus, short sitting height is also a surrogate measure of maternal undernutrition in-utero. Our observation which is first to report that short sitting height imposes significant risk for LBW even after adjustment of BMI and %body fat assumes importance.

In conclusion adverse maternal anthropometry at $< 13$ wk of gestation resulted in LBW. Among various indicators, lower maternal body fat indicative of poor energy stores revealed significant risk for LBW. Interestingly, birth weight was not only influenced by current maternal nutritional status but also by mother’s own malnourishment in utero as indicated by smaller head circumference and short sitting height pointing towards intergenerational influence on birth outcome.

Hence it is imperative to improve the nutritional status of young adolescent girls by including them in the existing nationwide nutrition intervention programs. The existing health workers can be trained to impart nutritional knowledge to young pregnant women in rural areas. The social change with regard to increased age at marriage and improved education are also important in delaying age at conception and thereby will reduce the risk of LBW.

Disclosure of state of COI

No conflicts of interest to be declared.

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