

Maternal Diet Influences Association of Gestational Weight Gain and Birth Weight Among Undernourished Mothers

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ABSTRACT

Objective: Maternal nutrition intervention improves birth outcomes in undernourished but not in well-nourished populations. Therefore, objective was to examine its role in association of weight gain and pregnancy outcome in undernourished mothers. **Design:** Prospective study **Setting:** Obstetrics and Gynaecology out patients department of Rural Hospital Talegaon, **Participants:** Mothers (n=370) registering within 20 weeks of gestation were studied for socioeconomic variables, diet, anthropometric measurements and were followed up till delivery. **Results:** Mothers were undernourished with mean weight 45.9 ± 7.3 kg, height 150.8 ± 6.1 cm and BMI 20.2 ± 3.1 kg/m². In fact proportion of mothers below LBW risk cut off for weight (38Kg), height (<145 cm) and BMI (18.5 kg/m²) was respectively 9.8 %, 8.6 % and 32.8%. Mothers in lower tertile of weight (<42.5 Kg), BMI (<18.5Kg/m²) body fat (<21.8%) had babies with significantly lower birth weights with highest prevalence of LBW. Maternal BMI associated inversely with weight gain but positively with birth weight indicating that foetal growth was not benefitted fully by gained weight in undernourished mothers. Consumption of milk/milk products, fruits, non-vegetarian foods, dal and roti was associated with birth weight but not with weight gain. Comparison of mothers of LBW and normal weight babies within low (18.5 kg/m²) and high (≥ 21.1 kg/m²) BMI groups showed that consumption of milk was discriminatory, indicating importance of proteins and micronutrients in facilitating foetal growth. **Conclusion:** Consumption of milk facilitated sparing of gained weight for foetal growth among undernourished mothers and promoting it could be a simple public health approach for prevention of LBW in rural India.

Key words: Maternal diet, weight gain, birth weight, undernourished mothers

INTRODUCTION

Almost 20 million low birth weight infants are born each year, a large majority of those births occurring in low and middle income countries (LMIC). Poor foetal growth in developing world is largely attributed to widespread maternal undernutrition. High prevalence of LBW in developing countries is therefore reflection of a more severe and massive problem related to maternal undernutrition. In fact, poor nutritional status at conception, low gestational weight gain due to inadequate dietary intake and short maternal stature due to mothers own childhood under nutrition and / or infection are believed to be the major determinants for LBW

in developing countries (1). It is worthwhile to note that the countries where high proportions of LBW are seen are also the countries where women have low body mass index indicating maternal undernutrition.

Although poor maternal nutritional status is a major determinant of LBW, the factors responsible range from socio demographic to genetic, illustrating a wide spectrum of underlying causes. For example, poor socio economic environment is known to affect food availability (2), the work load of the mother (3) and important decisions like seeking antenatal care during pregnancy (4) that influence birth outcome. Equally important are the demographic factors like early age at marriage and conception (5), delayed age of menarche coupled with early conception (6), short spacing (<2 yr) between successive deliveries (7, 8, 9, 10) and the history of repeated abortions make women from low socio-economic class more vulnerable for poor pregnancy outcome (11).

Mother's nutritional status prior to conception and her nutrition through pregnancy influence birth weight considerably. It is believed that the impact of poor nutritional status of mother is more pervasive than the impact of other factors on birth weight. In particular, maternal pre pregnancy weight, an indicator of current nutritional status, is known to have independent influence on birth weight. (12,13,14). Similarly, statistically significant associations between short maternal stature, an indicator of past undernutrition, and adverse birth outcome are reported (15) using extensive meta-analysis of large data sets from LMIC.

Gestational weight gain is yet another important factor associated with pregnancy outcome but most of the evidence is from developed countries (16). Therefore, these associations may differ by countries, ethnic diversity and especially among undernourished populations (17). For, in less developed Asian countries women achieve less gestational weight gain than IOM recommendations. Secondly, less is known about weight gain by time in pregnancy and its influence on birth size. Finally, inadequacy of key nutrients required for foetal growth may affect weight gain and its association with pregnancy outcome.

Although importance of maternal nutrition to foetal development and birth outcomes has been clearly demonstrated in experimental animal studies, the findings of studies in humans are much less consistent (18). Unfortunately, maternal diets in most developing countries are often inadequate both in macronutrients and micronutrients. But, studies of energy protein supplementation during pregnancy have produced varying and sometimes conflicting results (19). Similarly, available data on relationship of maternal micronutrient status with actual pregnancy outcome is extremely scanty and the more logical approach of multiple micronutrient supplements has been inadequately tested (20). Further, nutritional insults during different periods of gestation have differing effects on birth. For example, acute severe maternal malnutrition may adversely affect the birth weight of the foetus especially when the exposure is during the third trimester of pregnancy (21) while early work (22) has shown that undernutrition in early intra uterine life tends to produce small but normally proportional animals whereas undernutrition later in development leads to selective organ damage and disproportionate growth. Maternal nutrition is thus of paramount importance and needs critical understanding for planning effective strategies to improve birth outcome.

In a recent study (23) improved maternal intakes of milk in early gestation and of GLV and fruit in late gestation were reported to result in improved fetal growth and authors suggest that these foods probably provide a more effective combination of nutrients than do conventional supplements that contain only one or two micronutrients or macronutrients. Milk intake in pregnancy was also observed (24) to be associated with higher birth weight for gestational age, lower risk of SGA, and higher risk of LGA while a study in Ghana (25) reports that increase in dietary diversity is effective in reduction of prevalence of LBW. The implication is that, specific foods providing specific nutrients may be of importance rather than absolute intake of calories or proteins. The present study thus attempts to investigate the associations between maternal nutritional status at registration, nutrition and weight gain during gestation with birth weight.

MATERIALS AND METHODS

Present study was a hospital based prospective study, carried out at Dr. Bhausaheb Sardesai Rural Hospital Talegaon, attached to MIMER medical college.

Subjects - The study population comprised of Antenatal Care cases who registered at the Obstetrics and Gynaecology out patients department of the hospital within 20 weeks of gestation. Considering 35% prevalence of LBW with 5% tolerance estimated sample size was 425 cases allowing for 15% loss to follow up. Clinically apparently normal ANC cases within 18 to 40 years of age, were enrolled in the study after obtaining their oral informed consent. Out of 459 initially enrolled, there were exclusions due to abortions (21), still births (3), intra uterine growth retarded (IUGR) (2). Of the remaining 433 cases, exclusions due to multiple pregnancies (4), major illness (thyroid -1 and pregnancy induced hypertension-1), changing the place of delivery (6) and premature deliveries (51), data on 370 full term mothers is analysed. Ethical clearance was sought from Ethical Committee of MIMER medical college.

Qualitative information: Maternal socio economic and demographic information was collected on each enrolled woman at the time of registration using a structured and validated questionnaire. It comprised of size of the family, monthly income, education and occupation of the mother as well as her husband. The demographic information about her age at menarche, marriage and at registration was also recorded. Similarly, obstetric information on variables like parity, spacing and previous abortions, if any, was recorded for each mother. Maternal activity was also recorded as time spent in domestic work, leisure activities and work done outside, using pretested activity questionnaire.

Anthropometric measurements - Maternal height was measured (up to 0.1 cm) using stadiometer (Standard Steel Co. Model SECA213, India), weight was measured using (up to 100 g) digital weighing balance (Smart Care Co. Model SCS110A, India), Body fat (%) was recorded using body fat analyser (HBF300, OMRON Corporation, Japan) at each ANC visit. Babies were measured at birth using digital weighing scale (Homedics Group Ltd. Model Salter 914, India) was used for measuring length.

Maternal dietary intake - Dietary intake was assessed using pre tested food frequency questionnaire (FFQ) to record consumption of various foods and their frequency in last one month. It covered total of 54 food items divided into 13 groups such as milk, milk products, cereals, lentils, legumes, vegetables, green leafy vegetables, fruits, non-vegetarian foods, snacks,

bakery products etc. Amount of food intake was measured in terms of number of roties and in terms of serving spoons of standard size for other foods. Frequency of consumption in terms of once, twice or more in a day / week or month was noted.

Statistical methods – Variables deviating from normality were transformed for achieving it y before using them in the statistical analysis. Means of two groups were compared using 't' test while linearity in group means was tested using ANOVA. Logistic regression was done to estimate odd ratio (OR) for risk of LBW in higher category considering lower category as reference category for various risk factors. FFQ scores were used as grouped variable. Statistical analysis of data thus collected was done using SPSS 19.0 version.

RESULTS

Socio economic, demographic background of mothers

Most mothers (56.5%) had family size < 5 and over 80% of mothers and their husbands had education only up to 10th std (Table 1). Mothers were either housewives or were engaged in farming (92%). Their husbands were also largely (47.1 %) engaged in unskilled jobs and almost all had low monthly income. Mean age at registration was 22.6 ± 3.3 yr and majority (73.5%) of mothers were young i.e. below <25 yr.

Maternal nutritional status and birth weight

Mothers were overtly undernourished (Table 1). They were thin (mean weight 45.9 ± 7.3 kg) and short (mean height 150.9 ± 5.9 cm). Almost 9.6 % had lower weight than risk cut off (38 kg) and 8.4 % were shorter than risk cut off (145 cm) for height, which are considered to be risk cut offs for LBW. They were undernourished (mean BMI 20.2 ± 3.1 kg/m²) and almost 32.8 % mothers had BMI below 18.5 kg/m² indicating chronic energy deficiency. Their mean body fat was (24.7 ± 6.4 %) and indicated lower body energy source. Consequently, the overall mean birth weight was only 2571 ± 311 g and the prevalence of LBW was 41.4 %.

Maternal nutritional status is known to be a major determinant of birth weight and all the three anthropometric indicators of mother's nutritional status viz., weight, BMI, and body fat; showed positive association with birth weight (Table 2). Thus, mean birth weight of the babies born to mothers in the lowest tertile of weight (2541 ± 319 g), or BMI (2521 ± 309 g), or body fat (2526 ± 306 g) was lowest and increased significantly ($p < 0.05$) from lowest to highest tertile for each of the indicator. Thus mothers with poor weight (<42.5 Kg), lower BMI (<18.5 Kg/m²) and lower body fat (<21.8%) had babies with significantly lower birth weights compared to their counterparts. Consequently, the prevalence of LBW in the lowest tertile was highest but did not decrease significantly. In fact, even in the highest tertiles of these indicators it remained quite high, almost above 35%.

Maternal nutritional status and weight gain

Gestational weight gain is one of the major determinants of birth weight. The overall mean gestational weight gain was 7.38 ± 2.6 Kg (give mean gain for lbw and normal) and though it was correlated ($r = 0.129$; $p = 0.016$) with birth weight, the explained variation in birth weight was even <5%. Weight gain of mothers of LBW babies was comparable in early pregnancy but fell between 20th to 25th weeks and remained low thereafter. They seemed to gain with faster rate only towards the end of gestation (Fig1). Mean weight gain by tertiles of maternal

nutritional status indicators (Table 3) showed that mothers in the lower tertile of BMI actually had significantly higher gestational weight gain as compared to those in higher tertile showing significant ($p<0.000$) inverse association between the two. This was also true for other two indicators viz., maternal weight and body fat. These associations of maternal nutritional status with birth weight as well as gestational weight gain shown in Fig 2 suggest that babies born to undernourished mothers (poor nutritional status) have lower birth weights despite substantial weight gain during gestation. Clearly, deeper understanding of adverse pregnancy outcomes affected by poor maternal BMI and lower gestational weight gains is required. In particular, the role of maternal nutrition /nutrients during gestation needs attention.

Maternal diet and birth weight

We examined associations of consumption of certain foods/nutrients with foetal growth (Table 4). Higher consumption of staple food Roti ($> 4/d$) was significantly ($p=0.013$) associated with birth weight. Similarly, higher frequency of consumption of dal, the major source of protein in vegetarian diet, was also significantly associated with higher birth weight ($p=0.03$). Among the other food groups milk and milk products (considered together) and non-vegetarian foods, the major source for animal proteins, also showed significant ($p=0.02$ and $p=0.03$) associations with birth weight. Finally, higher consumption of seasonal fruits was also associated ($p=0.05$) with higher birth weight. It was however interesting to note that maternal consumption of any of these foods was not associated with weight gain. The suggestion is that the specific nutrients from specific foods may not have role in gaining the weight but rather in sparing the weight gained for foetal growth. Moreover, these associations may differ among undernourished and normal mothers.

It is for this reason we classified mothers as undernourished ($BMI<18.5 \text{ Kg/m}^2$) or well-nourished and compared maternal characteristics of mothers of LBW and normal babies within each group (Table5). Among the well-nourished group, maternal characteristics like mean weight, BMI, body fat (%) or gestational weight gain did not differ between mothers of LBW and normal weight. With regard to diet, significantly ($p=0.04$) lower proportion of mothers consumed non vegetarian foods more than once a week.

Among undernourished group, mothers of LBW babies had significantly lower mean weight, and mean BMI indicating importance of good maternal nutritional status in early pregnancy. Nevertheless, they had similar body fat percent and even similar gestational weight gain. In addition to non-vegetarian foods, significant difference was seen in the consumption of milk/milk products. Proportion of mothers of LBW babies having milk / milk products more than once a week was significantly lower than that for mothers of normal babies. Also only a smaller proportion seemed to have low dal consumption. Thus, the major discrimination between undernourished and well-nourished mothers seemed to be that of milk consumption.

DISCUSSION

Rates of maternal malnutrition in the developing countries are among the highest in the world, despite considerable increases in food grain production and materialistic improvements. Improved maternal nutrition has been associated with increased fetal growth and a reduction in adverse birth outcomes in developing countries and in populations with nutrient deficiencies, but not in well-nourished populations (26, 27, 23). Maternal nutrition is thus of

critical importance and needs understanding of role of macro and micronutrients in fetal growth. We observed that food consumption was not associated with weight gain but was correlated with birth weight. Moreover, among undernourished mothers consumption of dal (pulses, the source of protein) and milk products (micronutrients like calcium, B₁₂) made the difference in mothers of LBW and normal weight babies indicating possible role in the process/mechanism of sparing the gained weight for foetal growth.

Pre-pregnancy BMI and gestational weight gain is indicator of maternal reserves for foetal growth. Mothers in our study were thin, short and 32.8% were below the BMI of 18.5 indicating chronic energy deficiency. Mean maternal weight was comparable with those reported in various rural areas from for Maharashtra (23); for Karnataka (28) and for Uttar Pradesh (29). All the maternal nutritional status indicators viz., maternal weight, BMI and body fat; showed significant positive association with birth weight and inverse association with prevalence of LBW. In particular, mothers in lower tertile of weight (<42.5 Kg) or BMI (<18.5) had lowest birth weight and highest prevalence of LBW.

Weight gain on the other hand was inversely associated with maternal nutritional status. Thus mothers with poor maternal pre-pregnancy BMI (or weight /body fat) gained significantly more compared to mothers with higher BMI (or weight /body fat). Similar observations are reported among Indonesian women (16). Most women achieved less gestational weight gain than IOM recommendation. Though total weight gain for mothers of LBW was comparable with mothers of normal weight babies, they appeared to gain less in second trimester (beyond 20 wks.) compared to their counterpart indicating influence of weight change by time in pregnancy on outcome. It has been reported that weight gain in early pregnancy and not in third trimester predicted birth size (30,31).

Nutritional deficiencies are common in women of reproductive age in developing countries and epidemiological and biological studies suggest that specific nutritional deficiencies can influence the pregnancy outcome. For example, in a comparative study on women who delivered LBW babies with those who delivered normal weight babies, it was observed that the maternal diets in the former group were deficient in folate, iron and calcium (32). Placental and fetal growth is believed to be most vulnerable to maternal nutrition status, especially protein and micronutrients, in the early pregnancy (first trimester), a period of peri-implantation and of rapid placental development (33). Although nutrient requirement in the first trimester are quantitatively small, nutritional deprivations during this period can adversely affect placental structure and indirectly ultimately the birth weight. In our study nutritional assessment at registration showed that higher consumption of milk and milk products, fruits, non-vegetarian foods, dal and roti was associated with higher birth weight but not with higher weight gain.

Finally, role of nutrition was further revealed when we compared consumption of mothers of LBW and normal weight babies by considering their BMI (whether low or high) at registration. When maternal BMI at registration was high (>21Kg/m²) consumption of non-vegetarian foods made a difference in birth weight. In contrast, when mothers were undernourished (<18.5 Kg/m²) at registration, in addition to non-vegetarian foods consumption of milk and milk products and dal made the difference. Review of studies published in the recent decade also

reports a significant positive association between maternal milk consumption and fetal growth as well as infant birth weight and suggests its importance as a source of protein and other valuable nutrients (34, 35). In particular, milk is a rich and major source of calcium and B12 in vegetarian diets. Our data therefore suggest that among undernourished mothers despite higher weight gain, its sparing for foetal growth is perhaps conditioned by maternal intake of calcium as it has been reported in several animal studies that calcium triggers lipolysis. Further, it renders support to the observation (36) that this action of calcium is profoundly seen at levels of energy restriction. We have reported earlier that almost 75% of the mothers were having calorie intake below 80% of RDA while 50% were below this cut off for protein intake (37).

CONCLUSION

In conclusion, the relationships of pre pregnancy BMI, weight gain and pregnancy outcome may differ in undernourished populations. The observation that maternal underweight (or low BMI) was associated with significant risk of LBW was also reported by recent studies (38, 39) attempting meta-analysis. Improvement of nutrition and health status of adolescent girls is of vital importance since it is inextricably linked with the quality of the next generation as reported from study that followed birth cohort through their pregnancy (40). Secondly, besides the known influence of early pregnancy (<20 wks), our observation indicated that the birth weight appeared to be refractory to effects of weight change beyond 20th week. Since weight gain in third trimester (≥ 25 wk) does not show association with birth weight (30) the suggestion is that first 20 weeks could be the critical window for nutrition interventions during gestation in undernourished mothers.

Finally, in the event of scarce data on maternal nutritional intakes in undernourished mothers, our observation that consumption of dal and milk was discriminatory in mothers of LBW and normal weight babies has important implications. Because, in the event of low BMI before conception, dietary modification offers the only hope for improving birth weight. Food based interventions, using milk or distributing extra dal through PDS (Public Distribution Scheme) to pregnant mothers would be helpful as these foods are part of the conventional food basket. Alternatively administering health education aimed to create nutritional awareness and motivate rural mothers for promoting consumption of milk/ milk products and dal daily during gestation will be simple public health approach for tackling the massive problem of low birth weight in rural India.

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Table 1: Maternal anthropometric measures (mean $\pm$ sd)

Variable	N	Mean $\pm$ sd
Weight (kg)	335	46.1 $\pm$ 7.4
Height (cm)	335	150.9 $\pm$ 5.8
BMI (kg/m ²)	335	20.2 $\pm$ 3.1
Body fat (%)	335	24.7 $\pm$ 6.4
Below risk cut off for weight i.e. % below 38 Kg	33	9.6
Below risk cut off for height i.e. % below 145 cm	28	8.4
undernutrition i.e. BMI below 18.5 Kg/m ²	88	32.5

BMI – Body mass index**Table 2: Mean birth weight by maternal nutritional status**

Tertile	Nutritional status indicator					
	weight#	%LBW	BMI	%LBW	Body fat#	%LBW
Lower	2541 $\pm$ 319	47.6	2521 $\pm$ 309	48.2	2526 $\pm$ 304	45.4
Middle	2577 $\pm$ 300	38.8	2591 $\pm$ 315	36.9	2584 $\pm$ 303	38.0
Higher	2620 $\pm$ 304	33.9	2616 $\pm$ 299	36.5	2624 $\pm$ 327	38.9
p	0.04		0.02		0.02	

: values are transformed for achieving Normality

Table 3: Mean weight gain by maternal nutritional status

Tertile	Nutritional status indicator		
	weight#	BMI#	Body fat
Lower	7.90 $\pm$ 2.0	7.89 $\pm$ 2.0	7.68 $\pm$ 2.2
Middle	7.07 $\pm$ 2.1	7.18 $\pm$ 2.3	7.32 $\pm$ 2.2
Higher	6.81 $\pm$ 2.3	6.77 $\pm$ 2.1	6.86 $\pm$ 2.2
Linearity	0.00	0.00	0.004

: values are transformed for achieving Normality

Table 4: Mean birth weight by consumption of different foods.

Food item	Frequency of consumption	Mean birth weight (g)	P +
Milk products	Yes No	2605 ± 310 2540 ± 309	.05
Milk & milk product consumption	Yes No	2601 ± 303 2524 ± 318	.02
Fruit	< once/month Once/mo to once /d ≥ once/d	2554 ± 300 2511 ± 321 2633 ± 317	.05
Non vegetarian food	< Once /wk ≥ once /wk	2532 ± 311 2604 ± 307	.03
Roti	<2/d 2-4/d ≥4/d	2534±291 2546±318 2657±309	.01
Dal (Pulses)	< 1/wk 1/wk to alternate day ≥ alternate day	2534 ± 321 2496 ± 289 2607 ± 310	0.03

+ p for difference / trend in group means

Table 5: Comparison of mothers of LBW and normal babies in low and high BMI tertiles

Undernourished (BMI<18.5)		Maternal characteristics	Well nourished (BMI ≥21.1)	
Normal (n=56)	LBW (n=57)		Normal (n=69)	LBW (n=40)
40.9 ± 3.0	39.3 ± 3.7*	Maternal weight (Kg)	53.2 ± 7.2	53.7 ± 7.1
17.4 ± 0.75	17.0±1.2*	BMI (Kg / m ²)	23.5 ± 2.5	23.9 ± 2.6
20.3 ± 4.3	19.4 ± 4.7	Body fat (%)	29.7 ± 5.0	31.0 ± 5.7
7.83 ± 2.3	7.99 ± 1.7	Gestational weight gain (Kg)	6.77 ± 2.1	6.77 ± 2.1
2709 ± 285	2314 ± 175**	Mean Birth weight (g)	2757 ± 293	2386 ± 97**
53.6	35.7*	Milk products ≥ once/wk	58.0	47.5
66.1	50.0*	Total milk ≥ once/wk	68.1	64.3
37.5	16.1*	Legumes < once/wk	26.1	35.7
65.5	43.6*	Non veg. foods ≥ once/wk	62.3	43.9*

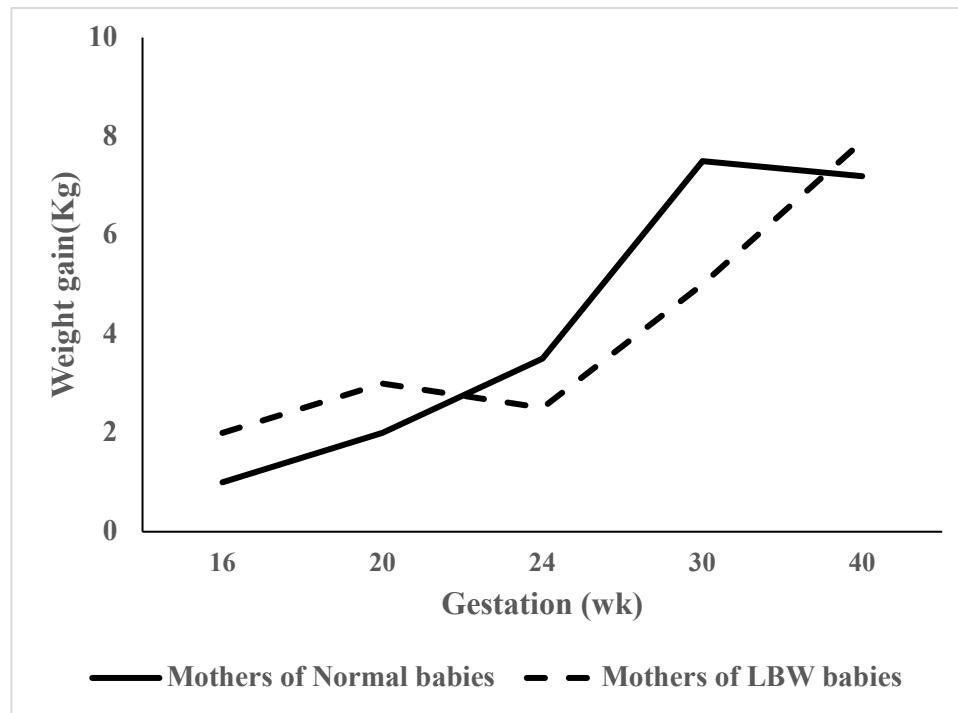


Fig 1: Mean weight gain of mothers of LBW and Normal babies during gestation

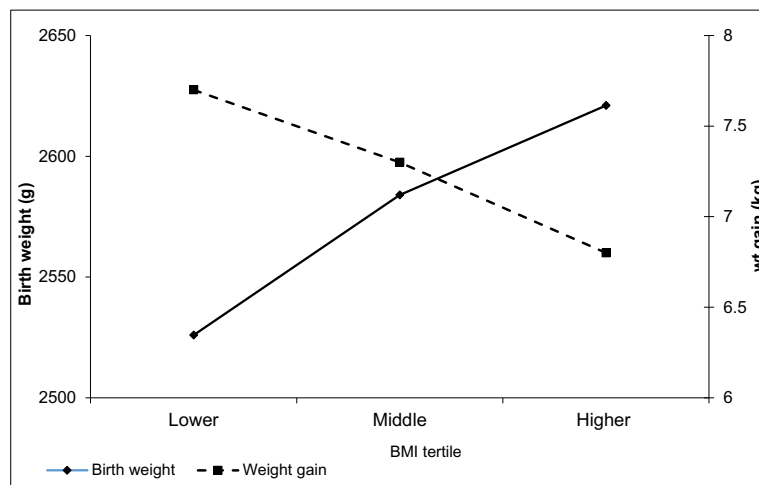


Fig 2: Gestational weight gain and birth weight by BMI tertiles