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Original article

Soft drink consumption and gestational diabetes risk in the SUN project

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SUMMARY

Background & aims: Gestational diabetes mellitus (GDM) prevalence is increasing worldwide. To the best of our knowledge the specific evaluation of soft drink consumption as a risk factor for developing GDM has only been conducted in the Nurses' Health Study II.
Objective: To investigate the incidence of GDM according to soft drink consumption in the SUN project.
Design: The "Seguimiento Universidad de Navarra" (SUN) project is a prospective and dynamic cohort which included data of 3396 women who notified at least one pregnancy between December 1999 and March 2012. A validated 136-item semi-quantitative food frequency questionnaire was used to assess soft drink consumption. Four categories of sugar-sweetened soft drink (SSSD) and diet soft drink (DSD) consumption (servings) were established: rarely or never (<1/month), low (1–3/month), intermediate (>3/month and ≤1/week) and high (≥2/week). Potential confounders were adjusted through non-conditional logistic regression models.
Results: During the follow-up, we identified 172 incident cases of GDM. After adjusting for age, baseline body mass index, family history of diabetes, smoking, total energy intake, physical activity, parity, fast-food consumption, adherence to Mediterranean dietary pattern, alcohol intake, multiple pregnancy, cardiovascular disease/hypertension at baseline, fiber intake, following special diet and snacking, SSSD consumption was significantly associated with an increased risk of incident GDM, with multivariable adjusted odds ratios (OR) of 2.06 (95% confidence interval [CI]: 1.28–3.34) and 1.67 (95% CI: 1.01–2.77) for the high and intermediate categories, respectively, versus the lowest category (p for linear trend: 0.006). Conversely, DSD consumption was not associated with GDM incidence (adjusted OR: 0.82; 95% CI: 0.52–1.31). Additional sensitivity analyses did not change the results.
Conclusion: Higher consumption of SSSDs before pregnancy was an independent risk factor for GDM, however, no association was observed between DSD consumption and GDM risk.

1. Introduction

Gestational diabetes mellitus (GDM), classically defined as glucose metabolic disorder first diagnosed during pregnancy [1], is increasing worldwide. In fact, prevalence has increased by 10–100% in the last 20 years [2]. Increasing age and body mass index (BMI) of pregnant women have contributed to the higher incidence of gestational diabetes. GDM increases risks and adverse outcomes for mothers (i.e., hypertensive disorders associated to pregnancy, and

Abbreviations: BMI, body mass index; CI, confidence intervals; DSD, diet soft drink; FFQ, food frequency questionnaire; GDM, gestational diabetes mellitus; OR, odds ratios; SSSD, sugar-sweetened soft drink; SUN, Seguimiento Universidad de Navarra.

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type 2 diabetes after pregnancy), and their offspring (i.e., neonatal metabolic disorders, macrosomic fetuses, traumatic births, and cesarean and operative vaginal deliveries rates) in short and long term [1,3]. Once GDM is established, interventions on diet, glycaemic control, or pharmacological therapy such as insulin, did not seem to significantly reduce the rates of some unfavorable outcomes [4]. Therefore, it is imperative to identify modifiable risk factors for GDM, such as overweight and dietary habits, in order to prevent these harmful outcomes [5].

Numerous observational studies have associated some dietary factors before pregnancy with GDM incidence. On the one hand, a preventive association between GDM risk and adherence to healthful dietary patterns prior to pregnancy has been reported [6]. On the other hand, several nutritional factors have been seen to increase the risk of developing GDM during pregnancy, such as considerable intakes of animal fat and cholesterol [7], low fiber consumption or dietary choices with high glycaemic load [8], high red and processed meat consumption [9], and fast-food consumption [10]. A recent systematic review summarizes and reinforces these findings [11].

Previous studies have supported that soft drink consumption increases the risk of developing type 2 diabetes [12,13]. However, the specific evaluation of sugar-sweetened beverage (SSB) consumption as a risk factor for developing GDM has only been conducted in the Nurses' Health Study II [14]. The positive association found in that cohort between SSB consumption and the incidence of GDM has never been replicated in any other study, to the best of our knowledge. Hence, we conducted the current analyses to assess whether soft drink consumption increases the risk or not of GDM in the "Seguimiento Universidad de Navarra" (SUN) project [15,16].

2. Materials and methods

2.1. Study population

The SUN project is a prospective, dynamic and multipurpose cohort. The recruitment began in 1999 and it is constantly open. It is completely composed of Spanish university graduates. In summary, a mailed questionnaire regarding dietary habits, lifestyles, and health conditions was used to invite graduates to participate in the study. The voluntary first response to the questionnaire implies informed consent to participate. After the baseline evaluation, information is updated every two years with a follow-up questionnaire. The study protocol was conducted according to the Declaration of Helsinki and it was supported by the Institutional Review Board of the University of Navarra. The design and methods used in the SUN project have been formerly described in detail [15,16].

For the current study, we have analyzed the latest database from December 2015. Out of a total 13,777 women, we included 13,233 women who responded the first questionnaire before March 2013, in order to make sure they would have completed at least the first follow-up questionnaire (2 years to have received first follow-up questionnaire and 9 additional months account for late responses to their questionnaire). Until then, 3555 women reporting pregnancies were identified. Women were not included in the analyses if they reported exceedingly low or high (limits percentile 1 and 99) values for total energy intake ($n = 70$), had been diagnosed with diabetes ($n = 16$) or had previous GDM ($n = 14$). We did not include women who responded that they had GDM in a previous pregnancy due to the fact that they were susceptible to change their dietary pattern and habits to reduce the risk of the diagnosis of GDM again in the next pregnancy. The ultimately available population included 3396 pregnant women (Fig. 1).

2.2. Dietary exposure evaluation

Previously validated and described in detail [17,18]. Semi-quantitative food frequency questionnaire (FFQ) with 136 food items was used to evaluate dietary habits (available at: http://www.unav.edu/departamento/preventiva/infoinvsun). Recently, the validity [19] and reproducibility [20] of this questionnaire have been reevaluated.

Soft drink consumption was assessed with two different items; one for sugar-sweetened soft drinks (SSSDs) and another for diet (sugar-free) soft drinks (DSDs), as previously reported [21,22]. One serving of any soft drink corresponds to 200 mL. Four categories of SSSD and DSD consumption were established: rarely or never (≤1 serving/month), low (1–3 servings/month), intermediate (>1–3 servings/month and ≤1 serving/week) and high (≥2 servings/week).

Nutrient intake was assessed through updated Spanish food composition tables. Nutritional scores were computed with a computer program specifically designed for this objective. Nutrient data bank was updated by a trained nutritionist and dietitian with current food composition tables for Spain [23,24] and Mediterranean diet adherence was assessed using the score proposed by Trichopoulou et al. [25].

2.3. Other non-dietary covariates

First/baseline questionnaire also assessed information on socio-demographic covariates, height, weight (before pregnancy), lifestyle habits (smoking status, physical activity and exercise), and clinical covariates (chronic medication, parity and current pregnancies, cardiovascular disease or hypertension, family history of diabetes). Self-reported anthropometric measurements (weight and BMI) have demonstrated a high validity in a sub sample of this cohort [26]. An independent category was added for women with missing values in smoking (current, former, never smokers, and missing [$n = 74$]). Physical activity and exercise was measured in metabolic equivalent tasks (METs) per week, calculating the usual energy expenditure on each activity multiplied by the time spent in hours per week on each of the activities [27]. It was shown to have an adequate correlation between objective measurements and information from questionnaires in a sub sample of this cohort (Spearman coefficient of 0.51 [$p = 0.002$] [28]).

2.4. Assessment of GDM

The variable of interest was GDM incidence. Pregnant women who reported a new diagnosis of GDM in the biennial questionnaire were considered possible incident cases of GDM. At that time, we posted an additional questionnaire to these participants, requesting their medical reports with written confirmation and date of the diagnosis. Besides, this additional questionnaire also asked about a prior diagnosis of glucose intolerance, the highest fasting glucose check, the first glycated hemoglobin value in the pregnancy, the results of the oral glucose tolerance test, and the need of insulin in the pregnancy. Then, a set of medical doctors classify each woman as a case of GDM or not. For these analyses, we only worked with confirmed cases (80% of the initially possible cases).

There are no universally standardized diagnostic criteria for GDM [29] and, therefore, many different protocols are used worldwide [30]. The most common diagnosis criteria for GDM in Spain are those that follow a 2 step approach during 24–28 gestational weeks using the cutoffs of Carpenter and Coustan [31], or the cutoffs from the National Diabetes Data Group [32], after a positive 100-g oral glucose tolerance test.

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