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Research Article

The Effect of Maternal and Nutritional Factors on Birth Weight: A Cohort Study in Tehran, Iran

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ABSTRACT

Background: Gestational dietary intake has a significant effect on fetal growth and birth consequences.

Objectives: This study aims to examine the effect of maternal food intake before and during pregnancy on birth weight. Most studies in this area are cross-sectional. This study enjoys a prospective cohort design. Considering the nutritional status of the mother and other related factors affecting birth weight, appropriate knowledge is needed to prevent and reduce risk factors and promote the health status of children and community.

Methods: As a prospective cohort study, a total of 585 pregnant women of first trimester, visiting Tehran Metropolitan Area public health centers and private sectors [clinics and hospitals], were interviewed at first phase, Pre-gestational dietary intake was obtained by a 168-item semi-quantitative food frequency questionnaire. The second interview collected food recalls from 342 women. The final stage included extraction of birth weight information from health records for 485 births. Univariate and multivariate analysis was used to explore the effect of maternal and nutritional factors on birth weight.

Results: The results of the analysis show that direct measures of nutrition, measured as food group consumption at first and third trimester of pregnancy, had no significant effect on birth weight once the confounding factors were controlled. Of control variables included in the analysis twin pregnancy outcome, pregnancy number, pre-pregnancy weight [marginally significant], and gestational age [marginally significant] were associated with birth weight.

Conclusions: The results of this study show no significant role of mother's nutrition during pregnancy on birth weight, while long term nutrition outcomes such as pre-pregnancy weight had significant role. It seems the main reasons behind less important role of pregnancy nutrition on birth weight in this study include: a] food intake deficiency is not a major problem for participants, and b] cross sectional data on food intake are less important on outcome of pregnancy weight than long term nutritional status outcome variables such as mother's weight and height.

Keywords: Cohort study; Maternal nutrition; Pregnancy; Birth weight; Iran

INTRODUCTION

Birth weight is an important determinant of the individual's survival [1]. Restricted fetal growth has been associated with higher risk of cardiovascular diseases and type II diabetes incidence after birth. On the other hand, birth weight higher than the normal range has been linked with higher possibility of obesity and cancer in early years of life [2].

Maternal height, pre-pregnancy Body Mass Index[BMI], pregnancy total weight gain , age of mother, family income, level of education, residence, mother's health status, and the number of children [2,3] are important factors related to birth weight.

As a modifiable factor, adequate maternal nutritional status before and during pregnancy is essential for fetal growth and development [1,3]. Nutritional status is an indication of mother

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and child overall wellbeing [4]. Poor nutrition is indicator of health risk to both mother and child [5]. It causes a state of biological competition between the mother and the fetus [6].

Studies in developing countries revealed a direct association between fetal birth anthropometric measures and gestational dietary intake [7]. The association is unclear in industrial countries, where profound malnutrition is uncommon. Observational studies have understood little and inappropriate associations among intake of macronutrients and infant size [8]. There is concern that deficiencies of macronutrients and micronutrients during pregnancy also may detrimentally affect the neural development of offspring [9].

Non-nutritional factors including twin pregnancy, socioeconomic status, chronic diseases, mother education[10-12], Physical activity [13,14], energy intake in pregnancy [15], mother's weight gain in pregnancy [16,17] which represents the mother's nutrition during pregnancy, height, and weight before pregnancy, also, affect birth weight [17,18].

METHODS

Subjects and dietary assessment methods: The study has a prospective cohort design. Pregnant women of first trimester recruited from public health facilities for first interview. The gathered data were including history of pregnancy, dietary intake, socioeconomic status, and other mother-related determinants associated with birth weight. The second interview contained two phone calls to collect 24-hour dietary recall [24-h DR] data from mother at third trimester. One of the recalls included a weekend day. The third step of data gathering included obtaining mother and infant data from health centers` routine registration system.

The population of this study included all pregnant women of first trimester attending the public health facilities, private clinics and hospitals in Tehran city between December, 2015 and May 2018. The first stage of interview included 585 first trimester pregnant women (gestation age <22 weeks). The samples are recruited form all the three Medical Sciences Universities at Tehran Metropolitan Area namely; Tehran University of Medical Sciences, Iran University of Medical Sciences, and Shahid Beheshti University of Medical Sciences.

Sample size was computed applying the Open-Epi Kelsey statistical software [19] based on the result of the study conducted by Melby et al. [20] and considering a 95% significance level.

Of 585 women of first stage interview only 342 women were available/willing to participate at second interview. Reasons for non-participation included loss of pregnancy (e.g. miscarriage), migration, and unwillingness to cooperate. At the third stage, maternal and neonatal information of 485 women extracted from health records. Additional reasons for data attrition at this stage were lack of information on birth weight and stillbirth.

The study was approved by the human research Ethical Committee of the National Nutrition and Food Technology Research Institute (NNFTRI) and Faculty of Nutrition Sciences and Food Technology, Shahid Beheshti University of Medical Sciences (approval code: IR.SBMU.NNFTRI.REC.1394.37).

Dietary intake data were collected by trained nutrition sciences students. Information about first stage dietary intake was obtained with a semi-quantitative FFQ with 168 food items (with standard serving sizes) through face to face interviews. The FFQ was designed according to Willet's method [19]. The reliability and validity of the questionnaire was evaluated earlier using a sample of adult women in Tehran [21,22]. For each food item, participants reported the consumption frequency according to suggested portion size during the past year.

Dietary intake of mothers at third trimester of gestation measured using two non-consecutive 24-hour dietary recalls including dietary intake for a common week day and a weekend day. Afterward, reported dietary intake by both dietary assessment methods were converted to daily consumption in grams by using household measures. Mean intake of two 24-h DR was considered for second step analysis. Finally, Total daily energy intake was computed by applying United States Department of Agriculture (USDA) food composition table data (USDA, Release 11, 1994) modified for Iranian food products.

Data on mother's age, marital duration, education, employment status, and pre-marital familial relationship with spouse, number of family members, household income, religion, ethnicity, and nationality were collected by a valid questionnaire [23]. Other variables included physical activity [24], general health [25], pregnancy problems, past medical history of mother, miscarriage, status of prenatal care, pregnancy number, and gestational age are also collected using validated and/or conventional tools.

Maternal and neonatal anthropometric measures: Pre-pregnancy weight was obtained from the health registry system. Mother's weight and height were measured at first interview, as well. Weight was measured to the nearest 100 g in the condition that participants were shoeless wearing fewest clothing. Height was measured to the nearest 1 mm in standing straight status keeping shoulders in normal site. Mother's Body Mass Index was calculated as weight [in kilograms] divided by height (in meters) squared. Mother's weight at third trimester obtained from health records after making adjustments for differences in measurement tools. The health facility scales were calibrated using research team scales. Information on birth weight and gestational age was obtained from medical records.

Statistical analysis: In this study, components of the food pyramid (i.e. food groups including cereals, meat, dairy products, vegetables and fruits) was considered as main nutritional variables.

Using food pyramid recommendation for pre-pregnancy and the third trimester pregnancy, the variables were dichotomized (0 for individuals consumed less than the recommended level, and 1 for individuals consumed equal to or greater than recommended level of each food group pyramid (See Table 1)).

Table 1: Recommended food group consumption at pre-pregnancy and third semester pregnancy based on daily food pyramid.

Food groups	Servings recommended [Pre-pregnancy]	Servings recommended [third trimester]
Cereals group	6	8
Meat group	2	6.5
Dairy group	2.5	3
Vegetables group	3	5
Fruits group	2	5

Data was analyzed using R software (version 3.3.1). Both univariate and multivariate analysis were conducted. For univariate analysis, frequency and percentage or mean and standard deviation was used depending on the measurement type. The relationships between the consumption of each food group with birth weight were analyzed at both pre-pregnancy and third trimester. Unadjusted and adjusted linear regression models were used to assess the relationships. Dependent variable for both unadjusted and adjusted linear models was birth weight. The independent variable for unadjusted models included only one food group. Other food groups and factors associated with birth weight were included as control variables in adjusted models. For instance, the unadjusted model for studying the association between cereal group and birth weight included only one independent variable, i.e. cereal group. The adjusted model for the same association included other food groups and all factors associated with birth weight in addition to cereal group. The unadjusted coefficient shows the uncontrolled association between independent and dependent variables. The adjusted coefficient, on the other hand, shows the association between the two variables when other background and confounding variables are controlled.

Results: Socioeconomic and demographic features of the mothers are shown at Table 2. According to the table, mothers were mainly aged 18 to 35 years. The educational level of mothers was mainly low or medium. The majority of them were also home makers. More than of women had no prior extended familial relationship with their husband. For majority of women, the household size was 4 or less. In terms of household income, more than half of households had monthly income of less than 14 Million Rials (i.e. twice the minimum monthly wage). Most of women participated in the study were Shiite Muslims, Persian or Turkish speaking, and Iranian.

Table 2: Socioeconomic and demographic features of the studied pregnant mothers at first stage of the study.

Characteristics	Frequency [percent]
Mother's age	
Less than 18 years	17 (2.9%)
18 to 35 years	464 (79.3%)
More than 35 years	104 (17.8%)
Mother education	
Low education	176 (30.1%)
Medium education	249 (42.5%)
College education	160 (27.4%)
Job Status of the Mother	
Housewife	532 (90.9%)
Employed	53 (9.1%)
Prior extended blood kinship	
Relative	204 (34.9%)
Non-relative	381 (65.1%)
Number of household members	
Four members or less	560 (95.7%)
Five members or more	25 (4.3%)
Household income	
Less than 14 million rials	295 (50.4%)
More than 14 million rials	290 (49.6%)
Religion	
Shia	526 (89.9%)
Other	59 (10.1%)
Ethnicity	
Fars	233 (39.8%)
Turkish	211 (36.1%)
Other	140 (23.9%)
Nationality	
Iranian	545 (93.2%)
Non iranian	40 (6.8%)

The mean and SD intake of different food groups are presented at Table 3. As the table shows, the average intake of cereal at pre-pregnancy (i.e. 13.4) and the third trimester of pregnancy (i.e. 10.83) are higher than the recommended amount. The average consumption of fruits and vegetables in the pre-pregnancy group is higher than recommended.

However, it is lower than recommended at third trimester. Dairy consumption at both periods (pre and third semester pregnancy) and meat consumption at pre-pregnancy are about the recommended levels. The meat consumption at third trimester is less than recommended, however.

Table 3: Mean consumption of food groups at pre-pregnancy and third trimester of Pregnancy.

	Before pregnancy		**Third trimester of pregnancy**	
Food groups	**Mean**	**SD**	**Mean**	**SD**
Cereals	13.38	7.76	10.83	5.62
Meat	2.24	1.13	3.22	1.85
Dairy	2.51	1.52	2.81	1.65
Vegetables	4.78	3.38	4.54	3.04
Fruits	6.24	3.62	4.73	3.12

As shown in Table 4, the average birth weight is 3167grams. The average age of women at first marriage is 22.2 years. Average Pre-pregnancy weight and weight gain in pregnancy is 63.4 kg, and 0.43 kg per week, respectively. Also, average energy intake before pregnancy is estimated as 2781.3 calories, while the average energy for third trimester of pregnancy is estimated as 2755.9.

Table 4: Summary of mother/child anthropometric and dietary intake measures of the study.

Measure	**Mean**	**SD**
Birth weight	3167	490.3
Age at first marriage	22.2	5.1
Mother's height	160.8	5.9
Pre-gestational weight	63.4	11.07
Total weight retain in gestation [kg per week]	.43	6.85
Pre-gestational total energy intake	2781.3	1054.3
Total energy intake at third trimester of pregnancy	2755.9	989.46

The average and SD of the birth weight by socio economic characteristics of mothers are presented at Table 5. The P-values are estimated using suitable parametric/non parametric statistical procedures. These bivariate results show no association between socioeconomic characteristics of mothers and birth weight.

Table 5: Association between Socio-economic characteristics of mothers and birth weight.

Characteristics	**Mean (SD)**	**P-Value**
Mother age		
Less than 18 years	3293 (551.1)	0.59
18 to 35 years	3167.9 (491.8)	
More than 35 years	3144.2 (482.1)	
Mother education		
Low education	3226.8(510.4)	0.2
Medium education	3140.8 (470.8)	
College education	3141.9 (497.3)	
Employment status of the mother		
Home maker	3161.8 (488.3)	0.3
Employed	3238.1 (516.7)	
Prior extended familial relationship		
Relative	3193.9 (451.2)	0.38
Non-relative	3153.1 (510.9)	
Number of family members		
Four members or less	3166.6 (487.3)	0.82
Five members or more	3190.0 (559.3)	
Household income		
Less than 14 million rials	3176.4 (614.6)	0.56
More than 14 million rials	3221.1(554.46)	
Religion		
Shia	3156.24 (476.94)	0.26

Other	3291.53 (567.42)	
Ethnicity		
Fars	3138.35 (522.82)	0.44
Turkish	3250.13 (481.83)	
Other	3241.69 (507.45)	
Nationality		
Iranian	3162.50 (492.42)	0.32
Non iranian	3148.62 (468.52)	

Based on the results of Tables 6, none of FFQ food groups, measuring intake for pre-pregnancy period, were associated with birth weight when the model included no control variables. With controlling confounding and underlying factors, association between food groups and birth weight did not change. Of control variables, twin pregnancy outcomes, pre-pregnancy weight, mother disease history, pregnancy number, gestational age, and mother age were associated with birth weight.

Table 6: Linear regression analysis of relationships between food groups intake and birth weight before and during pregnancy.

Adequate consumption of:	**Ffq**		**Recall**	
	N=585		**N=342**	
	Beta		**Beta**	
	Without control	**With control**	**Without control**	**With control**
Cereals group	-0.02	-0.07	-0.13.	0.59
Meat group	0.01	0.1	0.02	0.87
Dairy group	0	-0.01	-0.07	0.92
Vegetable group	0.05	-0.03	0	0.45
Fruits group	0.08	0.08	-0.16*	0.14
Twins		-0.26***		-0.24*
Pre-pregnancy weight		0.30***		0.16.
		0.1		0.11
Maternal height				
Pregnancy complications		0.04		-0.05
Mother disease		0.17*		0.09
Mother weight gain		0.05		0
Energy [kcal/day]		-0.1		0.15
Physical activity [met/week]		0		0.02
General health [ghq score]		0.03		0.07
Age at marriage		-0.01		0.04
The number of prenatal care		-0.04		-0.04
Pregnancy number		0.20*		0.22*
Gestational age		0.31***		0.18.
Mother age		-0.19*		-0.06

* P< 0.05 ** P< 0.01 *** P< 0.001 . P< 0.1

The unadjusted results of food intake data for the third trimester of pregnancy show cereals (marginally significant) and fruit group intake are associated with birth weight. Controlling the confounding/underlying factors fades out these associations, however. Of control variables included in the model twin pregnancy outcome, pregnancy number, pre-pregnancy weight (marginally significant), and gestational age (marginally significant) are associated with birth weight.

DISCUSSION

This paper investigated the relationship between dietary group intake before pregnancy and at the third trimester of pregnancy with birth weight. Important confounding and underlying causes of birth weight were also included in the analysis as control variables. We found no important effect of maternal nutrition on birth weight, when measured cross-sectional. Among control variables, twin pregnancy outcome, pre-pregnancy weight, pregnancy number, gestational age, and mother's age were associated with birth weight. We believe our results did not turn out as expected due to two main reasons: a) participants of this study are from the capital city of Iran (i.e. Tehran) where food intake deficiency is not a major problem and low birth weight is the lowest of the country, and b) cross sectional data on food intake are less important on outcome of pregnancy weight status than long term nutritional status outcome variables such as mothers weight and height. These long term nutritional status indicators show a significant relationship with birth weight even after controlling for potential confounding variables (e.g. twin pregnancy, pregnancy number, gestational age, and age).

In this study, cereal groups were not related with birth weight. Most of the literature we reviewed suggests an association between the two. For example, Godfrey found, women with high intake of carbohydrates in early pregnancy had infants with low birth weight [26]. Or in Moore's study, mothers who received high levels of carbohydrates at late gestation had low birth weight infants [27]. In Knudsen study, high intake of bread and cereals was associated with low birth weight [2]. These reverse associations could be related to low socioeconomic status of women [as high intake of carbohydrates could be associated with low socioeconomic status. In Rao study, there was no correlation between carbohydrate intake and birth weight [28]. Type of carbohydrate used in pregnancy causes a stable change in fetus weight and mother weight gain. Carbohydrates with high glycaemia are associated with overgrowth of the fetus and mother weight gain, while consuming low-glycemic carbohydrates leads to delivery of infants with birth weights between the 25th and the 50th percentile and normal gestational weight gain [29]. Carbohydrates are main fuel source and most important energy source. This food group is important especially at third trimester of pregnancy, where mother gains more weight and needs energy.

The results of this study also show no relationship between consumption of meat and birth weight. In existing studies, the meat group has not been studied as one of the components of pyramid. Only a specific type (for example fish, red meat) of this group has been investigated. In Rogers study, there was no association between intake of fish in the third trimester of pregnancy and birth weight with control of confounding factors [30]. In the study of Olsen, the relationship between seafood consumption in early pregnancy and fetal growth disappeared by controlling confounding factors [31]. Muthayya's study showed that among pregnant women with low intake of fish, fish consumption in the third trimester had positive association with birth weight [32]. Knudsen's study showed that consumption of processed meat in pregnancy caused a low birth weight of baby for gestational age and a diet rich in fish and poultry positively related to birth weight [2]. In Godfrey's study, women who had less intake of meat at later stages of pregnancy, regardless of mother's height and BMI, had neonates with low birth weight [33]. A study in Lanshan showed a significant low birth weight with consumption of red meat during pregnancy [34]. The relationship between meat group and birth weight is contradictory among studies. Because in these studies, the way meat is processed, the amount of meat fat and sample size varies. In our study, the consumption of meat in the pregnancy was much lower [mean of serving consumption=3.04] than that advised by the food pyramid.

In our study, dairy consumption in pregnancy was not associated with birth weight. In Rao's study, also, the relationship between dairy consumption and birth weight was not significant after controlling for the amount of fat [28]. Results of Knudsen et al study showed consuming high-fat dairy products in pregnancy causes a risk of low birth weight for gestational age [2]. Munnion et al revealed that milk intake during pregnancy is associated with birth weight independent of risk factors [35]. In Godfrey study women who had an insufficient consumption of dairy protein in late pregnancy had higher chance to deliver infants who were low birth weight [26]. Milk consumption during pregnancy was linked to a greater birth weight for gestational age in the Olsen research [31].In a cross-sectional study, higher consumption of milk in the last trimester of gestation was directly associated with birth weight [36, 37]. In the present study unlike most existing studies, there was no relationship between this group and birth weight [38]. Despite acceptable intake of dairy group (with average intake of 2.52 servings) it seems individuals over report their consumption [39,40].

CONCLUSION

In this study the association between fruit and vegetable intake and birth weight were not significant, as well. In a cross-sectional study no correlations between birth weight and consumption of all types of vegetables were observed, but a slight increase in birth weight was observed with tuber vegetables. This connection is due to the fact that tuber vegetables have higher energy content due to starchy carbohydrates. In Murphy's overview, there is generally limited evidence of a positive relationship between fruit and vegetable intake during pregnancy and birth weight. The majority of studies in more developed countries have shown no relationship between the consumption of vegetables and the birth weight. Limited data suggests that increasing vegetable and fruit diet is connected to higher newborn weights in women in less developed countries. In Mikkelsen study, consumption of fruits and vegetables in pregnancy is associated with birth weight for women with good nutrition, especially among lean women. Rao's study showed, the consumption of fruits and vegetables in third trimester of pregnancy was related to birth weight and it remained important by controlling the confounding factors (for example pre-pregnancy weight). Mother's weight is an important factor in relationship between consumption of fruits and vegetables. In the Ramon study, consumption of more vegetables during pregnancy was associated with a higher birth weight. In this study there was no relationship between the consumption of fruits and birth weight. Fruits and vegetables are not a major source of energy in terms of energy supply, but are rich source of phytochemicals and antioxidants, and some nutrients and phytochemicals in fruits and vegetables seem to be related to other indicators of fetal growth such as head circumferences.

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