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Associations of the Dietary Approaches To Stop Hypertension (DASH) Diet with Pregnancy Complications in Project Viva

Aarohee P. Fulay[1], **Sheryl L. Rifas-Shiman**[2], **Emily Oken**[2,3], and **Wei Perng**[1,4]

[1]Department of Nutritional Sciences, University of Michigan School of Public Health, 1415 Washington Heights, Ann Arbor, MI, 41809

[2]The Division of Chronic Disease Research Across the Lifecourse (CoRAL), Department of Population Medicine, Harvard Medical School and Harvard Pilgrim Healthcare Institute, 401 Park Drive, Boston, MA, 02215

[3]Department of Nutrition, Harvard T.H. Chan School of Public Health, Boston, MA, USA, 02215

[4]Department of Epidemiology, University of Michigan School of Public Health, 1415 Washington Heights, Ann Arbor, MI, 41809

Abstract

Background/Objectives—The Dietary Approaches to Stop Hypertension (DASH) diet has been shown to improve cardiometabolic outcomes in non-pregnant populations. Little is known regarding the impact of this diet on health during pregnancy. The objective of this research is to examine associations of adherence to the DASH diet with hypertensive disorders of pregnancy (HDP) and other pregnancy outcomes.

Subjects/Methods—We conducted analyses with data that came from 1,760 women in Project Viva, a Boston-area longitudinal cohort recruited in early pregnancy 1999-2002. We derived a DASH score using data from a food frequency questionnaire (FFQ) administered at median 11.1 weeks gestation. Next, we used multivariable linear regression models that accounted for the woman's age at enrollment, pre-pregnancy body mass index (BMI), education, smoking habits, race/ethnicity, gestational weight gain (GWG) up until the time of the FFQ, and total energy intake to examine associations of the DASH score with HDP, gestational diabetes, preterm delivery (<37 weeks), birth size, and GWG from FFQ to delivery. Models for HDP and GDM were additionally mutually adjusted for each other. Because pre-pregnancy weight status may modify these relationships, we tested for interactions between pre-pregnancy BMI and the DASH score.

Results—Mean±SD age of the women was 32.2±4.9 years; 71.9% were white. Overall, the DASH diet score (mean 24.0, SD 5.0) was not associated with any of the pregnancy outcomes or complications. However, we found a positive association between the DASH diet and subsequent

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Corresponding author: Wei Perng, Department of Nutritional Sciences, Department of Epidemiology, University of Michigan School of Public Health, 1415 Washington Heights, Ann Arbor, MI, 41809, perngwei@umich.edu, Telephone number: 734-647-0623, Fax number: 734-647-5762.

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GWG among women who were obese before pregnancy (0.19 [95% CI: 0.05, 0.34], $P \leq 0.05$; kg higher GWG per 1 unit DASH score).

Conclusions—Adherence to DASH diet during early pregnancy does not appear to be protective against HDP or other adverse pregnancy outcomes.

INTRODUCTION

The Dietary Approaches to Stop Hypertension (DASH) diet – a diet consisting of high consumption of fruits, vegetables, whole grains, and lean proteins; moderate consumption of unsaturated fats; and low consumption of red meats, sweets, saturated fats, trans fats, sugar, and sodium (1) – has been shown to reduce blood pressure (2-12), lower risk of cardiovascular disease risk (13), improve insulin sensitivity (14), and aid in weight loss (15) in non-pregnant populations. Each of these cardiovascular (blood pressure) and metabolic (glycemia, weight status) traits impact a woman's risk for pregnancy complications. For example, pre-pregnancy obesity, excess weight gain during pregnancy, and history of elevated blood pressure are risk factors for hypertensive disorders of pregnancy (16), preterm birth (17), and small-for-gestational age (17, 18); and poor glycemic control is a determinant of gestational diabetes, preterm delivery, and large-for-gestational age (19). Yet, little is known regarding the influence of the DASH diet during pregnancy, an important timeframe for short- and long-term health of both the mother and infant.

Current evidence regarding relations of the DASH diet with complications and/or outcomes of pregnancy consists of a small randomized controlled trial (RCT) (20-22), and an observational study of 15,000 women in the Nurses' Health Study (NHS) II (23). In a series of studies using data from the RCT, conducted among 34 women with gestational diabetes mellitus (GDM), Asemi et al. found that consumption of the DASH diet beginning at 24-28 weeks gestation lowered systolic blood pressure and plasma glucose, and improved lipid profile during the 4-week study period (20, 21). Similarly, analysis of NHS II data revealed that adherence to several healthful dietary patterns, including the DASH diet, prior to pregnancy corresponded with lower risk of GDM (23), although it should be noted that the physiological influence of diet before (as for the NHS II) vs. during pregnancy (as for the RCT in Asemi et al.) may not be comparable. Nevertheless, though these findings suggest a potential beneficial effect of the DASH diet on pregnancy complications, generalizability of the results is limited by the homogenous (e.g., NHS II is predominantly white) and specific (e.g., Asemi et al.'s RCT is comprised of women with GDM) study populations.

In this study, we examined associations of adherence to the DASH dietary pattern during the first trimester of pregnancy with hypertensive disorders of pregnancy and blood pressure in a multi-ethnic cohort of pregnant women (24). In addition, we investigated associations of the DASH diet with other complications and outcomes of pregnancy, including gestational diabetes, gestational weight gain, preterm delivery, and birth size.

MATERIALS AND METHODS

Study population

This study used data from Project Viva, an ongoing cohort of pregnant women and their children. Recruitment has been described elsewhere (25). Briefly, between 1999 and 2002, we recruited pregnant women during their first trimester from multi-specialty practices at Atrius Harvard Vanguard Medical Associates in Massachusetts (25). Eligibility criteria included a singleton pregnancy, <22 weeks of gestation at time of the first clinical visit, planning to reside in the study area until delivery, and ability to complete paperwork in English (25). At enrollment, we collected information from the women on self-reported race/ethnicity, age, education, and parity; household income; lifestyle characteristics during pregnancy; and partner's weight and height. The women also reported their pre-pregnancy weight; in conjunction with measured height, we calculated pre-pregnancy body mass index (BMI; kg/m^2) and used standard weight status criteria to assess weight status (26).

Because this was an exploratory study based on secondary analysis of existing data, we did not perform a formal power analysis. Instead, we selected participants for inclusion in the study based on the following criteria: of the 2,128 women enrolled, we excluded 16 with type 1 or 2 diabetes, followed by 7 missing information on all of the outcomes of interest, and 345 missing information on dietary data from the first trimester food frequency questionnaire (FFQ). The final analytic sample included 1,760 women. All participants provided written informed consent. The institutional review board of Harvard Pilgrim Health Care approved all study protocols; all procedures were conducted in accordance with ethical standards.

Exposure: DASH dietary pattern

The exposure of interest in this study was the DASH dietary pattern. In addition, we also considered the DASH OMNI pattern, which is based on the original DASH diet supplemented by higher unsaturated fat intake (27, 28). The DASH diet is similar to the Mediterranean dietary pattern in that both are rich in fruits, vegetables, legumes, whole grains, and healthy fats, with limited amounts of poultry, red meat, and dairy. A key difference is that the DASH diet focuses on intake of foods high in macro- and micronutrients that have been specifically demonstrated to be effective in reducing risk of hypertension – namely, reduced amounts of saturated fat, total fat, and cholesterol; and high levels of potassium, magnesium, and calcium (~75th percentile of U.S. consumption), along with high amounts of fiber and protein, and no more than 3 g of sodium per day (29).

We derived the two patterns from dietary data ascertained via a semi-quantitative FFQ administered during the at study enrollment (median 11.1 gestational weeks) (25). We focused on FFQ data from the first trimester since diagnoses of pregnancy complications around the time of the second trimester FFQ could affect dietary habits.

The FFQ, which was based on the instrument designed for the Nurses' Health Study and has been validated for pregnancy (25), inquired on frequency of intake and preparation methods of 140 foods since the last menstrual period, ranging from "Never/less than once per month" to "≥1 servings/day" (25, 30). To derive the DASH dietary patterns, we focused on intake of fruits, vegetables, whole grains, nuts/legumes, low-fat dairy, sodium, sugar-sweetened beverages, and red and/or processed meats (Table 1) (13). The DASH OMNI dietary pattern further included frequency of intake of total energy adjusted monounsaturated and polyunsaturated fats, estimated based on the Harvard nutrient composition database (31, 32). These dietary patterns were parameterized as a score, calculated as a weighted sum of frequency of intake/day of the above-mentioned food groups using a two-step process (13). First, we ranked the participants into quintiles of intake of each food group and assigned each individual with a score. Fruits, vegetables, whole grains, nuts/legumes, low-fat dairy, and monounsaturated and polyunsaturated fats (DASH OMNI only) received positive scores for higher intake (1 - lowest quintile of intake to 5 - highest quintile intake), while sodium, sugar-sweetened beverages, and red and/or processed meats were reverse scored (5 - lowest intake quintile to 1 - highest intake quintile). We then summed the scores for each food group for each participant to derive the DASH and DASH OMNI diet scores. For both diets, a higher score denotes greater adherence to the dietary pattern of interest. Score could range from 8-40 for DASH and 9-45 for DASH OMNI (13).

Outcomes: Pregnancy complications and outcomes

Hypertensive Disorders of Pregnancy (HDP) and Blood Pressure—In light of the existing literature regarding the beneficial effect of the DASH diet on blood pressure in non-pregnant populations, primary outcomes of interest in this study were hypertensive disorders of pregnancy (HDP) and third trimester blood pressure.

For HDP, we reviewed outpatient charts for blood pressure and urine protein results and derived a 4-level variable consisting of normotensive, chronic hypertension, gestational hypertension, and preeclampsia (33). We also examined HDP as a dichotomous variable, with women classified as “yes” if they had gestational hypertension or preeclampsia, and “no” if normotensive. We also used the outpatient charts to estimate third trimester blood pressure at 36 weeks gestation – a time during which many women may present with elevated blood pressure but are not likely to be recommended for induction of early labor (34).

For analyses of HDP and third trimester blood pressure, we excluded 24 participants with chronic hypertension (n=24) as these cases of elevated blood pressure existed prior to pregnancy.

Gestational Diabetes Mellitus—We used medical record results from 2-step clinical obstetric screening for gestational diabetes at 26–28 weeks and categorized women as having gestational diabetes mellitus (GDM), impaired glucose tolerance, isolated hyperglycemia, or normoglycemia (35). We also dichotomized this variable as GDM vs. no GDM (including all 3 other groups) for the analysis.

Preterm Delivery—Preterm delivery was defined as delivery prior to 37 weeks of gestation. Gestational age was ascertained by subtracting the date of the woman’s last menstrual cycle from the delivery date. If there was a discrepancy of ≥10 days in gestational age between these two techniques, the gestational age determined from the ultrasound was used (30).

Birth Size—Hospital medical records provided information on infant birthweight. We standardized birthweight into gestational-age and sex-specific values (birth-weight-for-gestational age z-score [BW/GA]) (36). For the analysis, we examined this variable as small-for-gestational age (SGA; <10th percentile of BW/GA), appropriate-for-gestational age (AGA; 10th – 90th percentile; referent), and large-for-gestational age (LGA; ≥90th percentile).

Gestational Weight Gain—We were interested in continuous gestational weight gain (GWG) from the time of the first trimester FFQ to delivery. To derive this variable, we performed linear interpolation between the two measures of weight assessed in closest temporal proximity to the date of FFQ administration and calculated the difference between the last clinically-measured weight prior to self-reported pre-pregnancy weight.

In addition to assessing GWG as an outcome, we also calculated GWG up until the time of the first trimester FFQ for use as a covariate in multivariable models, as it could confound the relationship between diet and subsequent pregnancy complications.

Data analysis

First, we carried out bivariate analysis to examine associations of background characteristics with the two diet scores. These associations, in conjunction with our knowledge of determinants of pregnancy complications, aided in selection of covariates.

For the main analysis, we initially evaluated associations of the diet scores in quartiles to assess for non-linear trends with the outcomes. The relationships were generally linear and monotonic, so we entered the diet scores into the models continuously. For the dichotomous outcomes, HDP, GDM, and preterm delivery, we used logistic regression. For birth size, which was categorized as SGA, AGA, and LGA, we used multinomial logistic regression with AGA as the referent. Across all four outcomes, we used a similar set of models. In Model 1, we adjusted for age at enrollment, race/ethnicity, education level, pre-pregnancy BMI, smoking habits during pregnancy, total energy intake and gestational weight gain up until the time of the first trimester FFQ. We also included GDM in models where HDP was the outcome of interest and vice versa given the high prevalence of co-occurrence of the two conditions (37). Then, in Model 2, we further adjusted for residuals from a model that regressed the DASH or DASH OMNI diet score on the Western and Prudent dietary patterns, two major dietary patterns that are associated with the DASH scores and have themselves been implicated in pregnancy outcomes (38). Use of residuals enabled us to parse out an effect of the DASH diet that is independent of the other two dietary patterns without running into issues of collinearity given the relatively high correlations between both dietary patterns and the two DASH diet scores ($R_{\text{Western vs. DASH}} = -0.45$, $R_{\text{Western vs. DASH OMNI}} = -0.39$; $R_{\text{Prudent vs. DASH}} = 0.47$; $R_{\text{Prudent/DASH OMNI}} = 0.47$).

In addition to investigating associations of the DASH diet with the pregnancy outcomes, we examined relations with GWG from the time of the first trimester FFQ to delivery, as the DASH diet has also been shown to lead to weight loss (15). Here, we included the same series of covariates as previously described for Models 1 above using linear regression. We then further adjusted for HDP (Model 2), GDM (Model 3), and the residuals from DASH regressed on the Western and Prudent dietary patterns (Model 4).

Because pre-pregnancy BMI and race/ethnicity may modify the relationship between diet and the outcomes, we tested for an interaction between both variables and the diet scores. We found evidence of an interaction (*P*-interaction <0.05) between pre-pregnancy BMI and the DASH scores for subsequent gestational weight gain. Thus, we carried stratified analysis within categories of pre-pregnancy weight status (underweight, normal weight, overweight, obese).

Finally, we performed sensitivity analyses. First, in addition to examining HDP and GDM as dichotomous outcomes, we evaluated them as the original 4-level variables using multinomial logistic regression. The results for both outcomes were generally null, so we present findings from the dichotomous variables for simplicity. Second, in addition to examining associations of the diet scores with HDP and GDM while mutually adjusting one condition for the other, we carried out analyses where we excluded participants with HDP from models with GDM as the outcome, vice versa for models where HDP was the outcome; doing so did not materially alter the results. Finally, we ran all models after including parity, which is a known determinant of preeclampsia (39). Including parity did not change the direction, magnitude, or precision of the results, thus was not included in the final models.

All models met standard assumptions for linear regression (linearity of the relationships of interest, multivariate normality, no multicollinearity, no auto-correlation, heteroscedasticity). For assessment of statistical significance in any test or model, we performed two-sided tests with a significance level of alpha <0.05. Because the goal of this study was to examine associations of the DASH diet with several correlated outcomes (rather than to predict the outcomes), we did not account for multiple comparisons.

Code availability

All analyses were performed using the SAS 9.4 (SAS Institute Inc., Cary, NC). SAS programs for this analysis are available by contacting Wei Perng (perngwei@umich.edu).

RESULTS

Mean ± SD age of the women at the time of enrollment was 32.2 ± 4.9 years; 71.9% were white. Median gestational age at the time of dietary assessment was 11.1 weeks (range: 5.0, 33.6).

Table 2 displays the distribution of the DASH and DASH OMNI diet scores, with higher scores of each indicating more healthful diet. In Table 3, we show the mean ± SD of the two diet scores across categories of background characteristics. Older age at enrollment, being white or Asian, being married or cohabiting, having attained a higher education, having a higher annual income, not smoking during pregnancy, lower parity, lower pre-pregnancy BMI, greater GWG up until the time of the FFQ, and engagement in more physical activity before and during pregnancy were each associated with higher scores for the DASH and DASH OMNI dietary patterns.

We did not find any associations of either dietary pattern with HDP, third trimester blood pressure, GDM, preterm delivery, or birth size (Table 4). However, adherence to both dietary patterns corresponded with greater subsequent GWG, an association that was driven by women who were obese prior to pregnancy (Table 5). Among obese women, each 1 unit increment in the DASH diet score was associated with 0.19 (95% CI: 0.05, 0.34) kg higher GWG from the time of dietary assessment to delivery, even after accounting for age, race/ethnicity, education level, pre-pregnancy BMI, smoking habits during pregnancy, previous gestational weight gain, and total energy intake. Likewise, each 1 unit increment in the DASH OMNI score corresponded with 0.20 (95% CI: 0.05, 0.35) kg higher subsequent GWG. These estimates did not change after adjustment for HDP, GDM, or the Western or Prudent dietary patterns (Table 5).

DISCUSSION

In this prospective study of 1,760 pregnant women, adherence to neither the DASH nor the DASH OMNI diet during early pregnancy was associated with risk of hypertensive disorders (HDP), gestational diabetes mellitus (GDM), preterm delivery, or large- or small-for-gestational age. However, higher compliance with both dietary patterns was related to greater gestational weight gain (GWG) among women who were obese prior to pregnancy.

Hypertensive disorders of pregnancy

Despite a wealth of evidence documenting beneficial effects of the DASH diet on blood pressure in non-pregnant populations (3, 7, 11, 40), we are aware of only one study – a RCT of 34 women with GDM – that evaluated its impact during late pregnancy (20). Contrary to findings of Asemi et al. (20), we did not find relations of either DASH dietary pattern during the first trimester with hypertensive disorders or blood pressure during the third trimester. A potential explanation for our null results could be that effects of the DASH diet were masked by other physiological processes during pregnancy that affect blood pressure, such as fluctuations in progesterone, relaxin, estradiol, the renin-angiotensin system (41, 42), and may occur regardless of dietary habits. It is also possible that the timeframe during which we ascertained dietary intake (i.e., during early pregnancy) was too proximal to the outcomes of interest such that the physiological impact of the DASH diet had not yet manifest. Additionally, we cannot rule out confounding by intake of foods that were not captured by the DASH dietary patterns, although accounting for the Prudent and Western dietary patterns did not change our results.

Gestational diabetes mellitus

So far, a few studies have examined the association between the DASH diet and GDM. Izadi et al. carried out a case-control study of 460 pregnant women with (n=200) vs. without GDM (n=260) and found that adherence to the DASH diet anywhere from 5 to 28 weeks of pregnancy was associated with 71% lower risk of GDM (43). Similarly, in the RCT by Asemi et al., women with GDM who were randomized to receive the DASH diet exhibited improved glucose tolerance according to plasma glucose levels at 60, 120, and 180 minutes after an oral glucose load as compared to controls (20). Given that these two studies oversampled women with GDM (e.g., Izadi et al. used a case-control design to match on

GDM status, and Asemi et al. examined effects of the DASH diet only among women with GDM), we may have been underpowered to detect associations given the relatively low prevalence of GDM in Project Viva (~5%). Additionally, we noted the possibility of reverse confounding in Izadi et al.'s study given that the dietary assessment (three 24-hour recalls) was carried out between 5 and 28 weeks of pregnancy and thus, some women may have completed their dietary recalls after GDM diagnosis, which typically occurs at 24-28 gestational weeks.

Preterm delivery & birth size

Published literature on the relationship of the DASH diet with preterm delivery and birth size is scant, but generally indicates a beneficial effect on both outcomes. In a prospective study of 3,143 mother-child pairs in the Pregnancy, Infection, and Nutrition (PIN) study, Martin et al. found an inverse relationship between adherence to the DASH diet and odds of preterm delivery (OR: 0.59 [95% CI: 0.40, 0.85] for women in the 4th vs. 1st quartile of adherence to the DASH score) (44). Our null findings could be related to differences in ethnic composition of the study population. Specifically, the PIN population comprised ~28% Black women, as compared to 12% in our study population. This is noteworthy in light of evidence that the DASH diet leads to a greater decrease in SBP among Black vs. Caucasian adults (45). Accordingly, even though we did not find a significant interaction between race/ethnicity and any of the outcomes, it is possible that the beneficial effects of the DASH diet during pregnancy may be more readily detectable in populations with a larger proportion of Black women.

With respect to birthweight, Asemi et al. found that women with GDM randomized to the DASH diet gave birth to infants who were approximately 600 g lighter than those who received the control diet (3223 vs. 3819 g, $P<0.0001$) (21). However, because a diagnosis of GDM was part of the criteria for inclusion in this trial, there are likely fundamental physiological differences between these women vs. those in Project Viva, the majority of whom were normoglycemic during pregnancy. Future studies in larger, more generalizable populations are warranted to ascertain the potential impact of the DASH diet on these pregnancy outcomes.

Gestational weight gain

We found that adherence to the DASH and DASH OMNI diets was associated with greater subsequent GWG among women who were obese prior to pregnancy. This finding was unexpected given that the DASH diet has been associated with weight loss in non-pregnant populations (15). The fact that we found an association in the opposite direction for obese participants suggests that other factors may underlie our findings, such as hormonal differences during pregnancy or genetic predisposition (15, 46). Alternatively, it is also possible that obese women were more likely to over-report consumption of healthy foods, such as fruits and vegetables, while underreporting intake of unhealthy foods (47-49).

Strengths & limitations

Strengths of this study include the large sample size, use of a validated FFQ to ascertain dietary intake, and prospectively collected data on pregnancy complications and delivery outcomes. Limitations include the observational study design, and potential reporting bias of dietary data. Further, because Project Viva is predominantly white and relatively well-educated, these results may not be generalizable to other populations.

Conclusions

Neither the DASH nor the DASH OMNI dietary patterns were associated with hypertensive disorders of pregnancy, gestational diabetes, preterm delivery or birth size. However, we found a positive association between both diet scores and gestational weight gain in obese women. As this is one of the first studies to look at the impact of the DASH diet on hypertensive disorders of pregnancy, more research needs to be done in this area to confirm our results. In the literature, studies have shown that adherence to other healthy dietary patterns, such as the Mediterranean diet and the alternate Healthy Eating Index, during the perinatal period is beneficial to metabolic health both during (e.g., lower risk of GDM (23); lower blood pressure (50)) and after pregnancy (e.g., lower risk of type 2 diabetes (46)). Given that pregnancy is a time when women not only regularly access the health care system, but may also be more receptive to lifestyle changes, a better understanding of how diet during pregnancy impacts pregnancy outcomes could have measurable impacts on population health.

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References

1. NIH: National Heart L, and Blood Institute. [2017 March 31] Description of the DASH Eating Plan [Website]. Online: NIH. 2015. updated September 16, 2015. Available from: https://www.nhlbi.nih.gov/health/health-topics/topics/dash
2. Svetkey LP, Simons-Morton D, Vollmer WM, Appel LJ, Conlin PR, Ryan DH, et al. Effects of dietary patterns on blood pressure: subgroup analysis of the Dietary Approaches to Stop Hypertension (DASH) randomized clinical trial. Arch Intern Med. 1999; 159(3):285–93. [PubMed: 9989541]
3. Harsha DW, Lin P-H, Obarzanek EVA, Karanja NM, Moore TJ, Caballero B. Dietary Approaches to Stop Hypertension. J Acad Nutr Diet. 1999; 99(8):S35–S9.
4. Moore TJ, Vollmer WM, Appel LJ, Sacks FM, Svetkey LP, Vogt TM, et al. Effect of dietary patterns on ambulatory blood pressure : results from the Dietary Approaches to Stop Hypertension (DASH) Trial. DASH Collaborative Research Group. Hypertension. 1999; 34(3):472–7. [PubMed: 10489396]
5. Sacks FM, Svetkey LP, Vollmer WM, Appel LJ, Bray GA, Harsha D, et al. Effects on blood pressure of reduced dietary sodium and the Dietary Approaches to Stop Hypertension (DASH) diet. DASH-Sodium Collaborative Research Group. N Engl J Med. 2001; 344(1):3–10. [PubMed: 11136953]
6. Bray GA, Vollmer WM, Sacks FM, Obarzanek E, Svetkey LP, Appel LJ, et al. A further subgroup analysis of the effects of the DASH diet and three dietary sodium levels on blood pressure: results of the DASH-Sodium Trial. Am J Cardiol. 2004; 94(2):222–7. [PubMed: 15246908]
7. Al-Solaiman Y, Jesri A, Mountford WK, Lackland DT, Zhao Y, Egan BM. DASH lowers blood pressure in obese hypertensives beyond potassium, magnesium and fibre. J Hum Hypertens. 2010; 24(4):237–46. [PubMed: 19626043]
8. Edwards KM, Wilson KL, Sadja J, Ziegler MG, Mills PJ. Effects on blood pressure and autonomic nervous system function of a 12-week exercise or exercise plus DASH-diet intervention in

individuals with elevated blood pressure. Acta Physiol (Oxf). 2011; 203(3):343–50. [PubMed: 21649862]

9. Hummel SL, Seymour EM, Brook RD, Kolias TJ, Sheth SS, Rosenblum HR, et al. Low-sodium dietary approaches to stop hypertension diet reduces blood pressure, arterial stiffness, and oxidative stress in hypertensive heart failure with preserved ejection fraction. Hypertension. 2012; 60(5): 1200–6. [PubMed: 23033371]
10. Hinderliter AL, Sherwood A, Craighead LW, Lin PH, Watkins L, Babyak MA, et al. The long-term effects of lifestyle change on blood pressure: One-year follow-up of the ENCORE study. Am J Hypertens. 2014; 27(5):734–41. [PubMed: 24084586]
11. Chiu S, Bergeron N, Williams PT, Bray GA, Sutherland B, Krauss RM. Comparison of the DASH (Dietary Approaches to Stop Hypertension) diet and a higher-fat DASH diet on blood pressure and lipids and lipoproteins: a randomized controlled trial. Am J Clin Nutr. 2016; 103(2):341–7. [PubMed: 26718414]
12. Sayer RD, Wright AJ, Chen N, Campbell WW. Dietary Approaches to Stop Hypertension diet retains effectiveness to reduce blood pressure when lean pork is substituted for chicken and fish as the predominant source of protein. Am J Clin Nutr. 2015; 102(2):302–8. [PubMed: 26063693]
13. Fung TT, Chiuve SE, McCullough ML, Rexrode KM, Logroscino GL, Hu FB. Adherence to a DASH-style diet and risk of coronary heart disease and stroke in women. Arch Intern Med. 2008; 168(7):713–20. [PubMed: 18413553]
14. Hinderliter AL, Babyak MA, Sherwood A, Blumenthal JA. The DASH diet and insulin sensitivity. Curr Hypertens Rep. 2011; 13(1):67–73. [PubMed: 21058045]
15. Razavi Zade M, Telkabadi MH, Bahmani F, Salehi B, Farshbaf S, Asemi Z. The effects of DASH diet on weight loss and metabolic status in adults with non-alcoholic fatty liver disease: a randomized clinical trial. Liver Int. 2016; 36(4):563–71. [PubMed: 26503843]
16. Tebeu PM, Foumane P, Mbu R, Fosso G, Biyaga PT, Fomulu JN. Risk Factors for Hypertensive Disorders in Pregnancy: A Report from the Maroua Regional Hospital, Cameroon. Journal of Reproduction & Infertility. 2011; 12(3):227–34. [PubMed: 23926507]
17. Goldenberg RL, Culhane JF, Iams JD, Romero R. Epidemiology and causes of preterm birth. The Lancet. 2008; 371(9606):75–84.
18. Stotland NE, Cheng YW, Hopkins LM, Caughey AB. Gestational Weight Gain and Adverse Neonatal Outcome Among Term Infants. Obstetrics & Gynecology. 2006; 108(3):635–43. [PubMed: 16946225]
19. Buhary BM, Almohareb O, Aljohani N, Alzahrani SH, Elkaissi S, Sherbeeni S, et al. Glycemic control and pregnancy outcomes in patients with diabetes in pregnancy: A retrospective study. Indian Journal of Endocrinology and Metabolism. 2016; 20(4):481–90. [PubMed: 27366714]
20. Asemi Z, Tabassi Z, Samimi M, Fahiminejad T, Esmaillzadeh A. Favourable effects of the Dietary Approaches to Stop Hypertension diet on glucose tolerance and lipid profiles in gestational diabetes: a randomised clinical trial. Br J Nutr. 2013; 109(11):2024–30. [PubMed: 23148885]
21. Asemi Z, Samimi M, Tabassi Z, Esmaillzadeh A. The effect of DASH diet on pregnancy outcomes in gestational diabetes: a randomized controlled clinical trial. European journal of clinical nutrition. 2014; 68(4):490–5. [PubMed: 24424076]
22. Asemi Z, Samimi M, Tabassi Z, Sabihi SS, Esmaillzadeh A. A randomized controlled clinical trial investigating the effect of DASH diet on insulin resistance, inflammation, and oxidative stress in gestational diabetes. Nutrition (Burbank, Los Angeles County, Calif). 2013; 29(4):619–24.
23. Tobias DK, Zhang C, Chavarro J, Bowers K, Rich-Edwards J, Rosner B, et al. Prepregnancy adherence to dietary patterns and lower risk of gestational diabetes mellitus. The American journal of clinical nutrition. 2012; 96(2):289–95. [PubMed: 22760563]
24. Oken E, Baccarelli AA, Gold DR, Kleinman KP, Litonjua AA, De Meo D, et al. Cohort profile: project viva. Int J Epidemiol. 2015; 44(1):37–48. [PubMed: 24639442]
25. Radesky JS, Oken E, Rifas-Shiman SL, Kleinman KP, Rich-Edwards JW, Gillman MW. Diet during early pregnancy and development of gestational diabetes. Paediatr Perinat Epidemiol. 2008; 22(1):47–59. [PubMed: 18173784]
26. World Health Organization. [21/05/2012] BMI Classification. Available from: http://apps.who.int/bmi/index.jsp?introPage=intro_3.html

27. Root MM, Dawson HR. DASH-like diets high in protein or monounsaturated fats improve metabolic syndrome and calculated vascular risk. Int J Vitam Nutr Res. 2013; 83(4):224–31. [PubMed: 25008012]
28. Carey VJ, Bishop L, Charleston J, Conlin P, Erlinger T, Laranjo N, et al. Rationale and design of the Optimal Macro-Nutrient Intake Heart Trial to Prevent Heart Disease (OMNI-Heart). Clin Trials. 2005; 2(6):529–37. [PubMed: 16422313]
29. Appel LJ, Moore TJ, Obarzanek E, Vollmer WM, Svetkey LP, Sacks FM, et al. A clinical trial of the effects of dietary patterns on blood pressure. DASH Collaborative Research Group. The New England journal of medicine. 1997; 336(16):1117–24. [PubMed: 9099655]
30. Oken E, Kleinman KP, Olsen SF, Rich-Edwards JW, Gillman MW. Associations of seafood and elongated n-3 fatty acid intake with fetal growth and length of gestation: results from a US pregnancy cohort. Am J Epidemiol. 2004; 160(8):774–83. [PubMed: 15466500]
31. Hu FB, Stampfer MJ, Manson JE, Rimm E, Colditz GA, Rosner BA, et al. Dietary fat intake and the risk of coronary heart disease in women. N Engl J Med. 1997; 337(21):1491–9. [PubMed: 9366580]
32. Rimm EB, Giovannucci EL, Stampfer MJ, Colditz GA, Litin LB, Willett WC. Reproducibility and validity of an expanded self-administered semiquantitative food frequency questionnaire among male health professionals. Am J Epidemiol. 1992; 135(10):1114–26. discussion 27-36. [PubMed: 1632423]
33. Perng W, Stuart J, Rifas-Shiman SL, Rich-Edwards JW, Stuebe A, Oken E. Preterm birth and long-term maternal cardiovascular health. Ann Epidemiol. 2015; 25(1):40–5. [PubMed: 25459086]
34. National Institute for Health and Clinical Excellence: Guidance. London: 2010. Hypertension in Pregnancy: The Management of Hypertensive Disorders During Pregnancy.
35. Regnault N, Gillman MW, Rifas-Shiman SL, Eggleston E, Oken E. Sex-Specific Associations of Gestational Glucose Tolerance With Childhood Body Composition. Diabetes care. 2013
36. Oken E, Kleinman KP, Rich-Edwards J, Gillman MW. A nearly continuous measure of birth weight for gestational age using a United States national reference. BMC Pediatr. 2003; 3:6. [PubMed: 12848901]
37. Weissgerber TL, Mudd LM. Preeclampsia and diabetes. Curr Diab Rep. 2015; 15(3):9. [PubMed: 25644816]
38. Chen X, Zhao D, Mao X, Xia Y, Baker PN, Zhang H. Maternal Dietary Patterns and Pregnancy Outcome. Nutrients. 2016; 8(6)
39. Eskenazi B, Fenster L, Sidney S. A multivariate analysis of risk factors for preeclampsia. JAMA. 1991; 266(2):237–41. [PubMed: 2056625]
40. Blumenthal JA, Babyak MA, Hinderliter A, Watkins LL, Craighead L, Lin PH, et al. Effects of the DASH diet alone and in combination with exercise and weight loss on blood pressure and cardiovascular biomarkers in men and women with high blood pressure: the ENCORE study. Arch Intern Med. 2010; 170(2):126–35. [PubMed: 20101007]
41. Baker SE, Limberg JK, Ranadive SM, Joyner MJ. Neurovascular control of blood pressure is influenced by aging, sex, and sex hormones. Am J Physiol Regul Integr Comp Physiol. 2016; 311(6):R1271–R5. [PubMed: 27856414]
42. Irani RA, Xia Y. Renin angiotensin signaling in normal pregnancy and preeclampsia. Semin Nephrol. 2011; 31(1):47–58. [PubMed: 21266264]
43. Izadi V, Tehrani H, Haghighatdoost F, Dehghan A, Surkan PJ, Azadbakht L. Adherence to the DASH and Mediterranean diets is associated with decreased risk for gestational diabetes mellitus. Nutrition. 2016; 32(10):1092–6. [PubMed: 27189908]
44. Martin CL, Sotres-Alvarez D, Siega-Riz AM. Maternal Dietary Patterns during the Second Trimester Are Associated with Preterm Birth. J Nutr. 2015; 145(8):1857–64. [PubMed: 26084362]
45. Prather AA, Blumenthal JA, Hinderliter AL, Sherwood A. Ethnic differences in the effects of the DASH diet on nocturnal blood pressure dipping in individuals with high blood pressure. Am J Hypertens. 2011; 24(12):1338–44. [PubMed: 21866183]
46. Tobias DK, Zhang C, Chavarro J, Olsen S, Bao W, Bjerregaard AA, et al. Healthful dietary patterns and long-term weight change among women with a history of gestational diabetes mellitus. Int J Obes (Lond). 2016; 40(11):1748–53. [PubMed: 27569683]

47. Kretsch MJ, Fong AK, Green MW. Behavioral and body size correlates of energy intake underreporting by obese and normal-weight women. J Am Diet Assoc. 1999; 99(3):300–6. quiz 7-8. [PubMed: 10076581]

48. Heitmann BL, Lissner L. Dietary underreporting by obese individuals--is it specific or non-specific? BMJ. 1995; 311(7011):986–9. [PubMed: 7580640]

49. Braam LA, Ocke MC, Bueno-de-Mesquita HB, Seidell JC. Determinants of obesity-related underreporting of energy intake. Am J Epidemiol. 1998; 147(11):1081–6. [PubMed: 9620052]

50. Timmermans S, Steegers-Theunissen RP, Vujkovic M, Bakker R, den Breeijen H, Raat H, et al. Major dietary patterns and blood pressure patterns during pregnancy: the Generation R Study. American journal of obstetrics and gynecology. 2011; 205(4):337.e1–12. [PubMed: 21855845]

Abbreviations

DASH	dietary approaches to stop hypertension
GDM	gestational diabetes mellitus
HDP	hypertensive disorders of pregnancy
RCT	randomized controlled trial
FFQ	food frequency questionnaire
SGA	small-for-gestational age
AGA	appropriate-for-gestational age
LGA	large-for-gestational age
BW/GA	birthweight-for-gestational age z-score
NHS	Nurses’ Health Study

Table 1

Foods and food groups used to calculate the DASH and DASH OMNI diet scores.

Food Group	**Original Food Items**
Fruits	
	Raisins or grapes
	Dried fruit
	Prunes
	Bananas
	Cantaloupe
	Avocado
	Applesauce
	Fresh apples or pears
	Oranges
	Grapefruit
	Strawberries (fresh, frozen, or canned)
	Blueberries (fresh, frozen, or canned)
	Peaches, apricots, or plums (1 fresh, or 1/2 cup canned)
	Apple juice or cider
	Orange juice (with calcium)
	Orange juice
	Grapefruit juice
	Other juice
Vegetables	
	Tomatoes
	Tomato juice
	Tomato sauce
	Salsa, picante, or taco sauce
	String beans
	Broccoli
	Cabbage or cole slaw
	Cauliflower
	Brussels sprouts
	Carrots (raw)
	Carrots (cooked) or carrot juice
	Corn (1 ear or 1/2 cup frozen or canned)
	Peas or lima beans (fresh, frozen or canned)
	Mixed vegetables
	Dark orange (winter) squash
	Eggplant, zucchini, or other summer squash
	Yams or sweet potatoes
	Spinach (cooked)

Food Group	Original Food Items
	Spinach (raw)
	Kale, mustard, or chard greens
	Iceberg or head lettuce
	Romaine or leaf lettuce
	Celery
	Green peppers
	Onions (as a garnish or in a salad)
	Onions (as a vegetable, rings, or soup)
Nuts/Legumes	
	Peanut butter
	Peanuts
	Other nuts
	Tofu or soybeans
	Beans or lentils (baked or dried)
	Peas or lima beans (fresh, frozen or canned)
Low-Fat Dairy	
	Skim milk
	Flavored yogurt
	Plain yogurt
	Cottage or ricotta cheese
Red/processed meats *	
	Bacon
	Beef or pork hot dog
	Processed meats, e.g., sausage, kielbasa, etc.
	Salami, bologna, or other processed meat sandwich
	Hamburger, lean or extra lean
	Hamburger, regular
	Beef, pork, or lamb (as a sandwich or mixed dish)
	Beef or lamb (as a main dish)
	Pork (as a main dish)
Sugar-Sweetened Beverages (SSB) *	
	Coke, Pepsi, or other cola
	Caffeine-Free Coke, Pepsi, or other cola
	Other carbonated beverage, e.g. 7-Up, Ginger Ale
	Hawaiian Punch, lemonade, or other non-carbonated fruit drinks
Whole Grains	
	Dark bread, including wheat pita bread

Food Group	**Original Food Items**
	Brown rice
	Other grains (eg. bulgur, kasha, couscous, etc.)
	Cooked oatmeal/oat bran
	Oat bran (added to food)
	Other bran (added to food)
	Wheat germ
	Hot cereal
	Wheat cereal
Sodium[*]	
Monounsaturated and Polyunsaturated Fats[**]	

[*] Reverse-scored (i.e. lower intake = higher score)

[**] Estimated based on the Harvard nutrient composition database; included in the DASH OMNI pattern only.

Table 2

Distribution of the DASH and DASH OMNI diet scores during the 1st trimester among 1,760 Project Viva women.

	DASH diet score	DASH OMNI diet score
Mean ± SD	24.0 ± 5.0	27.0 ± 4.8
Percentile		
Min	11	12
5th	16	19
25th	21	24
50th	24	27
75th	28	30
95th	32	35
Max	37	41

Table 3

Associations of background characteristics with the DASH and DASH OMNI diet scores during the first trimester among 1,760 Project Viva women.

	N	Mean ± SD DASH score during the 1st trimester			
		DASH	P^c	DASH OMNI	P^c
Age at enrollment			<0.0001		<0.0001
15-24 years	130	20.8 ± 4.4		23.8 ± 4.1	
25-34 years	1124	24.0 ± 4.9		26.9 ± 4.7	
35-44 years	506	25.0 ± 4.9		28.2 ± 4.7	
Race/ethnicity			<0.0001		<0.0001
Black	217	22.7 ± 5.1		25.6 ± 4.8	
Hispanic	115	22.8 ± 5.1		25.5 ± 4.9	
White	1266	24.5 ± 4.9		27.5 ± 4.7	
Asian	99	24.1 ± 4.5		27.0 ± 4.1	
Other	63	22.3 ± 5.3		25.6 ± 5.2	
Marital status			<0.0001		<0.0001
Married/cohabiting	1642	24.3 ± 4.9		27.3 ± 4.7	
Single	117	20.4 ± 4.7		23.5 ± 4.6	
Annual household income[d]			<0.0001		<0.0001
<$20,000	51	21.9 ± 5.1		24.7 ± 5.0	
$20,000 - $39,999	155	22.0 ± 5.2		25.0 ± 4.9	
$40,000 - $69,999	382	23.9 ± 5.0		26.8 ± 4.8	
>$70,000	1049	24.7 ± 4.7		27.7 ± 4.6	
Education			<0.0001		<0.0001
Primary	165	20.9 ± 4.8		23.9 ± 4.6	
Secondary	1031	23.6 ± 4.8		26.6 ± 4.6	
>=College	564	25.9 ± 4.6		28.8 ± 4.5	
Smoking habits			<0.0001		<0.0001
Never	1183	24.4 ± 4.9		27.3 ± 4.7	
Quit before pregnancy	380	24.2 ± 4.9		27.4 ± 4.7	
Smoked in pregnancy	191	21.3 ± 4.8		24.7 ± 4.6	
Parity			<0.0001		0.0002

	N	Mean ± SD DASH score during the 1st trimester			
		DASH	*P*^{c}	DASH OMNI	*P*^{c}
0	867	24.5 ± 5.0		27.4 ± 4.7	
1	622	23.9 ± 4.9		26.9 ± 4.8	
≥2	271	22.9 ± 4.9		26.1 ± 4.6	
Partner’s weight status			0.01		0.06
Not overweight/obese (<25 kg/m^2)	638	24.4 ± 5.1		27.3 ± 4.9	
Overweight/obese (≥25 kg/m^2)	1071	23.8 ± 4.8		26.9 ± 4.7	
Pre-pregnancy BMI			<0.0001		<0.0001
Underweight (<18.5 kg/m^2)	68	24.5 ± 5.6		27.6 ± 5.4	
Normal (18.5-24.9 kg/m^2)	1068	24.5 ± 4.9		27.4 ± 4.7	
Overweight (25.0-29.9 kg/m^2)	376	23.8 ± 4.8		26.8 ± 4.5	
Obese (≥30.0 kg/m^2)	224	22.4 ± 4.9		25.5 ± 4.8	
Gestational weight gain by the time of FFQ			0.02		0.002
Q1 (lowest)	437	23.4 ± 5.1		26.3 ± 4.9	
Q2	437	24.1 ± 5.0		27.1 ± 4.7	
Q3	447	24.6 ± 4.9		27.6 ± 4.6	
Q4 (highest)	428	24.1 ± 4.9		27.2 ± 4.7	
Physical activity before pregnancy			<0.0001		0.0001
Q1 (least)	398	23.0 ± 4.6		26.1 ± 4.4	
Q2	356	24.1 ± 5.1		27.1 ± 4.9	
Q3	448	24.8 ± 4.8		27.8 ± 4.6	
Q4 (most)	415	24.3 ± 5.1		27.2 ± 5.0	
First trimester Prudent dietary pattern			<0.0001		<0.0001
Q1 (lowest adherence)	440	20.7 ± 4.0		23.7 ± 4.0	
Q2	440	23.0 ± 4.5		26.1 ± 4.2	
Q3	440	25.2 ± 4.3		28.2 ± 4.0	
Q4 (highest adherence)	440	27.3 ± 4.5		30.2 ± 4.3	
First trimester Western dietary pattern			<0.0001		<0.0001
Q1 (lowest adherence)	440	26.8 ± 4.7		29.2 ± 4.5	
Q2	440	24.8 ± 4.3		27.8 ± 4.3	

	N	Mean ± SD DASH score during the 1st trimester			
		DASH	***P***[c]	**DASH OMNI**	***P***[c]
Q3	440	23.6 ± 4.4		26.8 ± 4.3	
Q4 (highest adherence)	440	21.0 ± 4.6		24.4 ± 4.6	
History of hypertension before pregnancy			0.49		0.5
Yes	79	23.7 ± 5.1		26.7 ± 4.9	
No	1681	24.1 ± 5.0		25.1 ± 4.8	

[a] Totals may be < 1760 due to missing values.

[b] Estimates are mean ± SD.

[c] Represents a test for linear trend in which the ordinal predictor is entered into the model as a continuous variable, except for race/ethnicity and smoking habits (Wald test).

[d] Reported at enrollment

Table 4

Associations of the DASH and DASH OMNI diet scores with odds of adverse pregnancy outcomes among 1,760 Project Viva women.

	DASH Diet	**DASH OMNI Diet**
	β (95% CI) blood pressure per unit diet score	
Third trimester SBP (mmHg)[a]		
n = 1719		
Model 1	0.07 (-0.04, 0.19)	0.05 (-0.06, 0.17)
Model 2	0.01 (-0.16, 0.18)	0.01 (-0.18, 0.20)
Third trimester DBP (mmHg)[a]		
n = 1719		
Model 1	0.05 (-0.04, 0.14)	0.05 (-0.04, 0.14)
Model 2	0.03 (-0.11, 0.16)	0.03 (-0.11, 0.18)
	OR (95% CI) of each pregnancy outcome per unit diet score	
Hypertensive disorders of pregnancy[a]		
n = 175 vs. 1503		
Model 1	1.00 (0.96, 1.03)	0.99 (0.96, 1.03)
Model 2	0.98 (0.93, 1.04)	0.98 (0.92, 1.04)
Gestational diabetes mellitus		
n = 88 vs. 1613		
Model 1	1.01 (0.96, 1.06)	1.01 (0.96, 1.06)
Model 2	1.01 (0.93, 1.09)	1.01 (0.93, 1.09)
Preterm delivery (<37 vs. ≥37 weeks)		
n = 127 vs. 1616		
Model 1	0.99 (0.95, 1.03)	0.97 (0.93, 1.02)
Model 2	0.96 (0.91, 1.03)	0.96 (0.90, 1.02)
Birth size		
Model 1		
SGA (*n* = 97)	0.97 (0.93, 1.02)	0.97 (0.93, 1.02)
AGA (*n* = 1412)	1.00 (reference)	1.00 (reference)
LGA (*n* = 234)	0.99 (0.96, 1.02)	0.99 (0.96, 1.02)
Model 2		
SGA (*n* = 97)	0.96 (0.89, 1.03)	0.96 (0.88, 1.04)
AGA (*n* = 1412)	1.00 (reference)	1.00 (reference)
LGA (*n* = 234)	0.94 (0.90, 0.99)	0.94 (0.89, 0.99)

[a] Sample for models where blood pressure and HDP are the outcomes of interest excludes 24 cases of chronic hypertension, as this condition was assessed prior to first trimester dietary intake.

Model 1: Adjusted for age, race/ethnicity, education level, pre-pregnancy BMI, smoking habits, gestational weight gain up until time of 1st trimester FFQ, and total energy intake. Models for hypertensive disorders and GDM are mutually adjusted for each other.
Model 2: Model 1 + Western and Prudent dietary patterns

Table 5

Associations of the DASH diet scores with subsequent gestational weight gain (GWG) in Project Viva women according to pre-pregnancy weight status.

	β (95% CI) in subsequent GWG per unit 1st trimester DASH score			
	Underweight **n = 68**	**Normal weight** **n = 1068**	**Overweight** **n = 376**	**Obese** **n = 244**
DASH dietary pattern				
Model 1	-0.08 (-0.23, 0.07)	0.01 (-0.04, 0.07)	0.10 (-0.01, 0.21)	0.19 (0.05, 0.34)
Model 2	-0.06 (-0.21, 0.09)	0.02 (-0.04, 0.07)	0.10 (-0.01, 0.21)	0.17 (0.02, 0.32) *
Model 3	-0.05 (-0.20, 0.10)	0.02 (-0.04, 0.07)	0.11 (0.00, 0.22) *	0.19 (0.04, 0.33) *
Model 4	0.18 (-0.05, 0.40)	-0.01 (-0.09, 0.08)	0.10 (-0.07, 0.27)	0.31 (0.08, 0.53) *
DASH OMNI dietary pattern				
Model 1	-0.12 (-0.28, 0.04)	-0.01 (-0.07, 0.05)	0.10 (-0.02, 0.21)	0.20 (0.05, 0.35) *
Model 2	-0.10 (-0.25, 0.06)	0.00 (-0.06, 0.06)	0.10 (-0.02, 0.22)	0.18 (0.03, 0.33) *
Model 3	-0.08 (-0.24, 0.08)	0.00 (-0.06, 0.05)	0.10 (-0.01, 0.22)	0.19 (0.04, 0.33) *
Model 4	0.16 (-0.08, 0.41)	-0.01 (-0.10, 0.09)	0.11 (-0.07, 0.30)	0.34 (0.09, 0.58) *

Model 1: Adjusted for maternal age, race/ethnicity, maternal education, pre-pregnancy BMI, smoking habits during pregnancy, gestational weight gain up until the 1st trimester FFQ, and total energy intake.

Model 2: Model 1 + hypertensive disorders of pregnancy (yes vs. no).

Model 3: Model 1 + gestational diabetes mellitus (yes vs. no).

Model 4: Model 1 + Western and Prudent dietary patterns.

[*] Indicates statistical significance at $P \leq 0.05$