Original Article

DOI: 103126/JNPS.V4113

Correlation Between Maternal Weight gain and Birth Weight Among term Babies

Umesh Kumar Singh[1], Indira Acharya[2]

[1]Assistant Professor, Department of Paediatrics, Shree Birendra Hospital, Nepalese Army Institute of Health Sciences, Bhandarkhal, Sanobharyang, Swoyambhu, Kathmandu, Nepal
[2] Associate Professor, Department of Obstetrics and Gynaecology, Shree Birendra Hospital, Nepalese Army Institute of Health Sciences, Bhandarkhal, Sanobharyang, Swoyambhu, Kathmandu, Nepal

Article History
Received On: 26 Jun, 2022
Accepted On: 09 May, 2023

Funding sources: None

Conflict of Interest: None

Keywords:
Body mass index, Gestational weight gain, Newborn, Pregnancy, Small for gestational age

Online Access

DOI:
https://doi.org/10.3126/jnps.v42i3.47566

***Corresponding Author**

Umesh Kumar Singh
Assistant Professor,
Department of Paediatrics,
Shree Birendra Hospital,
Nepalese Army Institute of Health Sciences,
Bhandarkhal, Sanobharyang,
Swoyambhu, Kathmandu, Nepal
Email: umesh3130@live.com

Abstract

Introduction: Healthy and well-nourished mother is likely to give birth to a healthy normal child with adequate birth weight. We aimed to determine the correlation of gestational weight gain and newborn's birth weight.

Methods: We studied participant-level data for 295 pregnant women coming for delivery services between January 2018 and December 2020 at Shree Birendra Hospital, Chhauni, Kathmandu, Nepal. A retrospective data of pre-pregnancy body mass index, maternal weight gain during different trimesters of pregnancy were collected. The prevalence of small and large for gestational babies were compared with mother's weight gain according to Institute of Medicine (IOM) guidelines. Pearson test was used to assess the correlation between gross maternal weight gain during pregnancy and birth weight.

Results: Among 295 women, 12.2% underweight, 55.6% normal weight, 26.1% overweight and 6.1% were obese. The overall mean gestational weight gain (GWG) was 11.78 kg. Birth weight of the babies ranged from 1500 gm to 5100 gm with mean weight of 3148 gm. Majority of small for gestational age and large for gestational babies were seen among women below and above IOM guidelines respectively.

Conclusions: Findings from this study suggest that maternal weight gain during pregnancy increases the birth weight. Across all BMI categories, insufficient GWG is associated with slightly increased risk of SGA, while relative risk of LGA is higher in excess GWG group.

Introduction

Babies with birth weight less than 10th percentile for their gestational age are designated as Small for Gestational Age (SGA). In contrast, Intrauterine Growth Retardation (IUGR) is a prenatal diagnosis to describe fetus who fails to reach in-utero growth potential.[1] Healthy and well-nourished mother is likely to give birth to a healthy child with adequate birth weight.[2] Maternal weight gain and fetal growth vary greatly throughout pregnancy.[3] There is rapid increase in fetal growth during the last trimester.

Poor maternal nutritional status leads to many complications like anemia, hypoalbuminemia, vitamins and minerals deficiency in mothers as well as IUGR, premature birth, congenital malformations such as neural tube defects in babies.[4,5] High maternal weight gain tend to decrease incidence of SGA, whereas excessive weight gain may precipitate fetal

Copyrights & Licensing © 2022 by author(s). This is an Open Access article distributed under Creative Commons Attribution License (CC BY NC)

as well as maternal complications like metabolic disorders such as gestational diabetes mellitus (GDM) and obesity due to excessive weight gain. Furthermore, excessive, and insufficient gestational weight gain are associated with adverse pregnancy outcomes including SGA, macrosomia, cesarean delivery, GDM, preeclampsia, postpartum weight retention, and offspring obesity.[6-10] Intrauterine malnutrition has more serious and far reaching consequences that affect tissue structure and function permanently.[11] These concerns make the fetal period a critical window of opportunity for nutrition intervention and improving birth weight will help break the vicious intergenerational cycle of malnutrition.[12]

In 2009, Institute of Medicine (IOM), the National Academy of Medicine (NAM) in United States published a weight gain guideline for singleton pregnancy based on pre-pregnancy BMI classes.[13] (Table 1) These guidelines are directed in primarily minimizing the adverse consequences. However, most of the previous studies were conducted in developed countries, and information regarding the effect of pregnancy weight gain are lacking from developing countries. We aimed to determine the correlation of gestational weight gain and newborn's birth weight in our region.

Methods

This is a cohort study, commenced from Jan 2018 and Dec 2020, in Shree Birendra Hospital after getting ethical clearance from the Institutional review Committee of our institute. Shree Birendra Hospital, Chhauni, Kathmandu, Nepal, is a tertiary care hospital that caters military and beneficiaries of Nepalese Army. We included 295 women over 18 years, with singleton full term pregnancies (delivering after 37 weeks of gestation). The mothers having high risk pregnancies, any underlying systemic disorders such as hypertension, diabetes mellitus, anemia or complications of pregnancy were excluded from the study. Infants were excluded if they were preterm, multiple gestation, neural tube defects, chromosomal aomalies, or other severe congenital disease.

Maternal demographic characteristics, anthropometric measurements, age, pre-pregnancy age, total pregnancy weight gain and birth weight were recorded for analysis. The maternal height and weight (light clothing) were measured to the nearest 0.5 cm or 0.1 kg respectively and taken with the same instruments that were calibrated in regular intervals for the whole population at each visit. The body mass index (BMI) was calculated as BMI = weight (kg) / height (m^2). Self-reported pre-gestational weight in kilograms (kg) was used.

Total pregnancy weight gain was defined as the difference between the final recorded maternal weight at the time of delivery and the maternal pre-pregnancy weight recorded at the first prenatal visit in antenatal clinic. The first visit was no later than the first month of pregnancy. Measurements in the hospital were taken using a KRUPS Digital BO12 weighing scale and stadiometer (Bio + plus). BMI and recommended gestational weight gain was classified according to IOM guidelines (Table 1).

Table 1: Gestational weight gain recommendation of IOM

Category	**BMI**	**Recommended total gestational weight gain(kg)**
Underweight	< 18.5 Kg/ m^2	12.5 - 18
Normal	18.5 – 24.9 Kg/m^2	11.5 – 16
Overweight	25 – 29.9 Kg/m^2	7 – 11.5
Obese	≥ 30 Kg/m^2	5 - 9

Newborn infants were weighed unclothed immediately after delivery using a Rossmax WE300 digital baby weighing scale. Neonates were classified as small, normal or large for gestational age in accordance with specific centiles for the Asian population[14] as recommended by Clausson et al.[15] small if the birth weight was below 10th percentile; normal if it was between 10th and 90th percentiles and large if it was above 90th percentile.[14] Small and large for gestational age (LGA) were defined as a weight at birth of < 2500 gm and > 4000 gm respectively.

The mean was calculated by the following formula:

$$\text{Mean} = \frac{\sum X}{N}$$

And Standard Deviation is calculated with the formula

$$\text{S.D} = \sqrt{\frac{\sum(x-\mu)2}{N}}$$

Similarly, the correlation calculated by following formula

$$r = \frac{N\sum XY - \sum X \sum y}{\sqrt{N\sum X^2 - (\sum X)^2} \times \sqrt{N\sum Y^2 - (\sum Y)^2}}$$

Results

A total of 295 women met the inclusion criteria. The age of the subjects ranged from 20 to 45 years old with mean age of 27.74 years, mean height and weight at the initial conception was 158 cm and 57.9 kg, respectively. Each maternal BMI category was examined for the association between gestational weight gain and the probability of delivering an infant too small or too large for gestational age.

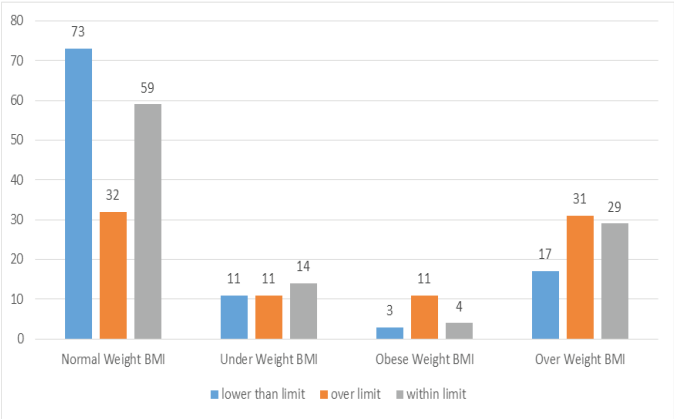

Figure 1: Correlation between BMI with GWG according to IOM guidelines

Table 2: Correlation between maternal BMI and birth weight

		BM	Birth weight
BMI	Pearson Correlation	1	.151
	Sig. (2-tailed)		.009
	N	295	295
Birth weight	Pearson Correlation	.151	1
	Sig. (2-tailed)	.009	
	N	295	295
Correlation is significant at the 0.01 level (2-tailed)			

Table 3: Descriptive of birth weight and gestational period

Descriptive								
	N	Mean	Std. Deviation	Std. Error	Confidence Interval 95% for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
weeks 37	26	2729.62	458.462	89.912	2544.44	2914.79	2000	3500
weeks 38	66	3002.12	421.705	51.908	2898.45	3105.79	2250	3930
weeks 39	65	3225.78	406.663	50.440	3125.02	3326.55	1880	4250
weeks 40	132	3252.95	459.403	39.986	3173.85	3332.06	1500	5100
weeks 41	6	3420.00	656.658	268.080	2730.88	4109.12	2900	4700
Total	295	3148.12	471.820	27.470	3094.06	3202.19	1500	5100

Table 4: ANOVA of the baby's birth weight and gestational period (F_4 = 10.453, P < 0.05)

ANOVA						
Birth weight	Sum of Squares	Df	Df	Mean Square	F	Sig.
Between Groups	8246927.711	K-1 (5-1)	4	2061731.928	10.453	000.
Within Groups	57201739.896	N-K (295-5)	290	197247.379		
Total	65448667.607	N- 1 (295-1)	294			

Discussion

Our cohort showed approximately two third of pregnant women did not comply with the current IOM guidelines of gestational weight gain. Rasmussen et al in his study mentioned two third of women gained weight outside the IOM recommendations.[13] Xue liu et al in a retrospective cohort study mentioned 72.4% of women had GWG outside the IOM guidelines.[16] A systematic review and meta-analysis of more than one million pregnant women pointed that 47% had gestational weight gain greater than IOM recommendations and 23% had gestational weight gain less than IOM recommendations.[17] Another study observed every second woman with overweight or obesity and more than one third of the normal weight women gained more weight than recommended, whereas the majority of underweight women failed to gain sufficient weight.[18] Available data suggest that 37% of normal-weight women and 64% of overweight women gain more that IOM recommendations.[19,20] Although there is a broad range of weight changes that are associated with healthy pregnancy outcomes,[20] weight gains that exceed the IOM recommended levels have been connected to gestational complications.

One third of the women in this study were characterized by overweight and obesity. Overall, 5.8% and 2.7% of all infants born to participant mothers were too small or too large for gestational age, respectively. The proportion of infants born small for gestational age varied in accordance with maternal BMI. Among women with low, normal and high BMI, the percentage whose infants were SGA was found to be 11.1%, 4.8% and 5.2% respectively and whose infants were LGA at an increasing rate of 0%, 2.4% and 4.2% respectively. Similarly rate of LBW babies among low, normal and high BMI women who gained less weight according to IOM guidelines 9%, 6.8% and 5% respectively. The proportion of normal weight babies born to all BMI group was 91.5% (Ranges from 88% to 92.6%) irrespective of the recommended weight gain guidelines of IOM. Women who gained weight within recommended guidelines and below, gave birth to normal weight babies ranging from 85.7% to 93.9%. However, the incidence of LGA babies increased in subjects who gained excess weight in comparison to women who gained below and recommended guidelines. Pregnancy weight gain, irrespective of pre-pregnancy BMI, is an independent predictor and is found to have a significant effect on fetal growth.[21,22] Compared with GWG within IOM guidelines, GWG below guidelines was associated with higher odds of preterm birth and SGA whereas maternal GWG above guidelines was associated with higher odds of macrosomia seen in another cohort.[16] The study confirms that none of the women with inadequate weight gain delivered LGA babies. This risk was lowest among the underweight BMI group where irrespective of gestational weight gain none of the women had large babies. Significantly large number of normal weight babies were born to all BMI group of pregnant women which ranges from 88 to 92.6%. The mean birth weight increased progressively in overweight and obese BMI groups with increasing antenatal weight gain. Charles Savona et al. confirms that irrespective of maternal BMI, there is a statistically significant trend towards LBW with decreasing antenatal weight gain and conversely macrosomia with increasing antenatal weight gain.[23] A significantly lowered mean birth weight was noted in the Dutch population who experienced severe famine during the winter of 1944 - 45.[24] Gestational weight gain above guidelines was associated with multiple adverse neonatal outcomes, whereas gestational weight gain below guidelines was only associated with SGA status.[25]

The proportion of SGA babies is highest within the below guidelines weight gain group and similarly large babies were seen in the above guidelines weight gain group. Another study done in Iran observed birth weight markedly improved in overweight groups when weight gain increased from below the IOM recommended range to withing it, rate of LBW was slightly decreased, and macrosomia increased when they gained weight more than the recommended range.[26]

Compared with recommended gestational weight gain, gain below guidelines was associated with 2% higher risk of SGA babies. Weight gain above guidelines was associated with 1.1% and 5.2% higher risk of delivery of SGA and LGA babies respectively in comparison to recommended weight gain group. The greater the gestational weight gain, the lower the risk of delivering an infant too small for gestational age. A large systematic review and meta-analysis by Goldstein RF et al observed gestational weight gain below guidelines was associated with lower risks of LGA and this association was lowest in underweight women.[27] Weight gain above guidelines was associated with higher risks of LGA and macrosomia, and underweight status was associated with the greatest risk.[27]

Similar findings were observed by multiple studies where pregnancy weight gain below the recommended range was associated with LBW and preterm birth, and weight gain above the recommended range was associated with birth weight more than 4000 gm or macrosomia, cesarean delivery and postpartum weight retention.[4,18,28-30]

Conclusions

Our findings suggest that high maternal weight gain during pregnancy increases birth weight. Across all BMI categories, insufficient GWG is associated with slightly increased risk of SGA, while relative risk of LGA is higher in excess GWG group. The IOM weight gain recommendation guidelines may not be applicable to all the women. Further studies need to be conducted to review the existing IOM guidelines in our context where information regarding health education, weight monitoring and nutritional interventions during pregnancy is lacking. Proper counseling directed to these issues of pregnancy demand high priority by ANC providers in developing countries.

References

1. Kliegman RM. Nelson textbook of pediatrics. Philadelphia: Elsevier; 2020
2. Singh M. Care of the newborn. Revised.(2016)
3. Strauss RS, Dietz WH. Low Maternal Weight Gain in the second or third trimester increases the risk for intrauterine growth retardation. J Nutr. 1999; 129(5):988–993. DOI: 10.1093/jn/129.5.988
4. Vause T, Martz P, Richard F. Nutrition for healthy pregnancy outcomes. Appl Physiol Nutr Metab. 2006;31(1):12-20. DOI: 10.1136/bmjopen-2016-014874
5. Winkvist A, Stenlund H, Hakimi M. Weight gain patterns from prepregnancy until delivery among women in Central Java, Indonesia. Am J Clin Nutr. 2002;75(6):1072-7. DOI: 10.1093/ajcn/75.6.1072

6. Nohr EA, Vaeth M, Baker JL, Sørensen TIA, Olsen J, Rasmussen KM. Combined associations of prepregnancy body mass index and gestational weight gain with the outcome of pregnancy. Am J Clin Nutr. 2008;87(6):1750-1759.
DOI: 10.1093/ajcn/87.6.1750

7. Hedderson MM, Gunderson EP, Ferrar A. Gestational weight gain and risk of gestational diabetes mellitus. Obstet Gynecol. 2010;115(3):597-604
DOI: 10.1097/AOG.0b013e3181cfce4f

8. Siega-Riz AM, Viswanathan M, Moos M-K, Deierlein A, Mumford S, Knaack J, et al. A systematic review of outcomes of maternal weight gain according to the Institute of Medicine recommendations: birth weight, fetal growth, and postpartum weight retention. Am J Obstet Gynecol. 2009;201(4):339
DOI: 10.1016/j.ajog.2009.07.002

9. Hrolfsdottir L, Rytter D, Olse SF. Gestational weight gain in normal weight women and offspring cardio-metabolic risk factors at 20 years of age. Int J Obes (Lond). 2015;39(4):671-676
DOI: 10.1038/ijo.2014.179

10. Drury MI. Carbohydrate metabolism in pregnancy and the newborn. Editors: H W Sutherland, J M Stowers. Publishers: Churchill Livingstone, Edinburgh, 1984. Pract. Diabetes. 1985;2(5):58
DOI: 10.1002/pdi.1960020524

11. Barker DJP. In utero programming of cardiovascular disease. Theriogenology. 2000; 53(2):555–74.
DOI: 10.1016/s0093-691x(99)00258-7

12. Shrimpton R. Maternal nutrition and the intergenerational cycle of growth failure. United Nations System • Standing Committee on Nutrition. Sixth report on the world nutrition situation. 2010; 62–75.

13. Rasmussen KM, Catalano PM, Yaktine AL. New guidelines for weight gain during pregnancy: what obstetrician/gynecologists should know. Curr Opin Obstet Gynecol. 2009;21(6):521–6.
DOI: 10.1097/GCO.0b013e328332d24e

14. Hong JS, Yi SW, Han YJ, Park YW, Nam CM, Kang HC, et al. Fetal growth and neonatal mortality in Korea. Paediatr Perinat Epidemiol. 2007;21: 397-410
DOI:10.1111/j.1365-3016.2007.00850.x

15. Clausson B, Gardosi J, Francis A, Cnattingius S. Perinatal outcome in SGA births defined by customised versus population-based birthweight standards. BJOG. 2001;108:830-4.
DOI:10.1111/j.1471-0528.2001.00205.x

16. Liu X, Wang H, Yang L, Zhao M, Magnussen CG, Xi B. Associations Between Gestational Weight Gain and Adverse Birth Outcomes: A Population-Based Retrospective Cohort Study of 9 Million Mother-Infant Pairs. Front Nutr. 2022;9.
DOI: 10.3389/fnut.2022.811217

17. Goldstein RF, Abell SK, Ranasinha S, Misso M, Boyle JA, Black MH, et al. Association of gestational weight gain with maternal and infant outcomes: a systematic review and meta-analysis. JAMA. 2017;317(21):2207–25.
DOI: 10.1001/jama.2017.3635

18. Diemert A, Lezius S, Pagenkemper M, Hansen G, Drozdowska A, Hecher K, et al. Maternal nutrition, inadequate gestational weight gain and birth weight: results from a prospective birth cohort. BMC Pregnancy Childbirth. 2016;16:224
DOI: 10.1186/s12884-016-1012-y

19. Keppel KG, Taffel SM. Pregnancy-related weight gain and retention: implications of the 1990 Institute of Medicine guidelines. Am J Public Health. 1993;83:1100–3.
DOI: 10.2105/ajph.83.8.1100

20. Olson CM, Strawderman MS, Hinton PS, Pearson TA. Gestational weight gain and postpartum behaviors associated with weight change from early pregnancy to 1 y postpartum. Int J Obes. 2003;27:117–27.
DOI: 10.1038/sj.ijo.0802156

21. Hector D, Hebden L. Prevention of excessive gestational weight gain: An evidence review to inform policy and practice. Phys Act Nutr Obes Res Gr. 2013 Corpus ID: 73246151

22. Lechtig A, Cornale G, Ugaz ME, Arias L. Decreasing stunting, anemia, and vitamin A deficiency in Peru: Results of the good start in life program. Food Nutr Bull. 2009; 30(1):37–48.
DOI: 10.1177/156482650903000104

23. Charles SV, George GB, Matthew M. Maternal weight gain and fetal growth. Malta Med. J. 2009;21(02):22-25

24. Habicht JP, Lechtig A, Yarbrough C, Klein RE. Maternal nutrition, birth weight and infant mortality. Ciba Found. Symp. 1974; 27 (new series): 353-77

25. Stotland NE, Cheng YW, Hopkins L, Caughey AB. Gestational weight gain and adverse neonatal outcome among term infants. Am College Obstetr Gynecol. 2006;108(3):635-43.
DOI: 10.1097/01.AOG.0000228960.16678.bd

26. Panahandeh Z. Gestational Weight Gain and Fetal Birth Weight in Rural Regions of Rasht/Iran. Iran J Pediatr. 2009; 19(1):18-24

27. Goldstein RF, Abell SK, Ranasinha S, Misso ML, Boyle JA, Harrison CL, et al. Gestational weight gain across continents and ethnicity: systematic review and meta-analysis of maternal and infant outcomes in more than one million women. BMC Med. 2018;16(1):153
DOI: 10.1186/s12916-018-1128-1

28. Abrams B, Altman SL, Pickett KE. Pregnancy weight gain: still controversial. Am J Clin Nutr. 2000;71(5):1233-41.
DOI: 10.1093/ajcn/71.5.1233s

29. Burrowes JD. Nutrition for a lifetime: Maternal Nutrition. Nutr. Today. 2006;41(6):267-73.
DOI: 10.1097/00017285-200611000-00007

30. Shobeiri F, Nazari M. Patterns of weight gain and birth weight amongst Indian women. Iran J Med Sci. 2006;31(1):94-7.