

# Dietary Fiber Intake and Chronic Diseases Outcome During Pregnancy

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**Abstract.** Pregnancy can cause many complications and chronic diseases. Dietary intervention has been impressed on the prevention and treatment of diseases during pregnancy. Reasonable dietary intake and nutritional fortification can contribute to decrease the risk diseases during pregnancy. Common pregnant diseases are postpartum depression, obesity, and diabetes. This paper is to review the maternal nutrition and the effect of fiber diet in patients with gestational diseases. It is well known that pregnant women require additional nutrition due to a series of alterations in the body's regular metabolic processes following fertilization. In addition to that, nutrition is regarded to be related to weight gain and gestational diabetes, which in turn affects the mental health of pregnant women negatively, hence improving nutritional intake may reduce these complications and their related short- and long-term morbidity. It has synthesized that pregnancy physiological changes may reveal the risk of chronic diseases, including insulin resistance and dyslipidemia as manifestations of diabetes and obesity. Although the direct influence of dietary soluble fiber on intestinal microbiota has been extensively researched, the impact of a high-fiber diet on pregnancy illnesses has yet to be properly investigated. Qualitative analysis shows that dietary fiber benefits to alleviate the impacts where pregnant diseases bring. High fiber dietary can control the calories intake and improve insulin resistant. Furthermore, dietary fiber is thought to be one of the dietary components that might help avoid the development of unfavorable mental health. Therefore, emphasize that the intake of dietary fiber is significantly vital to help improve maternal and child health.

**Keywords:** Nutrition, Fiber, Gestational Diabetes Mellitus, Obesity, Postpartum Depression.

## 1. Introduction

Pregnancy is a crucial period in a woman's life. Maternal health is critical important in pregnancy, whereas with the advancement of society, obesity rates and sedentary lifestyles have increased, as well as other risk factors, women suffering from gestational diabetes mellitus (GDM) are increasing, and their pregnancy outcomes have led to an increase in maternal and child complications. The common complications include postpartum depression, weight gain during pregnancy and obesity, etc. These diseases not only impact women's physical and mental health, but also there are negative influences on infant. For instance, GDM can lead severe pregnancy-induced hypertension syndrome, premature rupture of membranes, polyhydramnios, infant premature delivery, and low weight.

The physiological changes of pregnancy, such as insulin resistance and triglycerides increase, and these changes may indicate the development of pregnant diseases. GDM is mainly due to a series of physiological changes in the mother during pregnancy. Fetus' energy is obtained from the mother through the placenta. The fetus's requirement for glucose rises with gestational age, while the renal plasma flow and glomerular filtration rate both rise during pregnancy. The absorption rate cannot be increased correspondingly, leading to an increase in the amount of sugar excretion in some pregnant women, in addition to that, in the middle and late pregnancy, the substances that antagonize insulin in pregnant women increase, making the sensitivity of the pregnant woman's body to insulin decrease

with the increase in gestational age, making insulin secretion relatively insufficient, which is considered as insulin resistance. For these pregnant women, this physiological change during pregnancy cannot compensate for the increase in blood sugar, which makes the original diabetes aggravate or the appearance of gestational diabetes. Additionally, gestational diabetes during pregnancy may be due to the body's metabolic dysfunction, which can cause sugar to be stored in the human body, hence consuming some foods with high sugar content for a long time will generally increase the risk of GDM.

Pregnancy nutrition is critically vital to maternal and child health. The mother provides most of the nutrients required for fetal growth and development, and pregnant women must also reserve certain nutrients for delivery and nursing. As a result, pregnant women require more nutrition than normal. However, different pregnancy periods require different nutrition, especially protein and energy, due to the fetus's different growth and development paces. To maintain the health of the mother and the baby, it is vital to change the nutrition and diet of pregnant women to adapt to the particular physiology of the mother during pregnancy and to fully meet the diverse nutrient needs of the fetus's growth and development. Dietary and nutrition intervention is a key point to prevent and improve GDM. Though pregnant women are considering increasing their energy intake, mainly carbohydrates and protein, they should also avoid long-term excessive blood sugar, and generally lead to fat accumulation caused by insulin resistance.

Dietary fiber is regarded as a functional food that benefits people's health. One of the causes of diabetes is too little fiber in daily food. Dietary fiber pectin can affect the efficiency of food absorption in the intestine, as well as the rate of glucose absorption, so that the blood sugar will not rise sharply after a meal, which is conducive to the improvement of diabetes. Low glycemic index (LGI) diet is a preferred way to prevent and control diabetes. High-fiber dietary can reduce the secretion of insulin in the physiological range and reduce food intake. In addition to that, high-fiber foods can reduce the need for insulin or general oral hypoglycemic agents in diabetic patients, while still effectively controlling the concentration of blood sugar. Therefore, the long-term increase of dietary fiber can reduce the amount of insulin required and control the metabolism after a meal. It should be used as an auxiliary measure for the treatment of GDM. This article is going to illustrate the effect of fiber on maternal and child health.

## **2. Chronic pregnancy diseases**

It is critical to eat a healthy, diversified diet before and during pregnancy. From conception till birth, pregnancy is a vital period of rapid and deep physiological changes. If don't pay attention to these changes, it is easy to suffer a lot of chronic disease such as gestational weight gain (GWG), gestational diabetes mellitus (GDM), postpartum depression, etc.

### **2.1 Postpartum depression (PPD)**

Postpartum depression (PPD) is a common complication after delivery, and it always plagues many women. Postpartum depression without good treatment can affect the health of the mother and child and even the whole family. Symptoms of postpartum depression often include anxiety, irritability, sleep disturbances and feelings of being overwhelmed. And the incidence rate of PPD is around 15%-30% for most women in the first six months after delivery. Even if depression arises more than four weeks after birth or does not fulfill all the criteria for a major depressive episode, it can still be hazardous to the pregnant mother.

Despite the fact that the exact cause of postpartum depression is unknown, one reason of the mental problem is the decline of reproductive hormones. Other psychosocial and genetic factors are also a major part of the triggers for depression in women giving birth, including inadequate social support, previous abusive situations, marital difficulties, and some negative life event. Apart from that, a meta-analysis indicated that obesity women were more likely to suffered depression than that of women

who had a normal body weight. This point also reinforces the important role of dietary interventions in preventing postpartum depression.

## 2.2 Gestational weight gain (GWG)

According to one study, 68 percent of women gained weight beyond what the Institute of Medicine suggested in 2009. With the obesity epidemic, our research should focus on the need for pregnant women to meet, rather than exceed, standard weight gain goals. This is because of the increased incidence of complications associated with obesity in pregnancy, such as fetal macrosomia, hypertensive disorders of pregnancy, and cesarean delivery, etc. Also, there are risks associated with insufficient gestational weight gain including low birth weight of the baby and inability to breastfeed.

Due to the progressive increase in the prevalence of GWG, prevention of excessive GWG growth in advance is a key factor in ensuring maternal and infant health. Now many women have a desire to improve their health and weight increase during pregnancy is a potentially controllable risk factor, thus the pregnancy period is also seen as the best time to prevent excessive gestational weight gain through dietary interventions or exercise interventions, for example.

## 2.3 Gestational diabetes mellitus (GDM)

GDM is a serious complication of pregnancy. The prevalence of gestational diabetes mellitus (GDM) is gradually increasing as people's lifestyles and dietary structures change, and it has become the most prominent complication of pregnancy. In general, impaired glucose tolerance due to pancreatic beta-cell malfunction in the context of chronic insulin resistance causes this hyperglycemia.

However, the etiology of GDM differs from that of type 1 diabetes mellitus. GDM is a condition in which insulin is inefficient, called insulin resistance, influenced by hormones produced by the placenta, which affects glucose absorption, whereas type 1 diabetes mellitus is due to insulin deficiency. Hyperglycemia in mothers during pregnancy has been reported to not only increase the health risks for women, but also to cause fetal developmental defects. For example, hyperglycemia can lead to abnormal embryonic development or even death, and the incidence of miscarriage can range from 15% to 30%. In addition, type 2 diabetes is more likely to develop in pregnant women, although their glucose metabolism can return to normal after delivery. Therefore, preventing and treating gestational diabetes mellitus is especially important for the mother's and baby's health. And dietary intervention is the main approach that needs to be taken. Here, we present a table to reflect the prevalence of GDM and thus illustrate the need for GDM to be taken seriously.

**Table 1.** Prevalence of GDM for pregnant women in population-based studies in different countries.

| Author of Research | Country | Prevalence of GDM |
|--------------------|---------|-------------------|
| Rosenberg, 2005    | USA     | 3.7% (n= 329,671) |
| Janghorbani, 2006  | UK      | 1.8% (n= 4,942)   |
| Ostlund, 2004      | Sweden  | 1.7% (n=3,616)    |
| Keshavarz, 2005    | Iran    | 4.8% (n=1310)     |
| Al Mahroos, 2005   | Bahrain | 13.3% (n= 10,495) |
| Yang, 2002         | China   | 2.3% (n= 9,471)   |

## 3. The importance of a nutritious diet during pregnancy

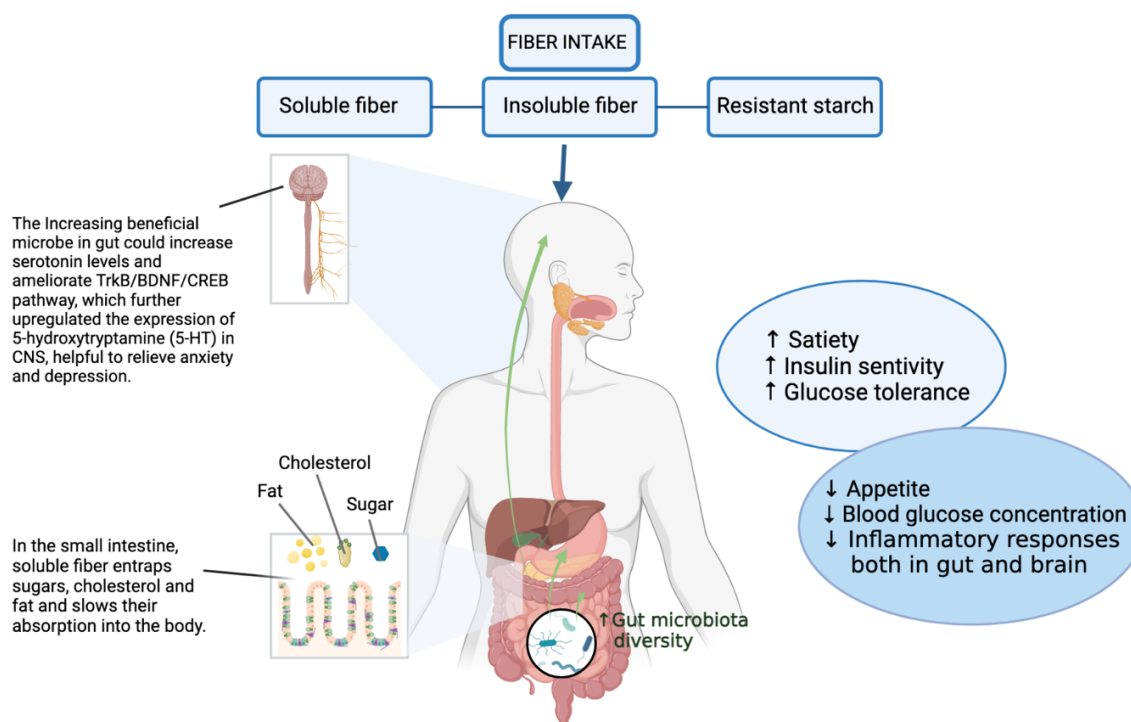
Nutritional inadequacies during pregnancy continue to be a major public health issue, particularly for underdeveloped countries. In recent years, an increasing number of projects have begun large-scale and rigorously designed experimental studies for pregnant women to evaluate the inevitable consequences of macronutrient and micronutrient deficiencies on pregnancy outcomes and to specify the potential influence of dietary interventions on improving these outcomes. Evidence suggests that maternal nutritional consumption at a specific period during pregnancy has a huge impact on the growth of offspring . Of all nutritional needs, chemical energy in the form of carbohydrates, fats, and

proteins is the most important because the energy changes, they provide play a fundamental role in maintaining life. Specifically, from the twelfth week of pregnancy, the total metabolic rate increased from 10 % to 12 %: this increase was due to the energy spent on building new tissues, the additional mechanical work brought to the mother as a result of her weight gain, and the supplementary work of the heart associated with the fetus circulation .

The detrimental health consequences of maternal malnutrition during pregnancy on their children are increasingly recognized, with one of the most undesirable consequences being the activation of many other disorders, giving rise to the "fetal origin of adult diseases" concept . Undernutrition during pregnancy, according to the Developmental Origins of Health and Disease (DOHaD) theory, can affect healthy development and lead to clinical complications on the structure, function, and metabolism of growing offspring. . Exposed to maternal high-fat or high-protein meals throughout gestation leaves a long-lasting metabolism problem on the innate immune system of fetus and the juvenile intestinal microbiota, predisposing the offspring to obesity and metabolic disorders, according to evidence from rodents and humans.. Additionally, high-quality adequate dietary fiber intake can improve the gut bacteria to protect future generations from obesity, diabetes, and other chronic diseases.

#### 4. Fiber intake during pregnancy and impacts on diseases

Fiber is a key macronutrient for both maternal and fetal growth. Dietary fiber is a term that refers to a wide range of carbohydrates derived from plants, and it could not be decomposed by digestive enzymes in human body. Soluble fiber like fruits, vegetables, and legumes, insoluble fiber like nuts, wholegrain bread and cereals, and resistant starch such as cooked potato and rice are the three categories. Raised dietary fiber consumption throughout pregnancy has the potentiality to improve gut microbiome variety, reduce the danger of pre-eclampsia and glucose intolerance, achieve normal gestational weight gain, and prevent puerperal constipation.



**Figure 1.** How fiber works in human body and its physiology mechanism to prevent the chronic diseases

Pregnancy is a decisive duration that experiences profound and rapid physiological changes from conception's time to birth. If don't pay attention to these changes, it is easy to suffer a lot of chronic diseases such as PPD, GWG, GDM, postpartum, etc. Research showed that fiber is an excellent

nutrient to prevent these diseases promoted during pregnancy. According to Figure1, Higher maternal dietary fiber intakes over pregnancy contributes to take precautions against depression, lower glucose intolerance and weight gain over pregnancy, prevent constipation, and increase microbial gut diversity.

#### 4.1 Fiber acts on PPD

It can be seen from the data that approximately 20% of parturient females suffer from a postpartum mood disorder, 7.1% of whom experiencing a major depressing disturbance, up to 19.2% undergoing depression within 3 months of child birth, and 8-12% of postpartum females that go through anxiety dysfunctions, including generalized anxiety and obsessive-compulsive dysfunction.. Dietary fiber has been cited as one of the latent dietary factors which affects the progression of depression. Noteworthy adverse associations have been stressed by Former studies between depressive symptoms and dietary fiber. For example, every 100-g increase in the intake of fruits or vegetables which is full of soluble fibers, the danger of depression drops by 3 %. High intake of dietary fiber contributes to avoid PPD, behavioral disorders like anxiety, as well as cognitive and recollection dysfunctions induced by high fiber diet (HFD). Research shows that dietary fiber might play a regulatory role in some mental diseases by influencing the gut–brain axis. Many evidence demonstrated the fact that intestinal microecology takes a critical position in the growth and working of the central nervous system (CNS). A high-fiber diet can promote the propagation of intestinal epithelial cells, strengthen the intestinal barrier, and improve the integrity of the intestinal tract, thereby preventing the incursion of pathogenic microorganisms, suppressing inflammatory responses, mediating systemic inflammation, and inhibiting neuroinflammation in an indirect way in mice fed HFD. In addition to reduce the impairments of gut barrier, high dietary fiber intake could change intestinal microbiota composition in mice after childbirth. Dietary fiber affects the composition of intestinal microbiome by promoting the variety of intestinal microbiota, impeding the growth of harmful microbes, increasing the beneficial microbe in the gut, such as *Lactobacillus* and *Bifidobacterium* and reducing *Firmicutes/Bacteroides* ratio. The ratio of *Firmicutes/Bacteroides*, *Lactobacillus/Clostridium* and *Lactobacillus/Bacteroides* could increase serotonin levels and guarantee the normal function of TrkB/BDNF/CREB pathway, thus improve the state of the oxidative stress which prevents proteins oxidation, inflammatory factor activation and neuronal damages. Some studies presented HFD feeding induced gestational weight gain, which further brought about the dysregulation of 5-hydroxytryptamine (5-HT) in the CNS, giving rise to PPD and other anxiety-like behavioral disorders. And high intake of dietary fiber has been proved to upregulate the expression of 5-HT and is helpful to relieve anxiety and depression. Besides, microglia are a kind of innate immune cells of the nervous system and prone to induce central nervous system damage. A high-fiber diet helps to inhibit the activation of microglia and protect the CNS. And mechanisms mentioned above to strengthen intestinal barrier, reduce inflammation, protect the nervous system, and resist depression are inseparable with the help of SCFAs fermented by dietary fiber.

#### 4.2 Fiber acts on GWG

There is much research verified that high fiber intake during pregnancy is helpful to control weight. For instance, an experiment showed that after receiving a high dietary fiber intervention, less body weight, fat mass, and more stable body weight maintenance were found in participants at 1 year postpartum. It could be found through meta-analysis that fiber could promote body-weight control via many different physiologic mechanisms. First, foods rich in fibers incline to be more satiating owing to their palatability and relatively lower energy density in comparison with foods that contained not much fiber. A lot of studies revealed that total energy intake and food intake were reduced significantly high-dietary fiber intervention in obese mice. And compared to the low fiber group, much lower abdominal fat pad, mesenteric, and gonadal weight were exhibited in rats fed the resistant cornstarch or the non-fermentable methylcellulose diets. Second, the viscosity would increase under the influence of dietary fiber especially the soluble type, thus slow down the digestion,

which is significant to the release of gastrointestinal hormones and enhance satiety. And the increasing of satiety hormones that causing lessened hunger and lower postprandial insulin and glucose responses could further lipid oxidization and lipolysis over fat storage. Besides, dietary fiber supplies a mechanical barrier to hinder other macronutrients' enzymatic digestion in the small intestine, such as starch and fat's digestion. Owing to that, the slower digestion and decreased absorption efficiency of carbohydrate and fat would be beneficial to a reduced postprandial blood glucose response, which could increase insulin sensitivity and influence the fuel distribution to advance fat oxidization in the long term. Moreover, dietary fiber is an essential substance for commensal bacteria to produce SCFAs acetate, propionate, and butyrate. And these are great to increase energy expenditure and attenuate body weight/fat gain induced by high fat intake. Dietary butyrate supplementation restrains weight gain by attenuating the storage of fat in adipose tissue in animals receiving high fat diets as well. For example, mice sodium supplemented with butyrate presented lower body fat proportions with lower total cholesterol and serum triglyceride levels.

### 4.3 Fiber acts on GDM

During pregnancy, the natural equilibrium of the gut microbiota alters to a more inflammatory state, which may contribute to insulin resistance and finally brings about GDM. In overweight and obese pregnant females, there is a strong bearing shown between their pregnant intestinal microbiota and their maternal metabolic circumstance, evincing an association between the gut microbiota and the insulin level. And this association could not be separated from fiber intake because fiber is a key factor to the composition of gut microbiota. For example, inadequate fiber intake was strongly associated with the genus *Collinsella* meaning that *Collinsella*'s abundance would be high without enough fiber intake and insulin resistance's process may be sped up by high *Collinsella* abundance during pregnancy. According to Holscher, H.D., dietary fiber per kilo-calorie has been proven to be positively related to both *Bifidobacterium* spp. abundances and lactic acid bacteria concentrations. And these kinds of gut microbiota can ferment fiber and produce SCFAs. SCFAs originated from microbial fermentation of dietary fibers was confirmed to be very important to increase insulin sensitivity and glucose tolerance. Some of the wholesome metabolic effects resulting from propionate and butyrate are mediated by de-novo-synthesized glucose via gut epithelium, and these are sensed and regulated in the portal vein and signals through a gut-brain neural circuit, thus increase insulin sensitivity and glucose tolerance. And both insulin levels and blood sugar concentration have decreased in mice fed inulin and SCFAs. In contrast with the mice fed high fat only, mice that received *C. Butyricum* probiotics together with high fat presented reduced fasting serum insulin levels and reduced blood glucose levels at both 30 and 120 min going after a test of intraperitoneal glucose tolerance. The interventions about oral vinegar which contains 4%–8% acetic acid might largely increase the concentration of circulating acetate and accelerate its co-ingestion function with carbohydrates, which seems very effective to decrease glucose levels and insulin resistance.

In general, high dietary fiber intervention is a prospective way to alleviate symptoms, control conditions and prevent the occurrence of depression, obesity, and GDM during pregnancy and postpartum. And there are many mechanics to explain it, the principal one of which is realized by intestinal microbiota affected via fibers. Dietary fiber influences the composition and the diversity of gut microbes, thus promoting the produce of SCFAs which is propitious to increase satiety, insulin sensitivity and glucose tolerance, to decrease appetite, blood glucose concentration and inflammatory responses both in gut and brain. There is still a lack of personalized suggestions for dietary intervention during pregnancy (for example, for special groups such as pregnant women who have suffered from some basic diseases). In the future, we need more measures to improve maternal and infant health during pregnancy.

## 5. Conclusions

Overall, pregnancy is a critical period that requires extra attention, during which the habits of the pregnant women and their dietary structure have a great impact on the health of the baby and even the health of the mother. Especially with the rising standard of living in the world, several chronic diseases are emerging because of changes in diet. This review found that improving dietary structure can also be effective in preventing the development of chronic diseases and promoting maternal and infant health. Specific data and examples for this situation have shown that dietary fiber is a healthy functional food, and that fiber is a key macronutrient for the health of the mother and child. In view of the specific pathogenesis and prevalence of several diseases that may occur during pregnancy, dietary fiber intake during pregnancy is a feasible and effective way to combat these diseases and plays a pivotal role in the overall health status of the mother and the baby. This review highlights the role of fiber intake in promoting maternal and infant health, thus providing some possible ideas for the prevention of some chronic diseases.

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