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Research Article

Maternal Nutrition and Birth Weight: Role of Vitamins and Trace Elements

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Abstract

Introduction: Pregnancy is a period of increased metabolic needs. Vitamins, minerals and trace elements are major determinants of the health of the pregnant woman and the fetus.

Objective: To evaluate maternal intakes of vitamins and trace elements in the first, second and third trimesters of pregnancy and assess their effect on birth weight.

Materials and methods: A prospective and longitudinal study have been conducted among 226 pregnant women throughout the whole period of pregnancy in the centers of prenatal consultations and follow up in Constantine (Algeria) from December 2013 to June 2016. We analyzed maternal intakes of iron, minerals and vitamins by comparing them to the normally recommended dietary allowances (ANC) and then by multivariate analysis, we studied the correlation between these intakes and birth weight. Statistics were performed using the Statview TM and SPSS software.

Results: This study noted the positive effect of some maternal factors on birth weight, such as maternal age, parity, pre-pregnancy BMI and pregnancy term. The average daily intake of minerals (iron, calcium, zinc and magnesium) and vitamins (B9, B1 and E) were below the recommended intakes (ANC). In contrast, average intakes of vitamin C in the 2nd and 3rd trimesters of pregnancy corresponded to the ANC. Only magnesium intakes in the first trimester ($p=0.02$) and vitamin B9 in third one ($p=0.004$) were significantly correlated with birth weight.

Conclusion: Intakes of trace elements and vitamins in our study population are reduced compared to the ANC. The correction of the pregnant women diet is urgently needed. Thus, promoting quality over quantity to avoid deficiencies in trace elements and vitamins which are harmful to the development and fetal growth.

Keywords: Pregnancy; Birth weight; Trace elements

Introduction

Pregnancy is a period of increased metabolic needs, due to physiological changes of the pregnant woman and needs of the fetus. Vitamins, minerals and trace elements, commonly known as micronutrients (calcium, iron, zinc, magnesium, vitamins B9 and C), are major determinants of the health of the pregnant woman and her fetus [1,2].

A diversified diet, naturally rich in vitamins and trace-elements, allows satisfying most needs during pregnancy and breastfeeding. Supplementation should not be systematic because it exists in pregnant women a physiological mechanism of adaptation which increases the assimilation of all micronutrients [3].

In fact, zinc is important for embryogenesis, fetal growth and protein synthesis [4]. Magnesium is essential for ossification, cellular integrity and the functioning of several enzymes [5]. Iron is involved in erythropoiesis, metabolism of the skin and mucous membranes, fights against infection, muscular function and cell growth [6]. Calcium allows bone mineralization of the fetus. It also intervenes in the functioning of the nervous system and muscular work as well as in blood coagulation [7].

During pregnancy, vitamins requirements are increased. Group B vitamins are used as co-enzymes. For example, thiamine (B1) allows the assimilation and metabolism of carbohydrates. The key role of folates in DNA synthesis means that a deficiency will be associated to dysfunctions at the time of cell division. The relationship between folate deficiency in pregnant women and neural tube formation abnormalities is now well established [8]. Vitamin C, or ascorbic acid is a vitamin that, by its role in the stabilization of the membranes and its antioxidant properties, can play a role on birth weight but the effects are mostly demonstrated in developed countries [9]. Vitamin E which plays a role of antioxidant, protecting thus polyunsaturated fatty acids of oxidative destruction in cell membranes [10]. It participates in the formation and structure of membrane phospholipids (in particular in brain cells) [11]. The serum levels of tocopherol are two times higher than those observed in non-pregnant women. The recommended intake is 12 mg/day [12].

Deficiency in one or more of these minerals and trace elements can promote the appearance of some complications such as prematurity and intrauterine growth restriction [13]. Recent studies have shown that most micronutrients can be limiting factors of fetal growth. Some are essential to the formation of body tissues, while others are indispensable for energy metabolism and the transcription of genes. In this context, the study of iron deficiency consequences, as well as the protective role of some vitamins against oxidative stress, of pre-eclampsia represents perhaps the most demonstrative examples [14,15].

However, a debate persists about the influence of trace elements intakes on birth weight and the importance of single or multiple supplementations in order to improve fetal trophicity. For some, systematic preventive martial supplementation would even be harmful in some situations [16].

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In scientific literature and in particular in our country (developing countries), few studies were interested in the evaluation of trace elements intakes during pregnancy and even less to their effect on birth weight. However, in these countries, we are witnessing an epidemiological transition and a change in eating habits with abandon of Mediterranean diet and a more frequent inactivity [17].

The objective of this study was to evaluate maternal intakes of trace elements and vitamins during all the period of pregnancy (first, second and third trimester) in our population and appreciate their correlation to birth weight.

Materials and Method

A prospective and a longitudinal study was conducted among 226 pregnant women throughout all the period of pregnancy at antenatal centers in Constantine (Algeria), from December 2013 to June 22016.

The principal objective of this study was to evaluate maternal intakes of trace elements and vitamins in a population of pregnant women during the first, second and third trimesters of pregnancy and to compare them with the recommended dietary allowances (ANC) [18]. The secondary objective was to detect by a multivariate analysis a possible correlation between dietary intakes of trace elements, vitamins and birth weight.

We excluded from the study women with a history of diabetes, hypertension, auto-immune or endocrine pathologies as well as women ignoring their starting weight. Among all women meeting the inclusion criteria, only 226 pregnant women were accepted to participate in the study.

Data used for this study was the interrogation and the study of blood tests of pregnant women at their presentation for prenatal follow-up consultations at each trimester of pregnancy. Gestational age was calculated from the last menstrual period and confirmed by an ultrasound of the first trimester of pregnancy.

After consent, all pregnant women were asked about their socio-demographic characteristics. For each pregnant woman, we noted age, parity, term and pre-pregnancy weight and height in order to calculate pre-pregnancy BMI. Fetal data were birth weight.

Pregnant women have also completed a food questionnaire based on 24 h recall method concerning their repeated usual diet during the three trimesters of pregnancy. Energy intakes, vitamins (B1, B9, C and E), trace-elements (Fe, Mg, Zn) and calcium have been calculated. The information collected was processed by Excel. Foods consumed per day are quantified, estimated using household units and photos then converted into proportions of macro and micronutrients (carbohydrates, lipids, proteins, vitamins and trace-elements) using equivalences previously established. The amounts of food are converted into nutrients using compiled tables [19,20].

Assessment of nutrient intakes was made on the basis of French Recommendations ANC 2001 [18].

Data processing was performed by Stat View and SPSS software, that of the conversion of foods into nutrients with Excel. Means were compared using the analysis of variance (ANOVA); t test allowed the comparison between group means of the three trimesters. The study of correlations was performed by the "Pearson correlation" test, univariate and multivariate analysis by the Chi^2 test. The statistical significance (p) was set at 0.05.

Results

During the study period, 226 pregnant women in the first trimester of pregnancy were included in the study. The age of women varied from 19 to 43 years with a mean of 30.1 ± 4.9 years. Epidemiological parameters of our population are represented in Table 1.

The mean birth weight (BW) of newborns was 3378.9 ± 667.6 g. Fetal macrosomia was observed in 22.1% of cases (50/226). 14.6% (33/226) of newborns have a low birth weight. The rate of caesarean deliveries was 39.4%.

We found a significant correlation between maternal age and birth weight (p=0.05) (Table 1). The rate of overweight and obesity was high in our population. In fact, 68.1% of pregnant women had a BMI ≥ 25 kg/m^2 (of which 31.4% obese) (Table 2).

Our study identified pre-pregnancy BMI as an independent factor and significantly correlated to birth weight (Table 2). Also, parity, pre-gestational weight and pregnancy term were the most correlated factors to birth weight with a correlation coefficient (r) of 0.22; 0.30 et 0.50 respectively (p<0.0001) (Table 1).

The study of daily food intakes showed an average daily caloric intake of (1831.3 ± 832.7 kcal/day, 2202.9 ± 852.7 kcal/day, 2096.2 ± 750.0 kcal/day), respectively in the three trimesters of pregnancy (Table 3). This is in concordance with insufficient daily intakes of trace elements.

Parameter	Mean[a]	Minimum	Maximum	r	p
Age (years)	30.1 ± 4.9	19.2	42.9	0.13	**0.05**
Parity	1.0 ± 1.0	0.0	4.0	0.22	**<0.0001**
Initial Weight (kg)	72.4 ± 13.8	45.0	114.0	0.30	**<0.0001**
Height (m)	1.6 ± 0.0	1.4	1.7	0.10	0.12
Pre-pregnancy BMI (kg/m^2)	27.8 ± 5.2	16.5	46.9	0.27	**<0.0001**
Term (SA)	38.9 ± 1.8	32.0	43.0	0.50	**<0.0001**

r: correlation coefficient; p: Degree of statistical significance
[a] Results are expressed as mean ± SD

Table 1: Epidemiological characteristics of pregnant women and their correlation with birth weight (univariate analysis).

Pre-pregnancy BMI (kg/m^2)	Effective	(%)	r	p
<18.5	4	1.8	-0.36	0.71
[18.5-24.9]	68	30.1	0.34	**0.004**
[25-29.9]	83	36.7	0.13	0.25
≥ 30	71	31.4	0.31	**0.007**

BMI: Body Mass Index; r: Correlation Coefficient; p: Degree of Statistical Significance

Table 2: Body mass index in the study population and its correlation to birth weight.

Macronutrients	Average intake[a] (g/j)			ANC[b]			Correlation coefficient (r)			p		
Trimesters	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
AETQ (kcal/j)	**1831.3 ± 832.7**	2202.9 ± 852.7	**2096.2 ± 750.0**	2000	2100-2200	2500	**0.17**	0.05	**0.13**	**0.009**	0.45	**0.04**
Protein Intake (g/j)	37.0 ± 11.8	36.5 ± 9.1	36.8 ± 9.4	47	52	61	-3.9	-0.06	0.05	0.99	0.33	0.44
Carbohydrate intake (g/j)	157.0 ± 27.0	157.4± 26.2	156.5 ± 25.9	250	250	300	0.007	-0.05	-0.02	0.91	0.44	0.76
Fat intake (g/j)	25.7 ± 10.4	25.7 ± 10.9	26.0 ± 10.4	80	80	80	-0.02	0.06	0.01	0.68	0.32	0.87

AETQ: Average Daily Energy Intake
a Results are expressed as mean ± SD
b Values are expressed as mean

Table 3: Average daily intakes of macronutrients in the population and their correlation to birth weight.

Element	Average intake[a] (mg/j)			ANC[b] (mg/j)			Correlation coefficient (r)			p		
Trimesters	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
Iron	9.3 ± 5.3	11.8 ± 6.9	11.1 ± 6.2	20-30	20-30	30	0.11	0.003	0.05	0.11	0.96	0.48
Magnesium	**202.5 ± 101.8**	257.2 ± 145.4	242.3 ± 121.3	400	400	400	**0.16**	-0.04	0.09	**0.02**	0.59	0.19
Zinc	7.5 ± 4.6	8.5 ± 4.5	8.3 ± 4.8	14	14	14	0.06	0.01	0.10	0.34	0.87	0.12
Calcium	493.1 ± 280.9	583.6 ± 286.0	**559.4 ± 269.5**	1000	1000	1000	0.09	0.04	**0.12**	0.18	0.57	0.06
Vitamin B9	**210.3 ± 122.1**	259.9 ± 140.7	**343.0 ± 148.8**	400	400	400	**0.12**	-0.07	**0.19**	0.07	0.27	**0.004**
Viatmin B1	**0.9 ± 0.5**	1.1 ± 0.5	1.0 ± 0.5	1.8	1.8	1.8	**0.11**	-0.07	0.09	0.09	0.31	0.20
Vitamin C	115.4 ± 111.2	135.2 ± 123.1	132.4 ± 118.3	120	120	120	0.06	-0.10	0.09	0.38	0.12	0.15
Vitamin E	5.0 ± 4.0	5.8 ± 4.8	5.9 ± 4.6	12	12	12	0.01	-0.05	0.06	0.84	0.49	0.40

a Results are expressed as mean ± SD
b Values are expressed as mean

Table 4: Correlation between trace elements intakes and birth weight.

In fact, daily intakes of iron in the three trimesters of pregnancy of our population were clearly lower than ANC. This deficiency was also noticed for the average daily intakes of calcium, zinc and magnesium, which were much lower than the ANC (Table 4).

In contrast, compared to other trace elements, we found a positive but not significant correlation between zinc intakes of the third trimester of pregnancy and birth weight (r=0.10; p=0.12). For magnesium, we found a positive and significant correlation between the intakes of the first trimester of pregnancy and birth weight (r=0.16; p=0.02). Concerning calcium, a positive but not significant correlation was noted between the intakes of the third trimester of pregnancy and birth weight (r=0.12; p=0.06) (Table 4).

Intakes of vitamin C corresponded to the ANC. On the other side, daily intakes of vitamin E in the three trimesters of pregnancy of our population were less than ANC. However, we found a positive but not significant correlation between the intakes of vitamin B1 (r=0.11; p=0.09) and birth weight in the first trimester of pregnancy. Our results showed a positive but not significant correlation in the first trimester (r=0.12; p=0.07) and a significant one in the third trimester (r=0.19; p=0.004) between folate intakes and birth weight (Table 4).

Discussion

There is a wide range of data which support the concept that micronutrients deficiencies adversely affect maternal health and pregnancy outcomes. It is important to highlight here that no micronutrient is alone responsible for these results. It is therefore very unlikely that the supplementation or the isolated correction of a deficiency causes important effects as long as the others remain.

This study allowed highlighting a net deficiency in trace elements intakes in our population compared to the ANC and an unsatisfactory average daily calorie intakes in the 1st and 3rd trimesters of pregnancy (1831.3 ± 832.7 Kcal/day; 2096.2 ± 750.0 Kcal/day), respectively. This carentiel state contrasts with a frequent overweight (68.1%).

In literature, martial deficiency and its influence on fetal weight and the pregnancy outcome were the most studied [21]. This is a global problem affecting both developing and developed countries. Indeed, according to a French study, more than two thirds of pregnant women have total depletion of iron reserves; leading to iron deficiency anemia in late pregnancy in 20 to 30% of them [21]. It is the same for our population, for whom daily iron intakes (9.3 ± 5.3 mg/j; 11.8 ± 6.9 mg/j; 11.1 ± 6.2 mg/j) respectively in the three trimesters of pregnancy are much lower than the ANC. Our study did not demonstrate a significant correlation between iron intakes and birth weight. This confirms the results of studies already published which did not show a significant effect of these intakes on birth weight, both at the first second and third trimesters of pregnancy [22,23].

The benefits of iron and folate supplementation was recently summarized in the Cochrane review [24], it appears that despite the reduction of maternal anemia by systematic supplementation, there is no evidence that iron alone or associated with folate is correlated with birth weight or fetal and/or neonatal morbidity. A fortiori, it currently seems that only the extreme values of maternal hemoglobin are associated with a greater risk of fetal hypotrophy [16]. Therefore, a systematic iron supplementation is currently much discussed because of its deleterious effect related to the Fenton/Haber-Weiss reaction and the free radicals it generates [25,26].

Our study showed a positive but not significant correlation between zinc intakes of the third trimester of pregnancy and birth weight (r=0.10; p=0.12); however this trace element plays an important role in the transcription of several proteins indispensable for embryogenesis, cell differentiation and fetal growth [27]. King has listed 41 related publications, including 17 reports a significant correlation between birth weight and various indicators of maternal zinc status. In contrast, these studies have not shown a net beneficial effect of zinc supplementation during pregnancy. Zinc intakes in our population was lower than the ANC, this could be explained by the high rate of overweight in our population; knowing that obese women with an excessive caloric intakes are particularly exposed to a zinc deficiency [28].

The results of studies on the effect of calcium or of its supplementation during pregnancy on birth weight are divergent. In a recent review of literature including ten studies, the majority shows no effect on birth weight and other neonatal parameters [29]. We noticed a positive but not significant correlation between calcium intakes and birth weight (r=0.12; p=0.06). It therefore deserves to be confirmed by wider studies before concluding that it has a direct and independent effect. Studies are concentrating on the effects of calcium on maternal hypertension and eclampsia. For now, no effect of calcium is demonstrated on birth weight [8].

Magnesium intakes in our population were lower than the recommended one; it is close to that observed in France (250 mg/day) [30]. In fact, magnesemia rates are variable depending on the time of pregnancy, it is known as being very low in the third trimester [31]. However, four of the seven supplementation studies included in the Cochrane review, have allowed establishing the relationship between birth weight and magnesium intakes [32]. It seems according to this review that magnesium supplementation allows reducing by 30% the risk of intrauterine growth restriction [31]. In several retrospective studies, they have found that magnesium rates during pregnancy were associated with risk of preeclampsia, preterm and small birth weight [33,34]. This promising association has triggered a number of controlled supplementation studies that have recently been reviewed [34]. The authors of the Cochrane review have concluded that there is not at present, enough evidences to demonstrate that a diet supplemented with magnesium during pregnancy can be beneficial. There are no studies of magnesium supplementation in developing countries, where the deficiency could be more important.

Daily folate intakes in the three trimesters of pregnancy of our population were much lower than the ANC. Our results showed a positive but non-significant correlation in the first trimester (r=0.12; p=0.07) and a significant one in the third trimester (r=0.19; p=0.004) between folate intakes and birth weight. Observational studies have shown associations between a low level of folate in maternal blood and premature births [8]. Rao et al. have then demonstrated that the increase in birth weight is related to the increased concentration of folate in maternal blood. They were able to conclude that the increase in the frequency of consumption of green leafy vegetables measured during the 28th week of gestation is associated with an increase in birth weight [35]. Birth weight increases on average by 141 g between pregnant women who consume green leafy vegetables less than once a week and those who consume them on alternate days.

Vitamins C and E are the two main antioxidant substances of the body; their deficiency would be implicated in the genesis of preeclampsia and intrauterine growth restriction [36,37]. Some studies have shown the positive correlation between maternal status in these two vitamins and birth weight [37,38]; however, these studies are old and of different methodology. Finally, in a recent update of the Cochrane database [37] No significant correlation between supplementation in these vitamins and fetal weight has not been demonstrated. Our results agree with these suggestions.

Finally, it is necessary to underline the difficulty of studies on the link between maternal nutrition and fetal growth; this one depends on maternal nutrition, but also on other factors that are often entangled [38] such as intestinal absorption, endocrine and metabolic state, genetic and environmental factors. However, this study allowed us to show that trace elements intakes of our population are lower than the ANC; this is secondary to an imbalance between quantity and quality of consumed food. This anomaly certainly translates the epidemiological and cultural transition that knows our population characterized by an abandonment of a Mediterranean diet based on vegetables and cereals towards a more energetic diet but less rich in trace elements.

Conclusion

Intakes of trace elements and vitamins in our study population are reduced compared to the ANC. The impact of nutritional status and wealth of food intakes in micronutrients (vitamins and trace elements) of the mother during pregnancy but also during the weeks before conception, on the development and growth of the fetus, is now well established. Thus, promoting quality over quantity to avoid deficiencies in trace elements and vitamins which are harmful to the development and fetal growth is urgently needed. Recent data suggest that maternal nutrition may also play a role on the health of the future adult.

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