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Review Article

Maternal Nutritional Status and Its Relation with Birth Weight

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ABSTRACT

This study aimed at establishing a relation between maternal nutritional status and birth weight through a literature search. For this review more than 200 research articles have been screened out on the subject and 101 relevant studies have been identified and included in paper writing. Maternal nutritional status could be considered as primary predictor factor for birth weight of infants. This relationship is influenced by many factors. Dietary intake during pregnancy is the main determinant of birth weight. Not only macronutrients but micronutrients also play important role in the growth and development of fetus. Micronutrient status during pregnancy is correlated with the birth weight of neonate. Prepregnancy maternal weight <45 kg, height <145 cm and low BMI <18.5kg/m^2 are associated with low birth weight and adverse birth outcomes. Low socio economic status is the strongest predictor for low birth weight. Although it does not affect it directly but indirectly it affects all the variables that can directly cause low birth weight. Educational level of mother also plays important role. Hence maternal nutritional status is the major factor affecting the fetal growth and birth weight and is influenced by many biological, social and demographic factors.

Key Words: Maternal nutritional status, adverse birth outcomes, Low birth weight

INTRODUCTION

Maternal nutritional status could be considered as primary predictor for the nutritional status of neonates, however the association between maternal nutrition and birth outcome is complex and is influenced by many biological, socio economic and demographic factors. The state of maternal nutrition is one of the important environmental factors which might be expected to influence the course of pregnancy. The growth of fetal tissues and other products of conception and the metabolic alterations consequent on pregnancy impose great stress and result in an increase in the expectant mother's nutritional requirements. [1] The birth weight of an infant is a reliable index of intrauterine growth and a major factor determining child survival, future physical growth and mental development. Birth weight indicates the quality of life, socio- economic status, health awareness and nutritional status of the community. [2] Researches from different part of the world from time to time indicated a close relation between the maternal nutritional status and the health of the pregnant woman and her offspring. Maternal nutrition before and during pregnancy may play an important role in maternal, neonatal, and child health outcomes [3] hence this study aimed at establishing a relation between the nutritional status of mother and birth weight of the new born.

METHOD

For this review we searched PubMed, Medline, and Google Scholar using terms related to nutritional status of pregnant women and relation with birth weight ("maternal nutritional status" OR "nutritional status during pregnancy" "Dietary intake in pregnancy and birth weight" OR "Micronutrient profile in pregnancy and birth weight" OR "Maternal anthropometry and birth weight " OR "Socio- economic status and birth weight"). More than 200 research articles have been screened out on the subject and the references of retrieved full-text articles were examined for additional articles. 99 relevant studies showing correlation with birth weight have been identified and included in paper writing.

1. **Dietary intake during pregnancy and birth weight**

"Eat for two during pregnancy" is an old saying. To check the truthfulness of these words or impact of maternal dietary intake during pregnancy on the nutritional status of offspring researchers across the world conducted numerous studies. Nutritional status of neonate is dependent upon macro and micronutrient intake of mother and inadequate dietary intake during this rapid growth phase of gestation results in growth failure. Recommended dietary allowances (RDA) for Indians, ICMR, 2010 recommended additional intake of energy by 350 kcal/day and protein by 23 gm/day . Fat intake should increase to 30gm/day, calcium 1200 mg/day, iron 35 mg/day and retinol 800 µg/day. [4] International Organizations (FAO/ WHO/ UN) recommended that pregnant women should increase their energy intake by 85 kcal/ day during first trimester, 285 kcal/ day during second trimester and 475 kcal/ day during third trimester. [5]

1.1 Intake of Different Food groups: Poor women from rural as well as urban area have low intakes of a range of micronutrient dense foods such as green leafy vegetables, fruits and dairy products. [6,7] The Pune Maternal Nutrition study find out that mothers with higher intakes of milk at 18 week and green leafy vegetables and fruits at 28 week had larger infants almost 200g heavier than those who never ate them. [8] Women who consumed less or no milk gave birth to infants who weighed less than those born to women who consumed more milk. [9,10] while the lengths and head circumferences were similar. [9] Dietary diversity was positively correlated with nutrient intake and nutritional status. [11]

1.2 Macro nutrient intake: Prevalence of low birth weight (LBW) was higher significantly among pregnant women with mean caloric intake of less than 70% of the RDA [2,12-13] and protein intake of less than 40 gm (60%), during the last trimester of pregnancy. [12] Calorie intake during pregnancy is positively associated with the birth weight of the newborn. [8,14-15] Energy supplementation to chronically undernourished populations in sufficient quantity and duration lead to significant increase in birth weight as well as decreases in rates of LBW and small for gestational age (SGA) birth. [16] Birth weight of neonates was correlated significantly with Energy, protein and calcium intakes during third trimester. [17-18] Observational studies suggested that maternal fat intake might be associated with gestational weight gain. [19] Higher fat intake at week 18 was associated with neonatal length ($p<0.001$), birth weight ($p<0.05$) and triceps skin fold thickness ($p<0.05$). [8] Low concentrations of most n-3 fatty acids and 20:3 n-6 and high concentrations of 20:4 n-6 remained associated with lower birth weight, higher SGA risk, or both. [20-21] Consumption of low saturated fatty acids was associated with decreased birth weight and an increased risk of SGA. [21] Significantly higher risk of LBW was found among pregnant women who did not eat fish or had low EPA (Eicosapentaenoic acid) intake during third trimester. [22]

1.3 Micronutrient Intake: Majority of pregnant women are consuming <50 % of the recommended calories moreover 99, 86.2, 75.4, 23.6 and 3.9 percent of the pregnant women were consuming <50% of the recommended folic acid, zinc, iron, copper and magnesium respectively. [23-24] Some studies found no relation between mean birth weight of infants and maternal energy and protein intake but instead demonstrated a stronger relationship with dietary intake of micronutrient rich foods [8] or low positive correlation between the mean dietary iron, folic acid, carotene and vitamin B12 intake. [25] Iron supplementation considering total iron intake from food and supplements, is significantly associated with increased birth weight [26-28,8] and the association was stronger in the high vitamin C intake group. [27] Each mg increase in vitamin C was associated with a 50.8 g increase in birth weight. [29] Neonatal measurements were also related to maternal folate and vitamin C status independent of food intake. [30]

Appropriate birth weight and 1-min Apgar score of newborns was significantly correlated with adequate maternal calcium and vitamin D intake and weight gain of mothers during pregnancy. [31] Optimal calcium intake and adequate maternal vitamin D status are both needed to maximize fetal bone growth and improvement in status of these nutrients may have a positive effect on fetal skeletal development. [32] Birth weight was positively associated with increasing pantothenic acid/ biotin ratios (P=0.011), magnesium (P=0.000) and vitamin D (P=0.015) intakes during pregnancy. [28]

However, studies from developed countries showed that high calorie and protein intake exceeding the RDA, do not help but have adverse effect on birth weight, [33-34] and a higher intake of protein associated with a reduction in birth weight and a reduced ponderal index among large birth weight infants but not LBW infants. [34] There is need for proper, adequate and balanced micronutrient during pregnancy to affect neonates as healthy outcome. [35]

2. Micronutrient Deficiency during pregnancy and birth weight

Pregnancy is a period of increased metabolic demands, with changes in the woman's physiology and the requirements of a growing foetus. [36] During this time inadequate stores or intake of vitamins and minerals, collectively referred as micronutrients, can have adverse effects on the mother, such as anemia, hypertension, complications of labor and even death. [37] In South East Asia, iron deficiency and anemia affect more than 40% of pregnant women and the prevalence of folic acid deficiency may be upto 30-50%. [38-39]

2.1 Anemia: The prevalence of low LBW, preterm birth, perinatal mortality, and neonatal mortality was significantly higher among anemic pregnant women. Overall, in low- and middle-income countries, 12% of LBW, 19% of preterm births, and 18% of perinatal mortality were attributable to maternal anemia. [38] A significant relation was found between maternal haemoglobin level and pregnancy outcome such as type of delivery and birth weight. [40] Maternal anemia was an independent risk factor for preterm delivery, [41-43] LBW, [41,43-45] low Apgar scores and intrauterine fetal death. [43] The cord serum iron, transferrin saturation and ferritin concentrations had significant correlation with maternal haemoglobin. The significant low levels of these parameters suggested that maternal anaemia adversely affected the iron status including iron stores of the newborns. [46] Perinatal mortality was increased with exposure to Hb < 7.0 g/dl. [47] Iron supplementation was significantly associated with birth weight. Maternal hemoglobin was significantly higher (+5.56 g/L) for mothers who had iron supplementation [48] and those not received iron supplementation during pregnancy were more likely to have LBW infants. [49] The risk of having smaller than average birth size newborn was significantly reduced by 18% for mothers who used any IFA supplements compared with those who did not. [50] Infants of iron-depleted mothers, as indicated by maternal serum ferritin had lower cord-blood serum ferritin than the mothers who had adequate levels [51-52] and between anemic and non anemic groups, mean gestational age, weight, length and head circumference of the neonates differed significantly ($p<0.01$). [53] Prevalence of iron deficiency was higher among infants born to iron deficient mothers as compared to the infants born to healthy mothers. [54-55]

2.2 Vitamin B-12 Deficiency: Vitamin B-12 insufficiency was 21%, 19%, and 29% in the first, second, and third trimesters, respectively, with high rates for the Indian subcontinent and the Eastern Mediterranean. [56] There is a relationship between increasing antenatal vitamin B12 concentrations and birth weight in Indian babies. The low maternal vitamin B12 status translates into a low neonatal vitamin B12 status as evinced by cord serum vitamin B12 concentrations. [57] Lower vitamin B12 concentrations during each of the three trimesters of pregnancy had significantly higher risk of delivering an IUGR (Intra uterine growth retardation) [57] or LBW [58] baby, when compared to women with higher concentrations.

2.3 Zinc deficiency: Zinc deficiency has been associated in some but not all studies with complications of pregnancy and delivery, as well as with growth retardation, congenital abnormalities and retarded neurobehavioural and immunological development in foetus. [59] Maternal zinc restriction significantly decreased the birth weight and body weight of the offsprings at later time point. [60] Birth weight of children of mothers in the zinc supplemented group were significantly higher (300 to 800 g difference) than the birth weight of children of mothers in the control group. [61] Goldenberg et al, 1995 revealed that all women, infants in the zinc supplemented group have a significantly greater birth weight (126g, P= 0.3) and head circumference (0.4 cm, p= 0.2) than infants in the placebo group. [62] Maternal serum zinc, iron and calcium concentration influenced the birth weight of neonates as outcome of pregnancy. [35]

2.4 Iodine deficiency: Severe iodine deficiency during pregnancy results in increased pregnancy loss, mental retardation, cretinism and preterm delivery [59] but less is known for other outcomes especially in case of marginal iodine deficiency. [37] Urinary iodine concentration (UIC) below 1.0 mg/L, was significantly positively associated with birth weight and length. Birth weight and length increased by 9.3 g and 0.042 cm, respectively for each 0.1-mg/L increase in maternal urinary iodine concentration. No associations were observed between maternal urinary iodine concentration and head or chest circumference. [63]

2.5 Deficiency of Minerals and Trace elements: Deficiency of minerals such as magnesium, selenium, copper and calcium have also been associated with complications of pregnancy, child birth or fetal development. [59] Magnesium restriction did not affect the birth weight but if continued postnatally through lactation and weaning, it decreased the body weight of the offsprings at weaning and thereafter. [60] Except magnesium, the profile of other biochemical variables, namely, calcium, zinc and iron in the umbilical cord blood of the neonates with normal birth weight (NBW) were significantly higher than in the umbilical cord blood of neonates with LBW. [35]

2.6 Micronutrient Supplementation during pregnancy: There is controversy on whether dietary micronutrient supplementation in pregnancy can increase birth weight. Dietary supplementation and oral multiple-micronutrient (MMN) supplementation during pregnancy was associated with increase in maternal weight gain and mean birth weight and a significant decrease in the prevalence of LBW or SGA infants and a reduced rate of still birth. [64-65] No significant differences were shown for other maternal and pregnancy outcomes such as preterm births, maternal anemia, miscarriage, maternal mortality, perinatal mortality, neonatal mortality or risk of delivery via a caesarean section. [65] Small benefits from early food and multiple micronutrient supplementations were found in infants of low-BMI but not of high-BMI mothers. [66] Multiple micronutrient supplementations resulted in a 27% reduction in the rate of stunting. An effect of the MMN supplementation on weight-for-length and head circumference-for-age became apparent by the end of the first year of life. By the age of 30 months, children from the supplementation group had a higher weight-for-height. [67] The findings, consistently observed in several systematic evaluations of evidence, provide a strong basis to guide the replacement of iron and folic acid with MMN supplements containing iron and folic acid for pregnant women in developing countries where MMN deficiencies are common among women of reproductive age. Efforts should be focused on the integration of this intervention in maternal nutrition and antenatal care programs in developing countries. [65]

3. Maternal anthropometry and birth weight

Maternal stature is a composite indicator that represents the genetic and environmental effects on the growing period of childhood. Poor nutrition of mother, both before and during pregnancy, contributes to impairment of fetal development and contributes to LBW and in turn to high rates of stunting. [68] Pregnancy outcomes can be better predicted by anthropometric measurements than dietary intake [69] and maternal measurements such as height, weight, BMI and fundal height were correlated significantly with birth weight. [70-73] Pre pregnancy maternal weight (<45 kgs) and maternal height (<145 cms) are significant risk factor for LBW. [74-76] Maternal height, weight and skinfold thickness at 6 and 9 month of pregnancy were positively associated with mean birth weight.

3.1 Maternal weight: Mean maternal weight at the first prenatal visit and at 6 and 9 month of pregnancy were positively associated with birth length and with linear growth between birth and 4,3 and 6 months of age. [77] Low maternal weight gain in the second trimester (< 5.7 Kg) was associated with decreased birth weights ranging from 48 to 248 gm, depending on the pattern of weight gain in the other trimesters. [78] The WHO collaborative study reported that mothers in the lowest quartile of prepregnancy weight carried an elevated risk of IUGR and LBW of 2.55 and 2.38 respectively compared to the upper quartile. [79

3.2: Maternal Height: Children whose mother's height was <145 cm, had two-fold higher odds of being stunted. [75]

3.3 Mid upper arm circumference (MUAC): The MUAC values below which most adverse effects were identified were <22 and <23 cm and hence a conservative cut-off of <23 cm is recommended to include most pregnant women at risk of LBW for their infants in the African and Asian contexts. [80]

Low weight and height of mothers were associated with increased risk of perinatal death, prematurity and SGA [80] and child's nutritional status as indicated by weight for age, was associated with BMI of the mother ($P<0.001$). [81]

3.4 Body Mass Index (BMI): Women with low BMI were found to have a higher probability of delivering a LBW baby[2], 35.4% of very low BMI and 33.7% of low BMI group delivered LBW babies as compared to 24% women in normal BMI group. [82] NNMB data reported that mean birth weights showed definite differences between BMI classes. The odds ratio for LBW was found to be three times more in severe chronic energy deficiency groups compared to normal BMI groups of mothers. [83] Prevalence of low BMI ($<18.5 kg/m^2$) in adult women has decreased in Africa and Asia since 1980, but remains higher than 10% in these two large developing regions.

During the same period, prevalence of overweight (BMI ≥ 25 kg/ m^2) and obesity (BMI ≥30 kg/ m^2) has been rising in all regions. Maternal obesity leads to several adverse maternal and fetal complications during pregnancy, delivery and postpartum. There are four times more chances to develop gestational diabetes and two times more chances to develop pre-eclampsia among obese women compared to women with normal BMI. Low maternal BMI in early pregnancy also put infants at higher risk of SGA. BMI of 25 or greater was somewhat protective against term and preterm SGA. [84]

More studies are needed before BMI and weight gain can be used as a robust measure to determine when intervention is needed, but it is clear that low BMI (<18.5 kg/m2) during pregnancy and low maternal weight is associated with smaller infant size. [85]

4. Socio- economic status and birth weight

Socio-economic status (SES) is a complex construct that has been used to define social inequality and usually includes measures of income, occupation and/ or educational attainment. [86] SES do not affect the fetal growth directly but rather affects the variables which are directly affecting the adverse outcomes such as quality of diet, antenatal care, maternal anthropometry, physical work and psychological factors such as stress, anxiety and depression. Women of low SES are at increased risk of delivering LBW babies, [87-90] whether SES is defined by income, occupation or education.

Educational level has been the strongest and most consistent predictor of health among social variables. A low educational level limits access to jobs and other social resources especially in industrialized countries and thus increases the risk of poverty. [86] Education may also have independent effects, above and beyond income, because more highly educated mothers may know more about family planning and healthy behaviours during pregnancy. [87] Mother's level of education may be considered as the most important determinant of birth weight. Low level of mother's education was predictor for LBW. [91] Mean birth weights of neonates of the higher educated and high income group were on average 290 and 260 gm higher respectively than of uneducated and lower income groups. [92] Most of the LBW (50%) infants came from the group of mothers without education but in NBW group 37% came from the mother completed primary education and 53% (238/448) from mother who completed secondary level or above. These data showed significant relationship between LBW and poor educational status. Majority of the mother (79.2%) in LBW came from poor economical class in comparison to mother of NBW (67.4%) showing association between LBW and poor socioeconomic status. [93]

Determinants for non-utilization of ANC were poverty, literacy, migration, duration of stay in the slum area and high parity. [94] Risk of malnutrition was more than twofold higher in pregnant women with low and medium autonomy of household decision-making than those who had high level of autonomy in household decision-making. [95]

Improved long-term nutritional situation and living conditions seems to be the most important prerequisites to counteract LBW in developing countries. [96] The overall prevalence of anemia was found to be high among illiterate (98.2%), Hindu (92.31%) and moderately working woman (83.34%). [97]

Studies of maternal dietary intake have also confirmed the importance of socio economic status. Among rural Indian women, intake of dairy products was strongly associated with SES and was also associated with birth size. [8] Mother with no education and from low income family was more likely to have LBW infant compared with mother with higher education and from higher income family. [98] Chronic malnutrition was associated with mother's age and educational level, type of residence, number of rooms, flooring, water supply, and LBW (< 2,500 g) in children aged ≤ 24 months. [99]

Kramer et al observed that the countries which had achieved the lowest rates of adverse birth outcomes had done so not through health care interventions but rather by reducing the prevalence of socio-economic disadvantage. It may not be possible to eliminate the higher risks of IUGR and preterm birth among the poor without eliminating poverty itself. [86]

CONCLUSION

Nutrition has profound effect on health throughout life but it plays very crucial role in influencing fetal growth and birth outcomes. It is a modifiable risk factor of public health importance. Macronutrient supplementation showed a positive effect in developing countries. Micronutrient profile during pregnancy plays a major role by affecting birth weight and other birth outcomes and is influenced by dietary intake before and during pregnancy. Maternal height, weight and skinfold thickness were positively associated with mean birth weight and mothers with low BMI were found to have a higher probability of delivering a LBW baby. Socio economic status is one such factor that may underpins many other aetiological factors. Education plays a major role and affects all the aetiological factors for LBW and unexpected birth outcomes. Although supplementary nutrition programme has been initiated by Govt. of India to improve the nutritional status of vulnerable group but undernutrition still continues to be a major health problem in India, the most vulnerable groups being women of reproductive age group and young children. Lack of awareness about the nutritional programmes and importance of adequate nutrition during pregnancy is the major factor for unutilization of health services. All these factors are interrelated so influencing each other. Hence it is necessary that educational interventions must be provided along with the supplementary nutrition programmes so that the services provided can be fully utilized by the target groups.

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