

Review

Nutrition in Reproductive Health: Nutritional Conditioning Factors during Pregnancy and Its Impact on Health

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Abstract: During the gestational period, women need to have optimal health to meet fetal requirements for growth and development. Nutrition is one of the most important factors that can ensure a mother's health and also that of their offspring. The role of maternal diet, before and during pregnancy, has been associated with adverse birth outcomes and a worsening of maternal health. Medical conditions that are closely related to dietary intake and may affect women before or during pregnancy have also been associated with the appearance of pathology in a newborn. To date, several studies have been carried out in order to identify the role of diet as a factor associated with child physiological and psychological health, both in the short and long term. Educating mothers regarding the influence of maternal dietary intake during pregnancy on infants' health could represent a simple but effective target for public health policies to improve pregnancy nutrition, and therefore help to avoid newborn diseases through the development.

Keywords: early programming factors; pregnancy; maternal diet; offspring

1. Introduction

A correct diet is essential in order to maintain an adequate nutritional status at all stages of life. During pregnancy, nutritional needs are increased in order to meet fetal requirements. Nutrition plays a fundamental role within the known concept of *early programming factors*, during both the gestational period and the preconception stage. For this reason, it is important to carry out a detailed analysis of lifestyle factors before a woman becomes pregnant in order to identify the factors that may influence her health and, either directly or indirectly, the health of her future baby. It is especially important, both before and during pregnancy, to conduct comprehensive health promotions which focus on the promotion of healthy lifestyles, empowering women to make the decisions needed for the acquisition of safe and healthy eating habits that guarantee a good health result, i.e., "a term pregnancy with the lowest physical risk and the highest quality of life possible for the pregnant woman and the birth of a healthy baby" [1].

In this article, we assess the influence of a mother's maternal diet and nutritional status, before and during pregnancy, on the appearance of several conditions in their fetus, newborn, and child. Given

the importance of this, as recognized by clinical guidelines, the component of nutritional intervention has been incorporated as one of the aspects to be carried out during prenatal and preconception care counseling.

During the care provided to women through primary health care for preconception health, carried out in the year before becoming pregnant, different aspects must be addressed. This care, although it has common components, should be adapted to the reality and needs of each woman. Thus, emphasis should be placed on adopting healthy lifestyles where the basic premises are as follows: maintaining an active lifestyle with adequate physical activity, avoiding alcohol consumption, encouraging smoking cessation, and promoting a balanced diet, among others. Pre-existing conditions, social support available to an expectant mother, and exposure to environmental factors such as atmospheric pollutants (concentrations of polycyclic aromatic hydrocarbons, carbon monoxide, etc.) must be assessed and verified. All of these are risk factors for the baby's health [2].

Preparation is necessary before pregnancy, in addition to the care that is carried out during pregnancy. Adequate antenatal follow-up reduces maternal, fetal, neonatal, and infant morbidity and mortality, up to five years of age [3–6]. Despite the benefits that adequate prenatal care has shown, many women still do not consider their prenatal care. Multiple factors and determinants have been identified, including a low socioeconomic and cultural level, domestic abuse, and excessive burden of their duties within the family that hinder prenatal care attendance [7–9]. Health strategies and policies must implement measures to encourage women to have adequate follow-up after a pregnancy, to ensure good progress of a pregnancy, and to be able to detect any alteration to the normal course of early pregnancy, in order to establish appropriate socio-sanitary measures to minimize any impact on the health of a mother and fetus. This could reduce healthcare costs derived from maternal and child comorbidities and also increase the quality of life for a pregnant woman.

This prenatal care, including preconception care, is not standard for all women because it is not present in all healthcare systems worldwide. The type of follow-up depends on the health provider, the evolution of the pregnancy, and the sociodemographic characteristics of the woman. Antenatal care involves a series of periodic reviews that encompasses prevention, diagnosis, and treatment of those factors that can condition maternal and neonatal morbidity and mortality. There are different guidelines in each country, and even within the same country. For example, in Spain, despite the existence of a practical care guide from the Spanish Society of Gynecology and Obstetrics (SEGO) [10], prenatal care varies among Spanish regions [11,12]. These guidelines are instruments that enable the monitoring to be carried out in a standardized way for each woman. The World Health Organization (WHO) has established several recommendations regarding routine prenatal care for all pregnant women. The purpose of this guide is to reflect and to answer the complex nature of the issues surrounding the practice of prenatal care. Furthermore, these guidelines are aimed at preventing the mortality and morbidity of a mother and fetus and prioritizing the well-being of a mother, in accordance with a human rights-based approach [13]. This guideline addresses various recommendations to be taken into account which include the following: nutritional interventions (food interventions, supplementation with micronutrients and vitamins); maternal evaluation (maternal anemia, asymptomatic bacteriuria, etc.); fetal evaluation (daily estimation of fetal movement, measurement of uterine height, etc.); precaution measures; and some interventions for common physiological symptoms such as leg cramps, nausea, vomiting, heartburn, low back pain, pelvic pain, constipation, varicose veins, and edema. Finally, these guidelines also contain information on specific interventions in health systems to improve the use and quality of prenatal care (perinatal card, midwifery continuity of care, etc.) [13].

2. Nutritional Status of Pregnant Women

The WHO defines nutritional status as the interpretation of information obtained from biochemical, anthropometric, and/or clinical studies used to determine the nutritional status of individuals or populations. Assessment of nutritional status is essential because it allows us to make a diagnosis and, if necessary, to propose treatment. The international approved measure is the body mass index (BMI)

(weight divided by height in meters squared), or the Quetelet index, in reference to the statistician who developed it. For pregnant women, according to the National Academy of Sciences, BMI is classified as follows [14]:

- * Low weight, BMI < 19.8 Kg/m²;
- * Normal, BMI 19.8–26 Kg/m²;
- * Overweight, BMI 26.1–29 Kg/m²;
- * Obesity, BMI > 29 Kg/m².

This BMI classification does not coincide with that of the WHO for the general adult population, although the differences between them are minimal. Thus, for example, the WHO cut-off point for overweight in the adult population is a BMI ≥ 25 Kg/m² [15].

The pregnancy weight gain curve, called Rosso and Mardones, is another resource used in Latin America to guide weight gain during pregnancy. It was designed as an instrument to evaluate the relationship between weight and height at each gestational age based on the perinatal result. The weight/height ratio is expressed as the percentage of the ideal or standard weight according to the BMI. The ideal weight is derived from the adequacy of weight for height in the tables developed for this purpose. The Rosso and Mardones defines categories of maternal nutritional status according to the mother's weight and height [16].

The nutritional status of a pregnant woman measured through BMI has been associated with different adverse maternal and neonatal outcomes. Nevertheless, it is important to note that the nutritional state of a mother influences offspring results, even before a woman becomes pregnant. Therefore, it is convenient to monitor preconception nutritional status and carry out necessary interventions so that a woman begins a pregnancy with an adequate nutritional status, preventing the possible appearance of maternal and neonatal conditions from the beginning.

Weight gain during pregnancy is another measure considered for assessing the nutritional status of a pregnant woman. This is a measure to assess the well-being of a pregnant woman and the fetus. When weight gain is insufficient or excessive, it represents a significant risk of certain maternal and fetal diseases, both in the short, medium, and long term [17]. For a well-nourished woman, normal weight gain by late pregnancy ranges from approximately 11 to 16 kg. Weight gain during pregnancy tends to be less, the higher the prepregnancy BMI, and also depends on whether it is a single or twin pregnancy. For a single gestation, the recommendations for weight gain, according to BMI, can be seen in Table 1 [10].

Table 1. Recommendations for weight gain during pregnancy, according to body mass index (BMI).

BMI Classification	Recommended Weight Gain for Single Gestation	Recommended Weight Gain for Twin Pregnancy
With a normal weight (BMI: 18.5 and 24.9 kg/m ²)	Between 11.5 and 16 kg	Between 16.8 and 24.5 kg
Overweight (BMI: 25 and 29.9 kg/m ²)	Between 7 and 12.5 kg	Between 14.1 and 22.7 kg
With obesity (BMI ≥ 30 kg/m ²)	Between 5 and 9 kg	Between 11 and 19.1 kg

Dietary evaluation and nutritional education of a pregnant woman should be routine practices incorporated into obstetric clinics as tools to improve health during pregnancy and puerperium. Accordingly, it is essential to know the preconception weight and height and monitor the BMI/gestational age according to the curve at each scheduled consultation. Likewise, evaluation of dietary practices is highly advisable to detect harmful and inadvisable dietary habits that should be modified to improve the nutritional status of women and children [18].

3. Effects of Nutritional Status of Pregnant Women on Maternal Morbidity

During the course of a normal pregnancy, different diseases can appear and influence the normal development of pregnancy. Among these diseases, those noteworthy for their frequency and consequences include gestational diabetes, different hypertensive disorders (preeclampsia, hellp syndrome, etc.), premature rupture of membranes, maternal anemia, liver diseases (such as cholestasis gravidarum), and psychiatric disorders (such as depression and anxiety). These maternal diseases have repercussions on the health and well-being of a fetus, a newborn, and later a child at a physical and psychological level. Some of the offspring pathologies associated with the presence of maternal disease during pregnancy are the following: attention deficit hyperactivity disorder (ADHD); intrauterine growth retardation with several consequences for a baby's physical and psychological health in the short, medium, and long term; liver disease; bone marrow disorders; poor growth; and an increased risk of endocrine, nutritional, and metabolic disorders during adolescence and early adulthood [19–25].

The maternal nutritional status analyzed in terms of nutritional intake, taking into account a deficient or excessive intake of some nutrients, as well as a mother's dietary pattern, BMI, and pregnancy weight gain, has been associated with a higher incidence of diseases during pregnancy and a negative impact on a baby's health. Therefore, maternal diet, nutritional status, or weight gain during pregnancy have an indirect impact on the incidence of disease in babies through an increased risk of disease during pregnancy. Along these lines, the Mediterranean dietary pattern is associated with a lower incidence of gestational diabetes. Considering each of the food groups, a high intake of vegetables prevents the appearance of preeclampsia, and the intake of vegetables, fruits, nuts, legumes, fish and seafood, olive oil, and dairy products has a protective effect against depressive symptoms in pregnant women. As far as micronutrients are concerned, low consumption of nutrients rich in iron content is a risk factor for developing anemia in pregnancy, while a high weight gain during pregnancy represents a greater risk of pre-eclampsia [26–30]. Obesity is also associated with the type of delivery and is a risk factor for non-eutocic delivery with the consequences that this entails for a baby's health [31]. Poor maternal dietary habits contribute to micronutrient deficiencies, despite an increase in energy content. Hence, maternal dietary guidelines emphasize the importance of a varied, balanced, and moderated diet to reduce the risk of diet-related chronic diseases such as the dual burden of malnutrition during pregnancy.

4. Effects of Nutritional Status of Pregnant Women on the Fetus, the Newborn, and the Child

A fetus feeds and receives oxygen through the placenta. Accordingly, the placenta and its correct functioning play a fundamental role in the development of a fetus. Deficits or excess of specific nutrients in a mother have an impact on the fetus. Therefore, mothers need to maintain an adequate nutritional status before and during pregnancy. Some epidemiological studies have shown that poor vascular perfusion on the fetal side of the placenta (related to maternal pathology such as hypertension) is associated with an increased risk of neonatal encephalopathy or a higher incidence of small-for-gestational-age newborns [32,33].

The maternal diet and the nutritional status of a mother, both before and during pregnancy, will condition the state of health and the presence of disease in the fetus, during its intrauterine life and including into adulthood. Deficient nutrient intake during the prenatal stage can play an important role in the programming of multiple organ systems and could increase the general susceptibility to disease in the offspring [34]. There is a significant number of unintended pregnancies; therefore, women of reproductive age should maintain an adequate intake of nutrients and a correct nutritional status. Health professionals must influence the need for an adequate diet for the entire population, but with special emphasis on women of reproductive age.

Excess weight in a mother has been associated with a higher heart rate and less variability during the fetal stage. This has also been associated with the appearance of chronic diseases that begin in early childhood and that have serious consequences in adulthood such as childhood obesity, cancer, type 2 diabetes, increased cardiovascular risk, atypical neurological development, increased risk of psychiatric

disorders (cognitive impairment, autism spectrum disorders, ADHD), cerebral palsy, anxiety and depression, schizophrenia, and eating disorders [35–42].

Insufficient weight gain during pregnancy, or a low BMI, has also been associated with an increased risk of perinatal death and severe neonatal morbidity [43]. For all these reasons, it is essential to highlight the importance for pregnant women to maintain an adequate nutritional status within the recommended parameters, avoiding not only excess but also deficient weight.

The most studied effects, in terms of their association with BMI or weight gain during pregnancy, are a small-for-gestational-age newborn, low birth weight newborn, and a preterm newborn. These three circumstances carry serious consequences for the health of a child in the short, medium, and long term, i.e., growth disorders, adrenarche, intellectual and neurological disorders (cognitive disorders, hyperactivity, lower professional level, etc.) and metabolic consequences [44–47]. Insufficient BMI, or weight gain of a mother during pregnancy, has been associated with a higher incidence of low birth weight newborns, i.e., weighing less than 2500 g, or small for gestational age newborn, i.e., size, head circumference, or birth weight below the 10th percentile, and preterm birth, that is, before 37 weeks of gestation [48–51].

Poor quality of the periconceptional diet is associated with neonatal adverse outcomes such as premature delivery, admission to the neonatal intensive care unit, small for gestational age infants, and low birth weight [52].

During the course of pregnancy, women's dietary habits, dietary pattern, nutrient deficient intake, and supplement intake have also been associated with the risk of fetal, neonatal, and childhood diseases. Greater adherence to a dietary pattern of fast food and sweets before pregnancy increases the chances of birth of a large-for-gestational-age newborn, while greater adherence to vegetables and dairy decreases the chances of premature delivery [53]. A higher prevalence of maternal nutritional deficiencies, a lower dietary diversity score, and consumption of a smaller variety of dairy products, have been significantly associated with a lower risk of having a small-for-gestational-age newborn [54].

Many nutrients have been investigated and associated with different conditions in a baby. For example, adequate consumption of folates, vegetables (green leafy), and folic acid supplements reduce the risk of developing neural tube defects, such as spina bifida, and decrease the incidence of small-for-gestational-age newborns [55–57]. A moderate intake of fish, high adherence to the Mediterranean diet pattern, consumption of olive oil, and intake of specific vitamins (A, D, B1, B3, B6, B9 and B12), and iron supplements reduce the risk of preterm delivery. It is debatable whether supplementation with n-3 LCPUFA during pregnancy or lactation can reduce allergic disease in children. Starch consumption has been differentially associated with childhood phenotypes, with a lower risk of wheezing, but a higher risk of eczema. High consumption of fish during pregnancy also seems to prevent the appearance of childhood eczema. Nut consumption during early pregnancy is associated with long-term childhood neuropsychological development. A maternal diet with significant consumption of pastries during pregnancy, consisting mainly of baked and sugary products, combined with a longer period of breastfeeding, can lead to the development of food allergies, suggesting a harmful effect of trans fat in the baby [58–68]. The maternal diet can even cushion the risk of other risk factors for neonatal pathology [63]. Another dietary pattern that has been fully addressed is maternal plant-based dietary intake. Vegetarian and vegan diets are becoming increasingly popular worldwide, especially among young adults. A recent prospective study carried out by Kesary et al. showed that a maternal vegan diet is a protective factor from excessive weight gain but associated with a higher risk for small-for-gestational-age newborn and lower birth weight centile [69], probably because vegans have been found to be at increased risk for deficiencies in vitamin levels, such as B12 and D, and in micronutrients, such as iron, zinc, iodine, and calcium that could increase this condition [70]. Regarding B12 vitamin, since there is no reliable plant-based food source for B12, several guidelines recommend that vegan women should receive adequate B12 supplementation and nutritional counseling [71]. Regarding vitamin D, and as pregnancy advances, the majority of women display a spontaneous reduction in circulating 25-hydroxyvitamin D (25(OH)D) maternal levels even

in sunny regions [72]. Taking into account the relationship between vitamin D levels and newborn conditions, epidemiological nutritional studies support vitamin D supplementation during pregnancy to improve maternal, fetal, and immediate and later offspring health [73].

5. Nutritional Recommendations for Pregnant Women by Health Professionals

Advising pregnant women about the importance of having a healthy lifestyle that combines a healthy diet and regular physical activity during pregnancy to stay healthy and not excessively gain weight during pregnancy is recommended. It should be remembered that diet during pregnancy must be personalized and adapted to the energy and nutrient needs of each pregnant woman, assuming that these also change during the different trimesters of pregnancy and also after delivery [74].

In undernourished populations, it is necessary to provide nutritional information about the importance of increasing calorie and protein intake in pregnant women to reduce the risk of giving birth to low birthweight neonates.

A healthy diet during pregnancy contains an adequate amount of energy, protein, vitamins, and minerals obtained through the consumption of varied and healthy foods, including vegetables, meat, fish, legumes, nuts, whole grains and fruit [75].

Nutritional counseling and education are key strategies that are used frequently to improve the nutritional status of women during pregnancy. These strategies focus mainly on the following elements: Improving the quality of the maternal diet by increasing the diversity and the amount of healthy food consumed and promoting an adequate weight gain through sufficient and balanced protein and energy intake. Furthermore, it should be noted that the recommendations for healthy foods such as intake of nuts or consumption of fruits (three pieces daily) and vegetables are taken for granted in many cases and are not addressed in depth. Finally, it is necessary to restrict and avoid unhealthy foods such as sweets and processed food rich in saturated fatty acids. Vegan women need to receive adequate B12 supplementation and nutritional counseling.

Available data indicate that nutrition education and counseling can improve pregnancy weight gain, reduce the risk of anemia in late pregnancy, increase birth weight, and reduce the risk of preterm delivery. These interventions may be more effective when women are also given nutritional support, for example, in the form of food supplements or micronutrient supplements. The systematic intake of micronutrient, iron, and multivitamin supplements in all pregnant women is not recommended as it has not been found to be exempt of risks. This advice must be adapted to the real needs of each woman [65,76,77]. However, folic acid supplementation by all pregnant women from the preconception stage for preventing neural tube defects does have support, although it has also been associated with adverse effects during pregnancy [78,79].

The energy cost of an entire pregnancy is approximately 75,000 kcal. Recommendations range from 200 kcal a day, recommended in only the third trimester by British institutions, to an extra 300 kcal daily recommended throughout pregnancy by the WHO. In Spain, pregnant women are recommended to increase their daily intake by 250 kcal/day during the second half of the pregnancy. Logically, these values vary depending on the previous weight of the pregnant woman. The sensible approach is to individualize each case according to BMI at the beginning of pregnancy and physical exercise, adapting the energy supply to the mother's weight gain, and avoiding ketosis.

The actual protein intake in the routine daily diet always exceeds the recommended intakes, which means that there are seldom problems of protein malnutrition, although the development of maternal and fetal tissues, a priori, would require an extra contribution.

During pregnancy, free fatty acids, triglycerides, total cholesterol, and phospholipids increase due to changes in liver and adipose tissue metabolism. These are also used for the formation of maternal and fetal tissues.

In terms of carbohydrates, it is advisable to distribute consumption throughout the day to avoid hypoglycemia. Foods must be rich in complex carbohydrates (starches and fiber) and less than 10% in the form of simple sugars [80].

It would also be advisable to make a series of recommendations regarding hygienic handling of food, precautions to be taken for some foods when cooking, reheating foods, etc. Advice should also include avoiding consuming certain foods during pregnancy such as swordfish, shark, bluefin tuna, raw milk, raw or undercooked meat, raw fish, pâtés sold refrigerated, and packaged sandwiches, etc. [81].

Some basic advice, in a language accessible to the entire population, that can be encouraged and remembered at each consultation is [18] as follows:

- I. Eat in moderation and include a variety of foods with each meal.
- II. Consume milk, yogurt, or cheese every day.
- III. Eat fruits and vegetables of all kinds and colors daily.
- IV. Eat a wide variety of red and white meats while removing visible fat.
- V. Prepare meals with preferably raw vegetable oil and avoid cooking fat.
- VI. Decrease the consumption of sugar and salt.
- VII. Consume a wide variety of bread, cereals, pasta, flours, starches, and legumes.
- VIII. Do not consume alcoholic beverages.
- IX. Drink plenty of drinking water throughout the day.
- X. Take advantage of mealtimes for getting together and chatting with others.

During pregnancy, a balanced and varied diet should be followed based on the recommendations of the nutritional pyramid with some adaptations such as the elimination of alcohol intake, although there are recent studies that associate very moderate alcohol consumption with lower indices of Small for Gestational Age (SGA) newborns [82]. Between four and five meals a day are recommended, with a full breakfast comprising the highest caloric intake of the day (made up of dairy products, fruits, and cereals), a not very abundant midday meal, a dinner a few hours before bedtime (being able to take a piece of fruit or dairy before bed), and avoid snacking between meals. Water consumption should be at least 2–2.5 L a day, and the consumption of foods rich in fats and sugars should be reduced, along with fried foods and salt [83]. Recent evidence, from vitamin D intervention studies and meta-analyses of a large number of studies, support vitamin D supplementation during pregnancy to improve maternal, fetal, and, immediate and long-term offspring health [73]. Informing mothers about all these nutritional aspects is essential to provide them with the education and information needed to make healthier decisions.

6. Conclusions

The maternal diet before and during pregnancy plays a fundamental role in the prevention of certain diseases in a child during early life and also at older ages. The maternal diet has a direct association with the appearance of diseases during pregnancy, and also has an indirect effect by playing an important role in the development of diseases during pregnancy that are associated with subsequent childhood diseases.

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