Korean Society of Maternal Fetal Medicine
Vol. 7 No. 3 September 2011

산모의 체성분과 출생 체중과의 연관성에 관한 연구

고려대학교 구로병원 산부인과교실[1], 내과학교실 심혈관센터[2]

조금준[1] · 윤효진[1] · 김응주[2] · 오민정[1] · 서홍석[2] · 김해중[1]

Maternal Extracellular Water is Associated With Birth Weight

Geum Joon Cho, M.D.[1], Hyo Jin Yoon, M.D.[1], Eung-Ju Kim, M.D.[2], Min-Jeong Oh, M.D.[1], Hong-Seog Seo, M.D.[2], Hai-Joong Kim, M.D.[1]

[1]Department of Obstetrics and Gynecology, [2]Cardiovascular Center, Division of Cardiology, Department of Internal Medicine, Korea University Guro Hospital, Korea University College of Medicine, Seoul, Korea

Objectives: Birth weight plays an important role in infant mortality and morbidity, child development, and adult metabolic diseases. Several studies have shown that maternal characteristics are an important indicator of offspring birth weight. In particular, maternal body composition is associated with birth weight. Bioelectrical impedance analysis (BIA) is an innocuous, non-invasive method that is useful in evaluating body composition, especially during pregnancy. The aim of this study was to evaluate the association of maternal body composition as measured by at-term BIA with birth weight.

Methods: A cross-sectional study was performed in 64 pairs of mothers and live singleton newborns with gestational ages of 37 weeks and older. Maternal body composition was measured using BIA before delivery at term. Pearson's correlation and multiple stepwise linear regression analyses were conducted to evaluate the association of body composition with birth weight.

Results: Birth weight was positively correlated with extracellular water (ECW), intracellular water, body mass index and free fat mass on Pearson's correlation analysis. The final stepwise linear regression analysis, with birth weight as the dependent variable, identified ECW, gender, parity, and gestational age at delivery as predictors of birth weight.

Conclusion: In this study, ECW, which is strictly linked to plasma volume, was positively associated with birth weight.

Key words: Body composition, Birth weight, Electrical impedance

Birth weight plays an important role in infant mortality and morbidity, child development, and adult metabolic diseases.[1-3] Several studies have shown that maternal characteristics are an important indicator of offspring birth weight. Maternal weight gain during pregnancy influences birth weight and can play a significant role in adverse pregnancy outcomes.[1-6] For example, excessive and insufficient weight gain during pregnancy are strongly associated with macrosomia and low birth weight, respectively.[1-3,7]

Maternal weight includes four components: the product of conception (fetus, placenta, amniotic fluid), uterine and mammary tissues, maternal body water (intracellular water {ICW} and extracellular water [ECW]), and fat mass.[8] These components can change to varying degrees during the course of pregnancy, thereby making it difficult to attribute weight fluctuations to a specific factor.[9] It is unclear which components have the most influence on birth weight.

Body composition can be determined using isotope dilution methods with deuterium or oxygen-18, yet this classic method is

투고일 : 2011. 6. 23. 수정일 : 2011. 8. 16. 확정일 : 2011. 8. 30.
주관책임자 : 오민정
E-mail : mjohmd@korea.ac.kr

expensive and not easy for routine use. In contrast, bioelectrical impedance analysis (BIA) is an innocuous, non-invasive method that is useful for evaluating body composition, especially during pregnancy.[8-15] Moreover, its validity to estimate body composition during pregnancy has been established.[9]

The aim of this study was to evaluate the association of maternal body composition according to BIA at term with birth weight.

MATERIALS AND METHODS

All mothers who gave birth to a live, full-term singleton at Korea University Guro Hospital were eligible to be included in this study. All mothers who agreed to participate provided written informed consent. None of the women were receiving medication known to influence lipid metabolism, and women with gestational diabetes mellitus or pregnancy-induced hypertension and newborns with congenital malformations were excluded. A total of 64 pairs of mothers and newborns were included in this cross-sectional study.

Information regarding self-reported pre-pregnancy body weight and parity were obtained at the first prenatal visit; while birth weight and length of pregnancy, in weeks, were obtained from medical records.

Body composition was measured using multi-frequency BIA with eight-point tactile electrodes (InBody 720; Biospace, Seoul, Korea). This analyzer uses an alternating current of 250 mA at variable frequencies of 1 kHz, 5 kHz, 50 kHz, 250 kHz, 500 kHz, and 1,000 kHz. Evaluation was performed at term before labor.

Data are expressed as mean plus standard deviation, range for continuous variables and as a percentage for categorical variables. The Pearson's correlation analysis was used to evaluate associations between birth weight and maternal body composition. To establish independent determinants of birth weight, a multiple stepwise linear regression analysis was conducted with birth weight as a dependent variable and controlling for age, parity, gestational age at delivery, neonatal gender, and maternal body composition. A P-value <0.05 was considered statistically significant. Statistical analyses were performed using SPSS 10.0 for Windows (SPSS Inc., Chicago, IL, USA).

RESULTS

The characteristics of the study subjects (mother/newborn) are presented in Table 1. The mean maternal age and gestational age at delivery were 33.84 ± 3.80 years and 39.12 ± 1.06 weeks, respectively, and the mean birth weight was 3.25 ± 0.48 kg. Using BIA, ICW, ECW, fat mass and free fat mass were measured (Table 1).

Table 2 provides summaries of Pearson's correlation coefficients between birth weight and maternal body composition. Birth weight was positively correlated with ECW, ICW, body mass index (BMI) and body fat mass. Birth weight and ECW exhibited a high positively correlation (Fig. 1).

The final stepwise linear regression analysis, with birth weight as the dependent variable, identified ECW, neonatal gender, parity, and gestational age at delivery as predictors of birth weight (Table 3).

DISCUSSION

In this study, maternal body composition at term, especially maternal ECW, was associated with birth weight after adjusting for other confounding factors. This result is similar to those of Levario-Carrillo et al.,[13] who reported a significant relationship between second trimester ECW and birth weight. Although the mechanism underlying this association is unclear, we can speculate on possible explanations. ECW is composed of interstitial fluid and plasma volume; plasma volume expansion during pregnancy has been known to be associated with birth weight, and defects in plasma volume expansion have been associated with low birth weight.[16,17] This can be explained by the fact that plasma volume may influence maternal hemodynamics such as cardiac output and, indirectly, uteroplacental blood flow, which contributes to normal fetal growth.[18-20] Therefore, the association between ECW and birth weight observed in this study may be attributed to aberrant maternal plasma volume.

Table 1. Characteristics of the study subjects

	Mean	SD	Range
Maternal age (years)	33.84	3.80	26–43
Parity (n)	0.50	0.64	0–2
Gestational age at delivery (weeks)	39.12	1.06	37.30–41.50
Birth weight (kg)	3.25	0.48	2.10–4.44
Neonatal gender–female (%)	46.9		
BMI (kg/m^2)	26.93	3.78	21.38–40.62
Waist/hip ratio	0.88	0.04	0.81–0.98
ICW (L)	20.30	2.14	16.50–26.60
ECW (L)	12.91	1.53	10.40–17.40
Fat mass (kg)	24.08	7.51	12.80–55.00
Free fat mass (kg)	45.24	4.90	37–60

BMI: body mass index, ICW: intracellular water, ECW: extracellular water, SD: standard deviation.

Table 2. Correlations between birth weight and maternal body composition

	r^*	*P*–value
BMI (kg/m^2)	0.284	0.024
Waist/hip ratio	0.165	0.196
ICW (L)	0.276	0.029
ECW (L)	0.313	0.013
Fat mass (kg)	0.173	0.175
Fat free mass (kg)	0.294	0.019

BMI: body mass index, ICW: intracellular water, ECW: extracellular water.
[*] Values are Pearson's coefficients.

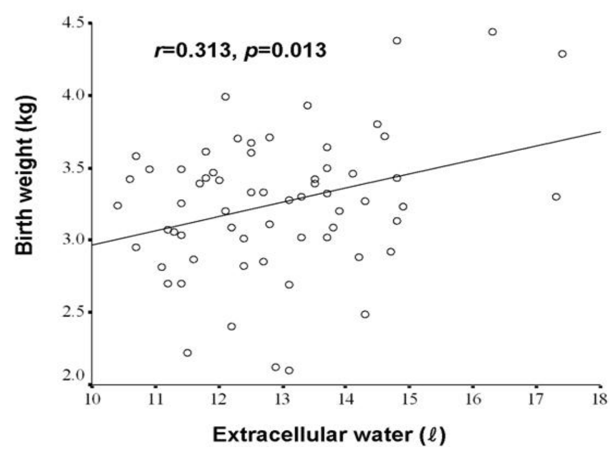

Fig. 1. Correlation between birth weight and maternal extracellular water.

There is a current debate regarding whether gestational period has the greatest impact on birth weight compared to those of other maternal factors. Levario-Carrillo et al.[13] reported that there was a significant relationship between second trimester maternal ECW and birth weight, and alternations in ECW in women who gave birth to small for gestational age (SGA) babies occurred in the second trimester. Maternal body composition undergoes a substantial adaptive change during the course of pregnancy.[14] In particular, ECW shows progressive increases throughout pregnancy.[14,15] In this study, ECW was measured at term and was positively associated with birth weight. Unfortunately, none of these previous studies included a longitudinal evaluation of maternal ECW throughout pregnancy. Therefore, it is difficult to determine whether net volume of ECW (including changes throughout pregnancy), which is measured at term, or the change itself is the associative factor.

Table 3. Results of stepwise multiple linear regression analysis with birth weight as the dependent variable and age, parity, gestational age at delivery, neonatal gender, and maternal body composition as independent variables

	β	t	*P*-value
Parity (n)	0.367	3.276	0.017
Gestational age at delivery (weeks)	0.232	2.078	0.042
Neonatal gender-female (%)	−0.275	−2.465	0.017
ECW (L)	0.367	3.276	0.002

β: standardized regression coefficient, t: corresponding t values, ECW: extracellular water.

Other studies evaluating the association of body composition with birth weight have concluded that total maternal body water was associated with birth weight.[8,16] However, total body water is made up of ICW and ECW. Intracellular water during pregnancy is likely to include changes in the maternal body such as increases in mammary and uterine tissues.[21] In this study, ICW was not associated with birth weight, inconsistent with results from other studies,[13] although ECW was significantly associated with birth weight. Our results suggest that plasma volume has a stronger association with ECW than it does with total body water. Therefore, true estimations of ECW and ICW are needed to evaluate the association of body composition with birth weight.

In this study, maternal fat mass was not associated with birth weight, inconsistent with results from other studies.[10,17] Other studies have reported that maternal fat mass is an important predictor of birth weight,[6] especially in the subgroup of women with low BMI.[8] The discrepancy of association between maternal fat mass and birth weight may be due to several factors, including the sample size, ethics, period of measurement, and technical differences concerning the methods used to measure body composition.

In 2009, the Institute of Medicine released new recommendations regarding weight gain during pregnancy.[22] However, weight gain recommendations have some problems. For example, gestational weight gain was shown to have opposing influences on the risks for large for gestational age (LGA) and SGA babies.[23] These inconsistencies may be due to inappropriate definition of body weight, which is made up of several components. Moreover, it is difficult to determine the adequate range of gestational weight gain associated with minimal risks for LGA and SGA. Therefore, BIA during pregnancy is an easy way to monitor changes in body weight and composition.

Several limitations should be kept in mind when interpreting our findings. First, because of the cross-sectional nature of this study, it was not possible to establish a cause-effect relationship between maternal body composition and birth weight. Second, amniotic fluid can influence final weight results.[14] Nevertheless, it has been reported that body composition was not different in mothers diagnosed with oligohydramnios or polyhydramnios.[13]

In this study, we have determined that maternal body composition, especially ECW, is positively associated with birth weight. The results indicate that BIA may allow for the possibility to identify patients at risk for improper fetal growth and to assess maternal hemodynamic adaptation to pregnancy.

참고문헌

1. Mohanty C, Prasad R, Srikanth Reddy A, Ghosh JK, Singh TB, Das BK. Maternal anthropometry as predictors of low birth weight. J Trop Pediatr 2006; 52: 24-9.
2. Cedergren M. Effects of gestational weight gain and body mass index on obstetric outcome in Sweden. Int J Gynaecol Obstet 2006; 93: 269-74.
3. US National Academies Committee on the Impact of Pregnancy Weight on Maternal and Child Health, US National Research Council Board on Children Youth and Families, US Institute of Medicine Food and Nutrition Board. Influence of pregnancy weight on maternal and child health: workshop report. Washington, DC: National Academies Press; 2007.
4. Yekta Z, Ayatollahi H, Porali R, Farzin A. The effect of pre-pregnancy body mass index and gestational weight gain on

pregnancy outcomes in urban care settings in Urmia-Iran. BMC Pregnancy Childbirth 2006; 6: 15.
5. Eastman NJ, Jackson E. Weight relationships in pregnancy. I. The bearing of maternal weight gain and pre-pregnancy weight on birth weight in full term pregnancies. Obstet Gynecol Surv 1968; 23: 1003-25.
6. Abrams BF, Laros RK Jr. Prepregnancy weight, weight gain, and birth weight. Am J Obstet Gynecol 1986; 154: 503-9.
7. Saunders C, Ramalho RA, de Lima AP, Gomes MM, Campos LF, dos Santos Silva BA, et al. Association between gestational night blindness and serum retinol in mother/newborn pairs in the city of Rio de Janeiro, Brazil. Nutrition 2005; 21: 456-61.
8. Sanin Aguirre LH, Reza-Lopez S, Levario-Carrillo M. Relation between maternal body composition and birth weight. Biol Neonate 2004; 86: 55-62.
9. Lukaski HC, Siders WA, Nielsen EJ, Hall CB. Total body water in pregnancy: assessment by using bioelectrical impedance. Am J Clin Nutr 1994; 59: 578-85.
10. Larciprete G, Valensise H, Vasapollo B, Di Pierro G, Menghini S, Magnani F, et al. Maternal body composition at term gestation and birth weight: is there a link? Acta Diabetol 2003; 40 Suppl 1: S222-4.
11. Kotler DP, Burastero S, Wang J, Pierson RN Jr. Prediction of body cell mass, fat-free mass, and total body water with bioelectrical impedance analysis: effects of race, sex, and disease. Am J Clin Nutr 1996; 64: 489S-97.
12. Ghezzi F, Franchi M, Balestreri D, Lischetti B, Mele MC, Alberico S, et al. Bioelectrical impedance analysis during pregnancy and neonatal birth weight. Eur J Obstet Gynecol Reprod Biol 2001; 98: 171-6.
13. Levario-Carrillo M, Rodriguez N, Tufino-Olivares E, Jimenez Mdel R, Delgado-Monge MC, Reza-Lopez S. Body composition of women with newborns who are small for gestational age. Neonatology 2009; 95: 15-22.
14. Larciprete G, Valensise H, Vasapollo B, Altomare F, Sorge R, Casalino B, et al. Body composition during normal pregnancy: reference ranges. Acta Diabetol 2003; 40 Suppl 1: S225-32.
15. Valensise H, Andreoli A, Lello S, Magnani F, Romanini C, De Lorenzo A. Multifrequency bioelectrical impedance analysis in women with a normal and hypertensive pregnancy. Am J Clin Nutr 2000; 72: 780-3.
16. Mardones-Santander F, Salazar G, Rosso P, Villarroel L. Maternal body composition near term and birth weight. Obstet Gynecol 1998; 91: 873-7.
17. Lederman SA, Paxton A, Heymsfield SB, Wang J, Thornton J, Pierson RN Jr. Maternal body fat and water during pregnancy: do they raise infant birth weight? Am J Obstet Gynecol 1999; 180: 235-40.
18. Salas SP, Giacaman A, Vio CP. Renal and hormonal effects of water deprivation in late-term pregnant rats. Hypertension 2004; 44: 334-9.
19. Davison JM. Edema in pregnancy. Kidney Int Suppl 1997; 59: S90-6.
20. Salas SP, Altermatt F, Campos M, Giacaman A, Rosso P. Effects of long-term nitric oxide synthesis inhibition on plasma volume expansion and fetal growth in the pregnant rat. Hypertension 1995; 26: 1019-23.
21. Lof M, Forsum E. Evaluation of bioimpedance spectroscopy for measurements of body water distribution in healthy women before, during, and after pregnancy. J Appl Physiol 2004; 96: 967-73.
22. US Institute of Medicine, US National Research Council Committee to Reexamine IOM Pregnancy Weight Guidelines, Rasmussen KM, Yaktine AL. Weight gain during pregnancy: reexamining the guidelines [2010/07/30]. Washington, DC: National Academies Press; 2009.
23. Park S, Sappenfield WM, Bish C, Salihu H, Goodman D, Bensyl DM. Assessment of the Institute of Medicine recommendations for weight gain during pregnancy: Florida, 2004-2007. Matern Child Health J 2011; 15: 289-301.

「국문초록」

목적: 출생 체중은 주사기 사망 및 이환 뿐만 아니라 성인기 대사질환의 발생과도 깊은 연관성이 있다. 여러 연구들에서는 산모의 다양한 특성이 이러한 출생 체중과 관련이 있으며 특히 산모의 체성분이 관련이 있는 것으로 보고하였다. 생체 전기 임피던스법(bioelectrical impedence analysis)은 체성분을 측정하기 위한 간단하고 비침습적인 방법으로 특히 임산부에서 유용하다. 이번 연구의 목적은 만삭 시 산모의 체성분과 출생 체중과의 연관성을 확인하기 위한 것이다.

연구방법: 본 연구는 고려대학교 구로병원 산부인과에서 만삭에 단태아를 정상 분만한 산모 및 태아를 대상으로 하였다. 산모의 체성분은 분만 전 만삭 시 생체전기 임피던스법을 이용, 측정하였다.

결과: 출생 체중은 다양한 산모의 체성분 중 세포외액, 세포내액, 제지방과 양의 상관 관계를 보였다. 선형 회귀분석 상 다양한 산모의 체성분 중 세포외액만이 출생 체중과 관련이 있었다.

결론: 본 연구에서는 다양한 산모의 체성분 중 혈장량과 관련이 있는 세포외액이 출생 체중과 양의 상관 관계를 보였다.

중심 단어: 체성분, 출생 체중, 전기 임피던스