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RESEARCH ARTICLE

STUDY OF THE ASSOCIATION BETWEEN EARLY PREGNANCY BMI AND GESTATIONAL WEIGHT GAIN IN RELATION TO NEONATAL BIRTH WEIGHT

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Abstract

Introduction: Neonatal Birth weight plays an important role in infant mortality and morbidity, childhood development and adult health. Low birth weight is a significant risk factor for adverse health outcomes, including many childhood diseases, including the risk of type 2 diabetes and ischaemic heart diseases in later life. At the other end of the birth weight spectrum, macrosomia increases the risk of caesarean section delivery, delivery complications (i.e. shoulder dystocia) and subsequent childhood obesity1.

Aims And Objectives: To analyse the influence of early pregnancy BMI and birth weight To study the association between maternal weight gain in pregnancy and birth weight To evaluate the relationship between early pregnancy BMI and maternal weight gain.

Methodology: In the present study, 108 pregnant women with singleton uncomplicated pregnancy, booked at Government General hospital, Kadapa, by 12 weeks of pregnancy and delivering at term, were studied during the period of June 2023 to July 2024. The criteria taken into consideration for the study were as follows:-

Inclusion Criteria: Singleton uncomplicated pregnancy, booked for regular antenatal care by 12 weeks of pregnancy.

Exclusion Criteria: Those having Hypertension, Endocrinal problems, Multiple gestation, Preterm delivery (before 37 completed weeks), Any medical illness complicating pregnancy. This study is an observational correlational study with a sample size of 108. This was estimated using nMaster software based on the study by Line Rode et al June 2007, 'Association between maternal weight gain and birth weight'. The American College of Obstetricians and Gynaecologists, Vol. 109, No.6, 1309-1315, considering the Odds ratio and Proportion of Low Birth weight among underweight women and the precision considered was 5% as Alpha error and 10% as Beta error.

Results: The study was done with 108 pregnant women with singleton uncomplicated pregnancy booked at Government General Hospital by 12 weeks of pregnancy for antenatal care, during the period of June 2023 to July 2024. The age majority of the women belonged to lower middle class 58.3%, with lower class being 18.5% and upper middle class being 23.1%. A very large correlation (r value = 0.707, p value

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<0.001) was noted between gestational weight gain and birth weight in the lower middle class.

Discussion: In the present study, 108 pregnant women with singleton uncomplicated pregnancy booked at Government General Hospital by 12 weeks of pregnancy for antenatal care and delivering at term, were studied during the period of June 2023 to July 2024. The mean age of women in the study was 24.89 years, with 73.1% being in the age group between 21-30 years.

Introduction:-

Neonatal Birth weight plays an important role in infant mortality and morbidity, childhood development and adult health. Low birth weight is a significant risk factor for adverse health outcomes, including many childhood diseases, including the risk of type 2 diabetes and ischaemic heart diseases in later life. At the other end of the birth weight spectrum, macrosomia increases the risk of caesarean section delivery, delivery complications (i.e. shoulder dystocia) and subsequent childhood obesity[1].

Past study results support direct and indirect influences of maternal, genetic, socio- cultural, demographic and behavioral factors on birth weight. For example, pre pregnancy body mass index (BMI) and gestational weight gain influence infant birth weight and play significant roles in adverse pregnancy outcomes including low birth weight and macrosomia. The Institute of Medicine (IOM) established guidelines for gestational weight gain based on pre-pregnancy BMI, aimed at achieving optimal pregnancy outcomes.[1]

Enough information is not available on the application of these IOM guidelines in our Indian set up. In addition, there is a need to validate the IOM gestational weight gain guidelines in different populations.

By doing this study, it would be possible to investigate the independent and combined association between early pregnancy BMI and infant birth weight, after controlling other maternal factors. In addition, it would also be possible to evaluate the extent to which women that are below, within and above IOM gestational weight gain guidelines deliver normal birth weight infants, as previously done among other populations.

Aims and Objectives:-

1. To analyse the influence of early pregnancy BMI and birth weight
2. To study the association between maternal weight gain in pregnancy and birth weight
3. To evaluate the relationship between early pregnancy BMI and maternal weight gain.

Methodology:-

In the present study, 108 pregnant women with singleton uncomplicated pregnancy, booked at Government General hospital, Kadapa, by 12 weeks of pregnancy and delivering at term, were studied during the period of June 2023 to July 2024.

The criteria taken into consideration for the study were as follows:-

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This study is an observational correlational study with a sample size of 108.

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Materials and Methods:-

Women with singleton pregnancy booked by 12 weeks of pregnancy and delivered at term, with no antenatal complications were included in the study. Informed consent was obtained from all participants. Participants were required to complete a questionnaire, which was given to them during their first visit. These questionnaires included basic information (name, age, occupation, education) of the participant and spouse, weight and height recorded at the first visit, weight gain throughout pregnancy, weight at 37 weeks of gestation, obstetric history (parity, any medical disorders complicating pregnancy, heart disease, preeclampsia, endocrine disorders), past and family history of any medical disorders, lifestyle factors like diet (veg /non veg) caffeine intake and any addictive habits. During the participant's antenatal check-ups detailed history and examination was done. Weight of the participant was recorded throughout every antenatal check-up. Information about the gestational age at delivery and birth weight of the neonate were collected from the case sheet following delivery.

During the study, if patient developed any medical or obstetric complications, they were excluded from the study and new participants were included to maintain the sample size of 108.

Results:-

1. The study was done with 108 pregnant women with singleton uncomplicated pregnancy booked at Government General Hospital by 12 weeks of pregnancy for antenatal care, during the period of June 2023 to July 2024.
2. The age majority of the women belonged to lower middle class 58.3%, with lower class being 18.5% and upper middle class being 23.1%. A very large correlation (r value = 0.707, p value <0.001) was noted between gestational weight gain and birth weight in the lower middle class.
3. The education level of 42.6% of the women in our study was less than 12 years in school. A very large correlation (r = 0.794 and p value <0.001) was seen between gestational weight gain and birth weight in these women.
4. 64.8% of women in the study were housewives and 35.2% were working women. There was a statistically more significant correlation (r value = 0.783, p < 0.001) between gestational weight gain and birth weight in housewives, when compared to working women (r value = 0.445, p<0.005)
5. 27.8% of women in the study had caffeine intake of more than 400 mg/day and 46.3% had caffeine intake of less than 400 mg/day. It was seen that when caffeine intake was less than 400 mg/day, average birth weight was higher. (3.09kg ± 0.48, r = 0.510, p<0.001), when compared to women whose caffeine intake was more than 400 mg/day, average birth weight in these women was 2.57 ± 0.42kg (r=0.830, p<0.001)
6. In the present study, 56.5% were nullipara and 43.5% were multipara. The correlation of gestational weight gain and birth weight was found to be statistically significant in both. A very large correlation (r=0.700, p<0.001) was seen in nulliparous women, compared to multiparous women (r=0.592, p<0.001)
7. The women in our study were divided into 4 BMI groups based on their early pregnancy BMI. 29.6% were underweight, 34.3% were normal weight 25.9% were over-weight and 10.2% were obese
8. A statistically significant correlation was noted between BMI and gestational weight gain. It was seen that weight gain significantly increased with increasing BMI (p<0.001) in the 1st trimester, with a similar trend in the 2nd trimester (p<0.001), while weight gain was not statistically associated with increasing BMI in 3rd trimester (p value 0.127). Overall, weight gain is significantly correlated with increasing BMI with p<0.001
9. It was also seen that lean women gained less net weight (10.20±1.47) when compared to women to other BMI classes.
10. Average weight gain in women of normal BMI was 12.19±1.5kg while maximum weight gain was seen in the obese group (12.55±1.63kg)
11. The mean birth weight in the study was 2.96±0.55kg
12. Correlation of birth weight and BMI according to the 4 BMI classes showed that lower BMI was significantly associated with lower birth weight (p<0.001)
13. It was also seen that as BMI increased birth weight also increased.

14. The net weight gain in the present study ranged between 8-15 kg, the average being 11.5kg.
15. When the total weight gain was 8 kg mean ±SD was 2.25±0.16, whereas when weight gain was 15kg, the mean birth weight was 3.64±0.26.
16. Thus it was seen that increasing total weight gain was positively and significantly associated with increasing birth weight ($p<0.001$)
17. It was also seen that increase in weight gain in 2nd trimester was significantly associated with an increase in birth weight ($p<0.001$)
18. Study of gestational weight gain based on the level of compliance with IOM guidelines showed that 24.1% gained weight above the IOM recommendations, 34.3% gained weight below the IOM recommendations and 41.7% gained weight within IOM recommendations.
19. The study also showed that mean gestational weight gain and mean birth weight was significantly less when weight gain was below IOM guidelines ($p<0.002$), when compared to weight gain above and within the guidelines.

Table 1:- BMI at presentation.

BMI (kg/m^2)	Number of subjects	%	95%CI
<18.5	32	29.6	21.84-38.82
18.5-24.9	37	34.3	25.99-43.61
25.0-29.9	28	25.9	18.59-34.92
30.0& above	11	10.2	5.78-17.32
Total	108	100.0	-

Mean ± SD: 22.74±4.33

Table 2:- Weight gain according to BMI.

gain in kg	BMI (kg/m^2)				P value
	<18.5	18.5-24.9	25.0-29.9	30.0 & above	
1st trimester	0.38±0.49	0.72±0.67	0.89±0.49	1.46±0.69	<0.001
2nd trimester	4.94±0.91	6.05±0.77	6.10±0.74	6.00±0.89	<0.001
3rd trimester	4.89±0.85	5.41±1.03	4.96±1.10	5.09±0.83	0.127
Total weight gain	10.20±1.47	12.19±1.52	11.96±1.55	12.55±1.63	<0.001

Results are mean weight gain

Table 3:- Birth weight (kg) distribution.

Birth weight (kg)	Number of Subjects	%	95%CI
<2.50	27	25.0	17.79-33.93
2.50-2.99	25	23.1	16.20-31.94
3.00-3.49	26	24.1	16.99-32.94
3.50-3.99	25	23.1	16.20-31.94
4.00 & above	5	4.6	1.99-10.38
Total	108	100.0	-

Mean ± SD: 2.96±0.55

Discussion:-

In the present study, 108 pregnant women with singleton uncomplicated pregnancy booked at Government General Hospital by 12 weeks of pregnancy for antenatal care and delivering at term, were studied during the period of June 2023 to July 2024.

The mean age of women in the study was 24.89 years, with 73.1% being in the age group between 21-30 years.

The education level of 57.4% of the women in our study was more than 12 years in school. Education level was important because most women in the study belonged to lower middle class with limited education, that hampered their knowledge of nutrition in pregnancy and helped us observe that education level was important in achieving optimal weight gain in pregnancy for a normal birth weight neonate. It was seen that there was a very large correlation (r 0.794) of gestational weight gain and birth weight in the women who had less than 12 years of education. This finding was similar to a study done by Rode et al where years of education was significant in gaining adequate gestational weight gain and birth weight, with p value < 0.001.[2] Gestational weight gain and birth weight were lesser in women with less than 12 years of education when compared to women who had higher education. Strong significance between gestational weight gain and birth weight was seen in both groups of women.

In this study 64.8% of women were housewives and 35.2% were working women. It was seen that there was a very large correlation (r value = 0.783, p < 0.001) of gestational weight gain and birth weight in housewives when compared to working women (r = 0.445,p=0.005). It was seen that working women had a better gestational weight gain of 11.63±1.76 kg and average birth weight of 3.11±0.55 kg, when compared to housewives where average weight gain was 11.55±1.77 kg and average birth weight was 2.88 ± 0.54.This could be because working women are more educated, mostly belonging to upper middle class who would have started pregnancy with a normal BMI, gained appropriate weight during pregnancy due to increased awareness of required weight gain and better idea of nutrition during pregnancy. Whereas housewives would not have paid much attention to their nutritional requirements, probably due to reduced awareness of the same or increased work in the house leading to inadequate rest and care of oneself during pregnancy to gain adequate weight.

This study shows that 46.3% of women had caffeine intake of less than 400 mg / day and 27.8 % had caffeine intake of more than 400 mg/ day, while 25.9 % of our study population did not take caffeine in any form. Studies by Rode et al and Orskou J et al have also shown that caffeine intake of more than 400 mg / day resulted in affecting the birth weight adversely.[2, 3] Similar findings were noted in our study. It was seen that when caffeine intake was less than 400 mg / day, average birth weight was higher (3.09 kg±0.48, r = 0.510, p < 0.001), when compared to women whose caffeine intake was more than 400 mg / day. Average birth weight in these women was 2.57± 0.42 kg (r = 0.830, p < 0.001).It was also noticed that gestational weight gain was lesser in the group who took more than 400 mg of caffeine per day (10.48± 1.9kg) whereas in the group who took less than 400 mg of caffeine per day the weight gain in pregnancy was also more (12.02 ± 1.42 kg) Therefore without further analysis on the effect of caffeine intake in pregnancy on birth weight ,it is hard to comment whether caffeine intake directly affected the birth weight or an incidental low gestational weight gain with multiple other factors has affected the birth weight.

In the present study, 56.5 % were nulliparae and 43.5% were multiparae. When the correlation of gestational weight gain and birth weight in the two groups were compared it was seen that there was a very large correlation with r = 0.700 and p < 0.001 in nulliparous women, whereas in multiparous women it was r = 0.592 and p value < 0.001. The average gestational weight gain in nulliparous and multiparous was almost similar with slightly more weight gain in multiparous women (11.67 ±1.72 kg) compared to nulliparous women (11.51 ±1.8 kg) In a study done by Abharam B and Parker et al [4] it was found that parity did not influence weight gain whereas in a study by Thorsdottir et al multiparous women were noticed to have gained more weight in pregnancy than nulliparae with p value < 0.02.[5]

This could be because multiparae start pregnancy with higher BMI as compared to nulliparae with more gestational weight gain leading to an increased neonatal birth weight when compared to nulliparae.

Average weight gain in women of nomal BMI (18.5 – 24.9) was 12.19 ± 1.52 kg while maximum weight gain was seen in the obese group. Their weight gain was 12.55 ± 1.63 kg. Whereas in a study by Ellen A Mohr et al[6] it was seen that the variation in gestational weight gain was high and also increased across BMI groups. Nearly half of the under weight and normal weight women gained 10 – 15kg while low weight gain was noted among the obese women which was less than 10kg.[7]

In this study frequency, percentage and 95% CI of Birth weight was done and it was seen that mean was ± SD: 2.96 ± 0.55. According to this study, 25% of infants had low birth weight, 23.1% had birth weight between 2.5 - 2.99kg, 24.1% had birth weight between 3.0 – 3.49kg, 23.1% had birth weight 3.5 – 3.99kg and 4.6% of the infants had a birth weight of 4.0kg and above. When a correlation of birth weight and BMI according to the four BMI classes was studied, it was noted that lower BMI was significantly associated with lower birth weight with p<0.001. Similar

findings were noted in a study by Ihunnaya O Frederick et al[1] and J.E.Brown et al[8] with p<0.001 and p value 0.0009 respectively.

It was seen that 81.3% of women in the lean group had birth weight less than 2.5kg whereas 63.6% in obese group had birth weight between 3.5 to 3.99kg. While in the normal BMI group, 40.5% had babies with birth weight of 3.0 – 3.49kg and 37.8% had babies with birth weight between 2.5 - 2.99kg where as in over weight group, 39.2% had babies with birth weight of 3.5 – 3.99kg and 35.7% between 3.0 – 3.49kg. Thus it was seen that as BMI increased birth weight also increased.Similar findings were noted in a study by Ellen A Mohr[7] and a study by Ihunnaya O Frederick et al[1] where it was seen that the risk of macrosomia increased with increasing pre- pregnancy BMI and gestational weight gain (p for linear trend < 0.001)

The net weight gain in the present study was seen to range between 8-15kg, the average being 11.5kg, similar to average weight gain recommended by Rode et al.[2] When total weight gain was 8kg the mean ±SD was 2.25 ± 0.16, whereas when weight gain was 15kg the mean birth weight was 3.64 ± 0.26, range being 3.20- 3.80kg.Thus it was seen that increasing total weight gain is positively and significantly associated with increasing birth weight with p<0.001.

In our study we tried to analyse whether weight gain in 2nd trimester or 3rd trimester contributes significantly to normal birth weight. It was seen that increase in weight gain in 2nd trimester was significantly associated with an increase in birth weight with p<0.001. Though increase in weight gain in 3rd trimester was also positively associated with increase in birth weight (p = 0.103), it was seen that weight gain in 2nd trimester was strongly significant for optimal birth weight. These findings corroborated with study done by Nobuko Sekiya,Anai et al ,where significant correlations between maternal weight gain rate in the second trimester and birth weight were found. (r=0.32,p=0.005).[9] In a study by C.N.M. Nyaruhucha, J.M.Msuya et al, it was seen that weight gain in the second and third trimesters were important in determining the birth weight (p < 0.05).[10]

Early pregnancy BMI measures were based on weight at first booking visit <12 weeks period of gestation, though weight gain was almost negligible in 1st trimester, some variation of 0.5 – 1.0kg was noted in women who booked by 6 weeks and women who booked by 10 – 12 weeks. This could have been avoided if we knew the pre pregnancy BMI. But most women in our group being in lower middle class with < 12 years of education did not know their pre pregnancy weight. Moreover it has been seen that self reported weight and height tend to be slightly lower than directly measured weight and height, especially among women.[11] Thus the validity of self reported weight and height is questionable.

Weight gain in this study is based on information at 37 weeks of gestation, i.e. for women delivering 2-3 weeks later total weight gain in pregnancy could be higher.[2] However, using the same gestational week for all women in the study renders results which are more comparable.

The participants of our study belonged to different socioeconomic classes, religion, education levels, working status and parity. Due to the hypothesized complex nature of relationship between infant birth weight and maternal factors, we cannot rule out the possibility of residual confounding due to variables not included in this analysis.

The relationship between pre-pregnancy BMI and fetal growth is biologically plausible, although the direct pathway by which pre-pregnancy BMI influences infant birth weight is not known. In a review of the relationship between maternal BMI, energy intake and pregnancy outcomes, Neggers and Goldenberg found that pre- pregnancy weight consistently predicted most neonatal measurements compared to other maternal factors.[12] The authors hypothesized a complex interaction of genetics, maternal nutrition, gestational weight gain and other factors for this relationship, likely mediated through maternal nutritional pathway. This notion of complex interaction among multiple maternal factors is supported by work performed by other investigators. Kramer et al. attributed temporal trends of increasing infant birth weight and cigarette smoking and changes in socio-demographic factors.[13] Our reported combined effect of pre-pregnancy BMI and gestational weight gain on infant birth weight lends support for this notion of a complex pathway involving multiple maternal factors.

Conclusion:-

Birth weight plays an important role in infant mortality and morbidity, childhood development and adult health. Low birth weight is a significant risk factor for adverse health outcomes, including many childhood diseases, increased risk

of type 2 diabetes and ischemic heart disease in later life while macrosomia increases the risk of caesarean section delivery, delivery complications like shoulder dystocia and subsequent childhood obesity.

It is therefore important to limit weight gain in pregnancy to reduce the risk of complications during pregnancy and delivery and also to avoid over weight and obesity later in life and the possible accompanying health – related problems.

Our study results, taken together with existing literature, suggest an independent role of pre-pregnancy BMI as a determinant of neonatal birth weight, as well as complex relationships between pre-pregnancy BMI, gestational weight gain, and other maternal factors with fetal growth, as measured by size at birth. The results are of public health importance because pre-pregnancy BMI and gestational weight gain are modifiable risk factors of adverse pregnancy outcomes.

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