Low Protein Diets for Pregnant Women and Its Association with Insulin Secretion and Resistance

Jacqueline Zarkos, Daniel Addai, Anna Tolekova

Department of Physiology, Faculty of Medicine, Trakia University, str. Armeyska 11, Stara Zagora 6000, Bulgaria

Abstract

Gestational diabetes mellitus (GDM) complicates 3.5% of pregnancies in England and Wales and continues to show an increase in incidence each year. GDM can lead to diabetes postpartum, it is associated with an increased perinatal risk, and an increase in neonatal mortality. This review article looks at different studies regarding protein diets and their potential effects on GDM. We aimed to determine if a certain protein diet could potentially help protect against GDM using. We found that while a few studies have shown that increasing proteins in the diet of pregnant women, specifically that from poultry, whey, fish, nuts and legumes, may reduce the risk of GDM, there is certainly room for further research on the topic.

Introduction

Gestational diabetes mellitus (GDM) is defined as an impaired glucose tolerance within the onset and duration of pregnancy [1]. Around 3.5% of pregnancies in England and Wales are complicated by GDM [2] and after delivery; a cumulative incidence of diabetes from 2.6% to over 70% in several studies that followed women from 6 weeks to 28 years postpartum was reported, adding to the existing burden of diabetes on the NHS [3]. Furthermore, a pregnancy complicated with GDM is still associated with high perinatal risk and increased neonatal mortality and morbidity [4]. Much research has been undertaken to find potential ways of preventing the insulin resistance that can occur during pregnancy and our review looks at the evidence of low protein diets and its relationship with GDM.

The relationship between pregnancy and hyperglycaemia

GDM, much like the other types of hyperglycaemia, is characterised by a pancreatic β-cell function that is insufficient to meet the pregnant body’s insulin needs [5], [6], [7]. During a normal pregnancy, the growth of the fetus and placenta causes increases in growth hormone, cortisol, estrogen, progesterone, prolactin and human placental lactogen which all result in hyperinsulinemia, insulin resistance, fasting hypoglycaemia and postprandial hyperglycaemia [6], [7], [8], [9]. Subsequently, pancreatic beta cell function adapts to compensate for the decreased insulin sensitivity and the increased requirement [6], [7], [10]. To compensate for the increased insulin levels, peripheral muscle glucose is utilised, however, as gestation advances, these responses become inadequate to meet the demands of the fetus, and consequently, insulin resistance occurs [6], [7].
Adverse Maternal and Fetal Effects

Women with GDM have an increased risk for pregnancy-related morbidity and high risk of developing type 2 diabetes in the years following the pregnancy [3], [13]. Further to this, their offspring have a higher risk of perinatal morbidity and an increased risk of childhood obesity and early onset type 2 diabetes mellitus [13], [22]. Studies have also shown that the risk of spontaneous preterm birth increased with increasing levels of glycemia during pregnancy [16], [17], [18], [19], [21]. Moreover, GDM has been shown to increase the risk of gestational hypertension and preeclampsia [20], [23].

Interestingly, it has been hypothesised that women with decreased insulin sensitivity may increase nutrient availability to the fetus, thus accounting for the possible fetal overgrowth and adiposity, otherwise known as macrosomia, a frequent result of GDM [14], [15], [18]. Another frequent complication for the infant is neonatal hypoglycaemia.

Methods

We searched for articles published in English through PubMed and Embase using the following search phrases: "GDM and protein diets", "GDM and insulin sensitivity" and "insulin sensitivity and protein diets". We included only published articles, from no more than 20 years ago, that have reported protein diets that influenced insulin sensitivity, insulin resistance and insulin levels in both animal and human models. We also included large cohort studies that looked at the incidence of GDM following specific dietary patterns.

Studies on the Effect of High Protein Diets and GDM

One group hypothesised that feeding insulin resistant rats with a high whey protein diet (32%) (HWP) containing whey protein concentrate (WPC) would increase insulin sensitivity compared to a diet containing red meat (RM). They fed rats a high-fat diet (300 g fat/kg diet) for 9 weeks, then changed to a diet containing either 80 or 320 g protein/kg diet, provided by either WPC or RM, for 6 weeks. They found that dietary WPC reduced plasma insulin concentration by 40% (P < 0.05) and increased insulin sensitivity, compared to RM (P < 0.05). Thus, their findings support the idea that an HWP diet is more effective than red meat in increasing insulin sensitivity [24].

Another study tested 57 overweight volunteers with fasting insulin concentrations > 12 mU/L. The participants were fed either a high-protein diet of meat, poultry, and dairy foods (HP diet) or a standard-protein diet low in those foods (SP diet) during 12 weeks. Interestingly, they found that among the volunteers on HP diet, there was significantly (P < 0.03) lowered postprandial glycemic response at weeks 0 and 16 compared to those on the SP diet. They concluded that replacing carbohydrate with protein from meat, poultry, and dairy foods has beneficial effects on glycemic response [25].

One group looked at pregnant patients with polycystic ovarian syndrome on a 1500-calorie/d, high-protein, diet, with 30% of calories as fat and metformin therapy, they found that women taking metformin along with the low-carbohydrate diet may have contributed to reduced development of gestational diabetes [26]. In another study, which included 21,411 pregnancies, they looked at pre-pregnancy low-carbohydrate dietary patterns in these women, and the subsequent incidence of GDM. They documented 867 GDM pregnancies, and their results showed that a prepregnancy low-carbohydrate dietary pattern with high protein and fat from animal sources is associated with an increased GDM risk, whereas a prepregnancy low-carbohydrate dietary pattern with high protein and fat from vegetable sources does not show a risk [27]. Interestingly, another paper also reported that, after adjustment for age, parity, nondietary and dietary factors, and body mass index (BMI), they found that the substitution of red meat with poultry, fish, nuts, or legumes showed a significantly lower risk of GDM [28].

One study examined the associations between dietary patterns and the risk of GDM in 3063 pregnant Chinese women. Their findings suggested that a vegetable-rich diet was associated with a decreased risk of GDM, while the sweets and seafood pattern was associated with an increased risk of GDM. They concluded that a high protein diet did not provide statistically significant findings on preventing GDM [29].

The Australian Longitudinal Study on Women's Health included 3,853 women without pre-existing diabetes who were followed-up between 2003 and 2012. They studied pre-pregnancy dietary patterns with the incidence of GDM. They suggested from their results general dietary recommendations for women of reproductive age, including consumption of a diet rich in vegetables, whole grains, nuts and fish, and low in red and processed meats and snacks [30].

Conclusion

Only a few published papers have studied the effects of a low protein diet on GDM, suggesting the need for further research in this, particularly topic. However, from the studies published, it is clear that selecting the right type of protein i.e. that from...
poultry, whey, fish, nuts and legumes contributes to a reduced risk of GDM and it is important in maintaining a healthy lifestyle during pregnancy. It is also important to note that whilst the majority of studies here did show the benefits of increased protein from sources other than red meat, one study did show that a high protein diet had no significant effects on the risk of GDM.

Furthermore, it is important to discuss that the reasons for the protective effect against GDM may not necessarily be a direct result of increasing the right types of protein in the diet, but may be indirect, by decreasing a woman's consumption of other foods associated with an increased risk of GDM such as carbohydrates and fats [31], [32], [33], [34], [35].

To conclude, while a few studies have shown that increasing proteins in the diet of pregnant women, specifically that from poultry, whey, fish, nuts and legumes, may reduce the risk of GDM, there is certainly room for further research on the topic. Future studies should aim to determine the exact type of protein and their specific quantities using a large sample group of pregnant women that will eventually lead to a recommended diet plan to reduce the risk of GDM.

References

1. McGovern A, Butler L, Jones S, van Vlymen J, Sadek K, Munro N, Carr H, de Lusignan S. Diabetes screening after gestational diabetes in England: a quantitative retrospective cohort study. Br J Gen Pract. 2014; 64(618):e17-23. https://doi.org/10.3399/bjgp14X676410 PMid:24567578 PMCID:PMC3876168

2. Genova M, Atanasova B, Ivanova I, Svinarov D. Trace Elements and Vitamin D in Gestational Diabetes. Acta Medica Bulgarica. 2018; 45(1):45-9. https://doi.org/10.2478/amb-2018-0009

3. Kim C, Newton KM, Knopp RH. Gestational diabetes and the incidence of type 2 diabetes: a systematic review. Diabetes care. 2002; 25(10):1862-8. https://doi.org/10.2337/diacare.25.10.1862 PMid:12351492

4. Nouh F, Omar M, Younis M. Gestational Diabetes Mellitus: Mother and Infancy outcome (Review). Scholars Academic Journal of Biosciences. 2017; 5(11):778-784.

5. Buchanan TA, Xiang A, Kjos SL, Watanabe R. What is gestational diabetes? Diabetes care. 2007; 30(Supplement 2):S105-11. https://doi.org/10.2337/dc07-s201 PMid:17596457

6. Piridiyan G, Benjamin TD. Update on gestational diabetes. Obstetrics and Gynecology Clinics. 2010; 37(2):255-67. https://doi.org/10.1016/j.ogc.2010.02.017 PMid:20685552

7. Setji TL, Brown AJ, Feinglos MN. Gestational diabetes mellitus. Clinical diabetes. 2005; 23(1):17-24. https://doi.org/10.1001/ajcn.2005.0117

8. Soma-Pillay P, Catherine NP, Tolppanen H, Mebazaa A, Tolppanen H, Mebazaa A. Physiological changes in pregnancy. Cardiovascular journal of Africa. 2016; 27(2):89. https://doi.org/10.5830/CVJA-2016-021 PMid:27213856 PMCID:PMC4928162

9. Nadal A, Alonso-Magdalena P, Soriano S, Ropero AB, Quesada I. The role of oestrogens in the adaptation of islets to insulin resistance. The Journal of physiology. 2009; 587(21):S503-7. https://doi.org/10.1113/jphysiol.2009.177188 PMid:19687125 PMCID:PMC2790246

10. Rieck S, Kaestner KH. Expansion of β-cell mass in response to pregnancy. Trends in Endocrinology & Metabolism. 2010; 21(3):151-8. https://doi.org/10.1016/j.tem.2009.11.001 PMid:20015659 PMCID:PMC3627215

11. Zhang H, Zhang J, Pope CF, Crawford LA, Vasavada RC, Jagasia SM, Gannon M. Gestational diabetes mellitus resulting from impaired β-cell compensation in the absence of FoxM1, a novel downstream effector of placental lactogen. Diabetes. 2010; 59(1):143-52. https://doi.org/10.2337/db09-0050 PMid:19833844 PMCID:PMC2797915

12. Fernandez-Morera JL, Rodriguez-Rodero S, Menendez-Torre E, Fraga MF. The possible role of epigenetics in gestational diabetes: cause, consequence, or both. Obstetrics and gynecology international. 2010; 2010.

13. Bener A, Saleh NM, Al-Hamaq A. Prevalence of gestational diabetes and associated maternal and neonatal complications in a fast-developing community: global comparisons. International journal of women's health. 2011; 3:367. https://doi.org/10.2147/WHJ.S201898 PMid:22140323

14. Catalano PM, Kirwan JP, Haulguel-de Mouzon S, King J. Gestational Diabetes and Insulin Resistance: Role in Short-and Long-Term Implications for Mother and Fetus. 2. The Journal of nutrition. 2003; 133(5):16745-83S. https://doi.org/10.1093/jn/133.5.1674S PMid:12730484

15. Catalano PM, McIntyre HD, Cruickshank JK, McCance DR, Dyer AR, Metzger BE, Lowe LP, Trimble ER, Coustan DR, Hadden DR, Persson B. The hyperglycemia and adverse pregnancy outcome study: associations of GDM and obesity with pregnancy outcomes. Diabetes care. 2012;DC111790. https://doi.org/10.2337/dci11-1790

16. Heddderson MM, Ferrara A, Sacks DA. Gestational diabetes mellitus and lesser and longer risk of pregnancy hyperglycaemia: association with increased risk of spontaneous preterm birth. Obstetrics & Gynecology. 2003; 102(4):850-6.

17. Kock K, Kock F, Klein K, Bancher-Todesca D, Helmer H. Diabetes mellitus and the risk of preterm birth with regard to the risk of spontaneous preterm birth. The Journal of Maternal-Fetal & Neonatal Medicine. 2010; 23(9):1004-8. https://doi.org/10.3109/14767050980351392 PMid:20059440

18. Xiong X, Saunders LD, Wang FL, Demianczuk NN. Gestational diabetes mellitus: prevalence, risk factors, maternal and infant outcomes. International Journal of Gynecology & Obstetrics. 2001; 75(3):221-8. https://doi.org/10.1016/S0020-7292(01)00496-9

19. Han Z, Lutsiv O, Mulla S, Rosen A, Beyene J, McDonald SD. Low gestational weight gain and the risk of preterm birth and low birthweight: a systematic review and meta-analyses. Acta obstetricia et gynecologica Scandinavica. 2011; 90(9):935-54. https://doi.org/10.1111/j.1600-0412.2011.01185.x PMid:21623738

20. Ros HS, Cnattingius S, Lipworth L. Comparison of risk factors for preclampsia and gestational hypertension in a population-based study. Journal of American journal of epidemiology. 1998; 147(11):1062-70. https://doi.org/10.1093/aje/kwj009 PMid:9620050

21. Sarkar S, Wattam J, Seigel WM, Schaeffer HA. A prospective controlled study of neonatal morbidity in infants born at 36 weeks or more gestation to Women with diet-controlled gestational diabetes (GDM-class AI). Journal of perinatology. 2003; 23(3):223. https://doi.org/10.1016/s0143-722x(02)54214-4 PMid:12732860

22. Boney CM, Verma A, Tucker R, Vohr BR. Metabolic syndrome in childhood: association with birth weight, maternal obesity, and gestational diabetes mellitus. Pediatrics. 2005; 115(3):e290-6. https://doi.org/10.1542/peds.2004-1803 PMid:15741354

23. Goldman M, Kitzmiller JL, Abrams B, Cowan RM, Laros RK.
Obstetric complications with GDM: effects of maternal weight. Diabetes. 1991; 40(Supplement 2):79-82. https://doi.org/10.2337/diab.40.2.S79 PMid:1748271

24. Belobrajdic DP, McIntosh GH, Owens JA. A high-whey-protein diet reduces body weight gain and alters insulin sensitivity relative to red meat in wistar rats. The Journal of nutrition. 2004; 134(6):1454-8. https://doi.org/10.1093/jn/134.6.1454 PMid:15173411

25. Farnsworth E, Luscombe ND, Noakes M, Wittert G, Argyiou E, Clifton PM. Effect of a high-protein, energy-restricted diet on body composition, glycemic control, and lipid concentrations in overweight and obese hyperinsulinemic men and women. The American journal of clinical nutrition. 2003; 78(1):31-39. https://doi.org/10.1093/ajcn/78.1.31 PMid:12816768

26. Glueck CJ, Wang P, Kobayashi S, Phillips H, Sieve-Smith L. Metformin therapy throughout pregnancy reduces the development of gestational diabetes in women with polycystic ovary syndrome. Fertility and sterility. 2002; 77(3):520-5. https://doi.org/10.1016/S0015-0282(01)03202-2

27. Bao W, Bowers K, Tobias DK, Olsen SF, Chavarro J, Vaag A, Kiely M, Zhang C. Prepregnancy low-carbohydrate dietary pattern and risk of gestational diabetes mellitus: a prospective cohort study. The American journal of clinical nutrition. 2014; 99(6):1378-84. https://doi.org/10.3945/ajcn.113.068296 PMid:24717341 PMCid:PMC4021782

28. Bao W, Bowers K, Tobias DK, Hu FB, Zhang C. Prepregnancy dietary protein intake, major dietary protein sources, and the risk of gestational diabetes mellitus: a prospective cohort study. Diabetes Care. 2013;DC122018. https://doi.org/10.2337/dc12-2018

29. He JR, Yuan MY, Chen NN, Lu JH, Hu CY, Mai WB, Zhang RF, Pan YH, Qiu L, Wu YF, Xiao WQ. Maternal dietary patterns and gestational diabetes mellitus: a large prospective cohort study in China. British Journal of Nutrition. 2015; 113(8):1292-300. https://doi.org/10.1017/S0007114515000707 PMid:25821944

30. Schoenaker DA, Soodamah-Muthu SS, Callaway LK, Mishra GD. Pre-pregnancy dietary patterns and risk of gestational diabetes mellitus: results from an Australian population-based prospective cohort study. Diabetologia. 2015; 58(12):2726-35. https://doi.org/10.1007/s00125-015-3742-1 PMid:26358582

31. Zhang C, Ning Y. Effect of dietary and lifestyle factors on the risk of gestational diabetes: review of epidemiologic evidence. The American journal of clinical nutrition. 2011; 94(Suppl 6):1975S-9S. https://doi.org/10.3945/ajcn.110.001032 PMid:21613563 PMCid:PMC3364079

32. Moses RG, Shand JL, Tapsell LC. The recurrence of gestational diabetes: could dietary differences in fat intake be an explanation? Diabetes care. 1997; 20(11):1647-50. https://doi.org/10.2337/diacare.20.11.1647 PMid:9353601

33. Metzger BE, Coustan DR, Organizing Committee. Summary and recommendations of the fourth international workshop-conference on gestational diabetes mellitus. Diabetes care. 1998; 21:161.

34. Bowers K, Tobias DK, Yeung E, Hu FB, Zhang C. A prospective study of prepregnancy dietary fat intake and risk of gestational diabetes. The American journal of clinical nutrition. 2012; 95(2):446-53. https://doi.org/10.3945/ajcn.111.026294 PMid:22218158 PMCid:PMC3260071

35. Saldana TM, Siega-Riz AM, Adair LS. Effect of macronutrient intake on the development of glucose intolerance during pregnancy. The American journal of clinical nutrition. 2004; 79(3):479-86. https://doi.org/10.1093/ajcn/79.3.479 PMid:14985225

36. Mitanchez D, Burguet A, Simeoni U. Infants born to mothers with gestational diabetes mellitus: mild neonatal effects, a long-term threat to global health. The Journal of pediatrics. 2014; 164(3):445-50. https://doi.org/10.1016/j.jpeds.2013.10.076 PMid:24351686