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Maternal BMI and Hb for the prediction of placental weight and neonatal outcome

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Abstract

***Background & Aims*:** Anthropomorphic and parametric features of mothers are associated with placental weight (PW) changes and its function. Anthropomorphic and parametric features can affect neonatal well-being. The aim of this research was to assess the prediction role of maternal body mass index (BMI) and hemoglobin (Hb) in placental weight and neonatal outcome.

***Materials & Methods*:** This study was a correlational descriptive–analytical study. The data were collected using a demographic-reproductive questionnaire completed by 365 parturient women referred to Valiasr Hospital in Kazeroun, Fars, Iran from May 1 to August 31, 2020. The inclusion criteria were singleton delivery at term (37–42 weeks) and mothers' consent to attend the study after recovery. The exclusion criteria were retained placenta, multiple pregnancies, and mothers' discontent to participate in the study. The data were analyzed using Pearson correlation coefficient and multiple regression analysis. All analyses were carried out with SPSS V.21. The significance level was considered less than 0.05.

***Results*:** The findings of the study showed that maternal BMI in early pregnancy ($\beta = 0.20$, $P < 0.01$), and gestational age ($\beta = 0.24$, $P < 0.01$) were the positive predictive factors for placental weight. Also, among the maternal traits, only maternal hemoglobin ($\beta = 0.14$, $P < 0.001$) turned out to be a positive predictor for the neonate's Apgar score. Of all fetal features, only neonatal weight had a significant correlation with placental weight ($P < 0.01$).

***Conclusion*:** Mother's BMI and Hb can predict placental weight and neonatal outcome. According to this finding, caregivers can help pregnant women with congruent education about proper nutrition to reach a safe BMI and create a positive outcome for the placenta and the newborn.

***Keywords*:** Maternal BMI, Maternal Hb, Neonatal Outcome, Placental Weight

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Introduction

Low or high body mass index (BMI) in pre-pregnancy and inadequate or excess gestational weight gain (GWG) are associated with an increased risk of adverse neonatal outcomes. Overweight and obese BMI scores and excess GWG have been linked to large-for-gestational-age (LGA) infants, preterm birth (PTB), and stillbirth; while underweight BMI and low GWG have been associated with small- for-gestational-age (SGA) infants and PTB (1). In addition, stress factors such as anemia, malnutrition, and severe physical activity play a significant role in the growth and development of the placenta and birth weight (2). Anemia is characterized by reduced blood hemoglobin (Hb) levels and reduced oxygen-carrying capacity in the blood. It is a common health complication in pregnancy, most often attributed to iron deficiency due to increased iron demands from the growing fetus and placenta and maternal blood volume expansion (3). Some studies indicated Hb changes as maternal anemia was associated with fetal growth restriction and low placental weight leading to impaired placental function (4, 5). In fact, the weight and size of the placenta could have a direct effect on placental function and fetal wellbeing (6). However, other studies have reported no effect of maternal anemia on placental weight, or even reduced placental weight with maternal anemia (7). Thus, the relationship between maternal Hb status and placental weight may be more complex and depend on additional factors such as the gestational age of anemia onset and whether the placenta and fetus maintained an appropriate level of Hb to sustain adequate oxygen delivery and growth (7). However, placental weight reflects placental functioning, but placental weight relative to birth weight (PW/BW ratio) is considered to be a more appropriate indicator of placental function than placental weight alone because placental weight is highly correlated with birth weight (6). Many studies about the relation between placental weight and birth weight have been done for more than a century. They indicated that placental weight was associated with pregnancy outcome. So that high weight of the placenta accompanied with placental hydrops, a low Apgar score, respiratory distress syndrome, perinatal death, and finally, a poor perinatal outcome, accompanied placenta with high weight. Conversely, a low placental weight was shown to be accompanied by medical complications in the mother (7-9). Placental growth and its functional capacity are naturally estimated in normal pregnancy (10). A high PW/BW ratio, due to a disproportionately heavy placenta compared to birthweight, is associated with higher risks for adverse birth outcomes and cardiovascular diseases in adulthood. Compensatory hypertrophy of the placenta in hypoxic conditions is one of the most important underlying mechanisms by which a high PW/BW ratio develops (6). In fact, functional capacities of the placenta and fetal nutritional conditions could be shown by placental weight. In some situations such as Ramadan (an annual period of daytime fasting for Muslims) and long fasting, placental weight is decreased during the second and third trimester of pregnancy, due to the changes in maternal diet (11, 12).

Considering the significance of maternal and child health as the main axis of sustainable development in the developing countries including Iran, and due to the limited studies conducted on this topic, there is a strong need for studying the predictive role of maternal BMI and Hb in placental weight and neonatal outcome.

Materials & Methods

This cross-sectional study was conducted on women who gave birth to live newborns in Valiasr Hospital of Kazeroon, Iran from May 1 to August 31, 2020.

Study Participants:

Three hundred and sixty-five parturient women who were eligible for the present study, participated. The inclusion criteria were singleton delivery at term (37–42 weeks), normal vaginal delivery, lack of retained placenta, and mothers' consent to participate in the study after recovery.

The exclusion criteria were lack of high-risk pregnancy (anorexia nervosa, anemia, gestational diabetes, preeclampsia…), multiple pregnancies, and incomplete questionnaire fulfillment. In addition, confounding variables were identified and omitted from this study.

Data Collection:

By using a research-made questionnaire that included demographic and reproductive characteristics (i.e., maternal age, gestational age by LMP (Last Menstrual Period) or ultrasound, parity, mother's weight and height in early pregnancy, BMI in early pregnancy, mother's Hb and HCT (Hematocrit) measured as routine antenatal care in the 28th week, placental weight (PW), neonatal weight (NW), gender of newborns, and Apgar score of the neonate) were investigated. All placentas, with their membranes and 2-3 cm cords being cut off after removing obvious blood clots, were weighed shortly after delivery using a calibrated weighing digital scale. Accordingly, the women were categorized as high placental weight (> 660 g), normal placental weight (500-650 g), and low placental weight (< 500 g) groups.

The weights of the newborn babies were recorded by a valid weighting scale and categorized as low neonatal weight (< 2500 g), normal neonatal weight (2500-4000g), and high neonatal weight (> 4000 g) groups.

All participants provided written, signed informed consent, and if an appropriate institutional review board reviewed and approved the study protocol.

Data Analysis:

In the present study, confounding variables were controlled as much as possible and data related to incomplete questionnaires were omitted from the analysis. Then, descriptive statistics such as Mean ± SDM were used for the description of demographic and reproductive characteristics of participants.

Data were analyzed with SPSS V.21 software. The correlations between variables were then investigated using Pearson's correlation test (r). Multiple linear regression analyses were performed to explore the predictors between the dependent variables by the independent variables. For assessing the fit of multivariable models, adjusted R2 and Anova were significant, and then multiple regression was used.

Results

Three hundred and sixty-five parturient women of various demographic and reproductive characteristics were included in this study (Table 1).

Table1. Maternal, Placental, and Fetal Characteristics

Variable	%	Mean ± SDM
Maternal age		
< 20	13.2	27.53 ± 5.99
20-35	83.3	
>35	2.2	
Gestational age		
<36	21.1	38.99 ± 1.44
38-40	50.1	
>40	25.2	
Maternal BMI in early pregnancy		
< 21	21.4	21.48 ± 1.001
21-23.9	21.4	
24-28.5	21.1	
> 28.6	21.1	
Maternal Hb		

Variable	%	Mean ± SDM
< 12	28.2	12.7 ± 94
≥ 12.1	65.5	
Parity		
1-2	65.4	2.2 ± 1.18
≥ 3	34.6	
Neonatal weight		
< 2500	5.2	3260 ± 4.43
2500-4000	91.4	
> 4000	3.3	
Apgar score		
< 8	3	9.8 ± 50
8-10	97	
Gender		
Male	48.4	1.5 ± 0.5
Female	51.6	
Placental weight		
< 500	32.9	583 ± 1.27
500-650	34.3	
> 660	32.9	

Table 2. Correlation between Maternal Characteristics with Placental Weight and Neonatal Features

Variables	Maternal age	Gestational age	BMI	Hb	HCT	Neonatal weight	Apgar	Placental weight
Maternal age	1							
Gesyational age	-0.007	1						
BMI	0.22**	0.05	1					
Hb	-0.05	0.003	0.08	1				
HCT	0.05	0.004	0.07	0.93**	1			
Neonatal weight	0.12*	0.42**	0.20**	-0.02	-0.006	1		
Apgar	0.05	0.05	0.09	0.14**	0.12*	0.06	1	
Placental weight	0.07	0.20*	0.25	0.05	0.05	0.52**	0.06	1
P < 0.05*	P < 0.01**							

Out of all maternal characteristics, only BMI in early pregnancy and gestational age were correlated with PW. The correlations between maternal features and fetal traits indicated that maternal age, gestational age, and BMI have significant relationships with NW. Out of all maternal features, only Hb and HCT have significant correlations with the Apgar score of the neonate. In addition, it was revealed that among all fetal features, only NW was correlated with PW (Table 2).

Considering the main objective of the present study, the researchers used the enter method for multiple regression analysis. As shown in Table 3, the results indicate that maternal BMI in early pregnancy (β = 0.20, P < 0.01) and gestational age (β = 0.24, P < 0.01) were positive predictive factors for placental weight. These variables explain 10% of the total variation score of the placental weight (Table 3).

Table 3. Multiple Regression Coefficients, ß, of the Maternal BMI and Gestational Age as Predictors of Placental Weight

Variables	β (STANDARDIZED COEFFICIENT)	P-value	CI Lower	CI Upper	Adjusted R^2
BMI	0.2	0.001	0.369	3.267	0.10
Gestational age	0.24	0.001	8.95	28.84	

The results shown in Table 4 indicated that out of the maternal traits (such as maternal age, gestational age, parity, BMI, Hb, and HCT), only maternal hemoglobin (β = 0.14, P < 0.001) was a positive predictor factor for the Apgar score of the neonate in this model. These variables explain 16% of the total variation of Apgar score in general. Because of the multicollinearity effect between HCT and Hb, this variable is not considered in the prediction of the Apgar score (Table 4).

Table 4. Multiple Regression Coefficients, ß, of the Maternal Hb as Predictors of Apgar Score

Variables	β (STANDARDIZED COEFFICIENT)	P-value	CI Lower	CI Upper	Adjusted R^2
Apgar score	0.14	0.0001	0.014	0.137	0.016

Discussion

The aim of this study was to determine the predictive role of maternal traits in placental weight and neonatal outcome. The results of the study indicated that, out of the maternal traits, only BMI in early pregnancy and gestational age correlated with PW and NW. We believe that high BMI or obese pregnant women have larger placentas and higher placental weight, and that the length of gestation is closely related to placental weight. It appeared that mother’s weight gain in early pregnancy led to hormonal increase in plasma and fat reserve, which was the cause of correlation between GA and PW. In agreement with the current study, results of the study done by Ratnasiri et al. revealed a significant relationship between BMI in early pregnancy and gestational age with PW and NW (1). Roland MC et al. showed an increase in a unit of BMI resulted in an increase of 0.79gm of placental weight in a study done on more than 1000 Scandinavian women (13). Conversely, Macdonald et al. reported that a PWR (placental weight ratio calculated as placental weight divided by birth weight) level less than 10th percentile is associated with an increase in maternal height, overweight, and obese body mass indexes, as well as with smoking and gestational diabetes (14).

In this study, we didn’t find any correlation between maternal age and PW, although some studies have reported a direct association between these variables (15). They argued these relationships are due to an increase in the placental barrier, a decrease in the vascularization of the terminal villi, or an increase in stroma and fibrin deposition in the placenta of mothers over 35 years old compared to the normal group (15, 16). However, the findings of this study revealed that maternal age is correlated with neonatal weight. This finding was similar to that of a study by Patimah conducted in Mother and Child Hospital Siti Fatimah Makassar in Indonesia (17).

Our findings indicated that placental weight significantly correlated with birth weight. This was consistent with the studies carried out by Thame et al., Salafia et al., and Alwasel et al. (13, 18, 19). Also, Palaskar et al. believed that placental weight has a significant role in the growth of the fetus and its function diversely supports the growth of the fetus. It transfers nutrients from the mother to the fetus and effects metabolic and endocrine function through regulation of metabolism in the mother and fetus. Therefore, it has an important role as a major regulator of fetal-placental metabolism (20).

Finally, our findings showed that maternal hemoglobin was a positive predictor for the Apgar score of the neonate. Consistent with this result, other studies mentioned that maternal anemia was associated with a low Apgar score, fetal growth restriction, and low placental weight because of low ferritin concentration (21, 22). Some findings suggest that low or elevated hemoglobin concentration may lead to placental compensatory hypertrophy and fetal growth restriction. However, these studies used different cutoffs for maternal hemoglobin concentration or unclear definitions or classifications of anemia, potentially affecting the association found between maternal anemia and placental weight. Mitsuda et al. (2020) found that there were a sex-dependent differences in placental function (6). Besides, they found out that Hb concentration in the mother has no relation with NW or PW, but it has been reported in some studies, especially systematic reviews, that both low and elevated maternal serum hemoglobin concentrations during pregnancy are associated with an increased PW/BW ratio (6). It is also reported in some other studies that Hb levels at “mid- or late- pregnancy" are inversely associated with birth weight/length and placental weight (23-25). Maybe there are intermediate factors interfering with this result which entails further studies.

Limitations of this study included lack of reliable data on pre-pregnancy regarding the BMI and difference in lifestyle, e.g., vegetarian women that affect their BMI and placental weight. To avoid recall bias, we calculated BMI based on measured height and weight at the first visit. Our findings would have been more reliable if we measured MCV, MCHC, MCH, and Ferritin of maternal serum, not taken into account in the study firstly due to budget constraint and secondly because they are not measured routinely in late pregnancy. Also, placental function cannot be accurately modeled by measuring weight alone. Other factors, such as placental vascularization, barrier thickness, volume, and hemodynamics are important considerations.

Conclusions

Our data support the hypothesis that some maternal traits predict placental weight and neonatal outcome. The differential effect of maternal factors on placental weight showed the relation between mother’s BMI and Hb on the placental weight and neonatal outcome. This means that caregivers can help pregnant women with congruent and necessary education about proper nutrition to reach the appropriate BMI and create a positive outcome for the placenta and newborn.

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Conflict of Interest

The authors have no conflict of interest in this study.

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Data Availability

The datasets used and/or analyzed during the current study are available from the corresponding author on a reasonable request.

Ethical Statement

Institutional review board approval and patient consent were not required.

Authors’ Contributions:

P Y and Sh N and Gh M aided in the conceptualization, design, and critical revision of the final manuscript, P Y and F.P. aided in design, preparation of manuscript and critical revision of the final manuscript. P Y and K H aided in data analysis and critical revision of the final manuscript. All authors read and approved the final manuscript.

References

1. Ratnasiri AW, Lee HC, Lakshminrusimha S, Parry SS, Arief VN, DeLacy IH, et al. Trends in maternal prepregnancy body mass index (BMI) and its association with birth and maternal outcomes in California, 2007–2016: A retrospective cohort study. PloS one 2019;14(9):e0222458. http://dx.doi.org/10.1371/journal.pone.0222458
2. Matsuda Y, Itoh T, Itoh H, Ogawa M, Sasaki K, Kanayama N, et al. Impact of placental weight and fetal/placental weight ratio Z score on fetal growth and the perinatal outcome. Int J Med Sci 2018;15(5):484. http://dx.doi.org/10.7150/ijms.23107
3. Breymann C, editor Iron deficiency anemia in pregnancy. Seminars in hematology; 2015: Elsevier.
4. Fallatah AM, Bifari AE, Alshehri HZ, Wali SM, Alghamdi SA, Almusallam SA, et al. Anemia and Cost-Effectiveness of Complete Blood Count Testing Among Pregnant Women at King Abdulaziz University Hospital: A Single Tertiary Center Experience. Cureus 2020;12(9):e10493. http://dx.doi.org/10.7759/cureus.10493
5. Jwa SC, Fujiwara T, Yamanobe Y, Kozuka K, Sago H. Changes in maternal hemoglobin during pregnancy and birth outcomes. BMC Pregn Childbirth 2015;15(1):80. http://dx.doi.org/10.1186/s12884-015-0516-1
6. Mitsuda N, JP NA, Eitoku M, Maeda N, Fujieda M, Suganuma N, et al. Association between maternal hemoglobin concentration and placental weight to birthweight ratio: Japan Environment and Children's Study. Placenta 2020;101:132-8. http://dx.doi.org/10.22541/au.158645560.02907152
7. Gragasin FS, Ospina MB, Serrano-Lomelin J, Kim SH, Kokotilo M, Woodman AG, et al. Maternal and cord blood hemoglobin as determinants of placental weight: a cross-sectional study. J Clin Med 2021;10(5):997. http://dx.doi.org/10.3390/jcm10050997
8. Russa AD, Kaziri KM. the Effect of Placental Weight and Cotyledon Count to the Fetal Birth Outcome At a Regional Referral Hospital in Tanzania. Int J Anat Res 2017;5(4.2):4538-42. http://dx.doi.org/10.16965/ijar.2017.150
9. Afodun AM, Ajao MS, Enaibe BU. Placental anthropometric features: maternal and neonate characteristics in North Central Nigeria. Adv Anat Embryol Cell Biol 2015;2015. http://dx.doi.org/10.1155/2015/790617
10. Aji AS, Yusrawati Y, Malik SG, Kusuma C, Lipoeto N. Association of Prepregnancy Nutritional Status and Physical Activity Levels with Birth Size Outcomes among West Sumatran Pregnant Women: Results from the Vitamin D Pregnant Mothers Cohort Study in Indonesia. Maced J Med Sci 2021;9(E):880-6. http://dx.doi.org/10.3889/oamjms.2021.6898
11. Baanter NS, Elsayed AA, Aljerian K, Aldahmash WM, Al-Qahtani WS, Alwasel SH. Changes in Maternal Lifestyle during Ramadan Altered Placental Development. Adv Reprod Sci 2020;8(2):126-42. http://dx.doi.org/10.4236/arsci.2020.82011
12. Glazier JD, Hayes DJ, Hussain S, D’Souza SW, Whitcombe J, Heazell AE, et al. The effect of Ramadan fasting during pregnancy on perinatal outcomes: a systematic review and meta-analysis. BMC Pregn

Childbirth 2018;18(1):1-11. http://dx.doi.org/10.1186/s12884-018-2048-y

13. Gul Z, Rajar S, Shaikh ZF, Shafique K, Hossain N. Perinatal outcome among fasting and non-fasting mothers during the month of Ramadan. Pak J Med Sci 2018;34(4):989. http://dx.doi.org/10.12669/pjms.344.15654
14. Macdonald E, Natale R, Regnault T, Koval J, Campbell M. Obstetric conditions and the placental weight ratio. Placenta 2014;35(8):582-6. http://dx.doi.org/10.1016/j.placenta.2014.04.019
15. Meteeb RL, Al-Dhalimy AMB. The relation between maternal age with placental weight: Histological study. Eurasian J Biosci 2020;14(1):529-33.
16. de Jongh B, Mackley A, Jain N, Locke R, Paul D. Effects of advanced maternal age and race/ethnicity on placental weight and placental weight/birthweight ratio in very low birthweight infants. Maternal and child health journal. Springer 2015;19(7):1553-8. http://dx.doi.org/10.1007/s10995-014-1662-1
17. Patimah S, Syauqi Y, Thaha AR. The correlation between placental weight and birth weight. Int Proc Chem Biol Environ Eng 2015;86:58-64.
18. Thame M, Osmond C, Trotman H. Fetal growth and birth size is associated with maternal anthropometry and body composition. Maternal & Child Nutrition. Wiley Online Library 2015;11(4):574-82. http://dx.doi.org/10.1111/mcn.12027
19. O'Connor TG, Miller RK, Salafia CM. Placental studies for child development. Child Dev Perspect 2019;13(3):193-8. http://dx.doi.org/10.1111/cdep.12338
20. Mehare T, Kebede D. Fetoplacental weight relationship in normal pregnancy and pregnancy complicated by pregnancy-induced hypertension and abruption of placenta among mothers who gave birth in Southern Ethiopia, 2018. Obstet Gynecol Int 2020;2020. http://dx.doi.org/10.1155/2020/6839416
21. Mosha D, Chilongola J, Ndeserua R, Mwingira F, Genton B. Effectiveness of intermittent preventive treatment with sulfadoxine–pyrimethamine during pregnancy on placental malaria, maternal anaemia and birthweight in areas with high and low malaria transmission intensity in T anzania. Trop Med Int Health 2014;19(9):1048-56. http://dx.doi.org/10.1111/tmi.12349
22. Alizadeh L, Raoofi A, Salehi L, Ramzi M. Impact of maternal hemoglobin concentration on fetal outcomes in adolescent pregnant women. Iran Red Cresc Med J 2014;16(8). http://dx.doi.org/10.5812/ircmj.19670
23. Jwa SC, Fujiwara T, Yamanobe Y, Kozuka K, Sago H. Changes in maternal hemoglobin during pregnancy and birth outcomes. BMC Pregn Childbirth 2015;15(1):1-10. http://dx.doi.org/10.1186/s12884-015-0516-1
24. Ahankari A, Leonardi-Bee J. Maternal hemoglobin and birth weight: systematic review and meta-analysis. Int J Med Sci Public Health 2015;4(4):435-45. http://dx.doi.org/10.5455/ijmsph.2015.2212201489
25. Yildiz Y, Özgü E, Unlu SB, Salman B, Eyi EGY. The relationship between third trimester maternal hemoglobin and birth weight/length; results from the tertiary center in Turkey. J Matern Fetal Neonatal Med 2014;27(7):729-32. http://dx.doi.org/10.3109/14767058.2013.837445