ORIGINAL ARTICLE

Influence of carbohydrate intake on oxidative status among women with and without gestational diabetes mellitus

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ABSTRACT

Objective: To identify the influence of carbohydrate (CHO) intake on oxidative status among women with and without gestational diabetes mellitus (GDM).
Materials and methods: A cross-sectional, observational and comparative study was carried out with two groups of 21 women each with and without GDM in the city of Toluca, Mexico, from January to December 2022. The sociodemographic parameters were determined by administering the patients a medical history questionnaire; anthropometric parameters such as body weight and height were measured; and biochemical parameters including total cholesterol (TC) and triglycerides (TG) were calculated. The oxidant/antioxidant status was assessed as follows: malondialdehyde (MDA) as oxidative stress marker; and catalase (CAT), superoxide dismutase (SOD) and total antioxidant capacity (TAC) as antioxidants. Dietary habits were evaluated through a 24-hour reminder in both groups of women to obtain the macronutrient classes, i.e., proteins, fats and CHOs. Based on the total carbohydrates (TCHOs), complex carbohydrates (CCHOs) and simple carbohydrates (SCHOs) such as sucrose were calculated. SCHOs per day were measured using the list of foods with sucrose content per 100 grams according to the Mexican Food Equivalence System (SMAE). The NutriKcal VO program was used for the dietary analysis. Statistical tests such as Student's *t* test and Mann-Whitney *U* test were performed for the independent samples and non-homogeneous variables, respectively, and Spearman's rank correlation coefficient ($p < 0.05$) was determined using the IBM SPSS Statistics V19.
Results: The results showed that the difference between the levels of TC ($p < 0.029$), TG ($p < 0.029$), enzymes CAT ($p < 0.011$) and SOD ($p < 0.013$), as well as MDA ($p < 0.039$), was significantly higher among patients in the group with GDM compared to that in the group without GDM. In addition, the group with GDM consumed a higher proportion of sucrose.
Conclusions: Women with GDM have an imbalance in the oxidant/antioxidant status, influenced by the type of CHO they consume, particularly SCHOs such as sucrose.

Keywords: Carbohydrates; Oxidative Stress; Diabetes, Gestational; Antioxidants; Sucrose (Source: MeSH NLM).

INTRODUCTION

The natural course of pregnancy involves metabolic changes in women [1], characterized by heightened demands for nutrients and oxygen, leading to increased generation of reactive oxygen species (ROS) within maternal and fetal tissues [2]. The balance of these factors typically supports a healthy pregnancy, but their imbalance—together with unfavorable genetic, environmental and nutritional factors—can predispose the onset of gestational diabetes mellitus (GDM) [3]. GDM, akin to type 2 diabetes mellitus (T2DM) and obesity, represents a prevalent global health concern [4]. It manifests as a transient state marked by compromised insulin sensitivity and carbohydrate (CHO) intolerance [5], disrupting glucose homeostasis [6] and inducing maternal hyperglycemia. Maternal hyperglycemia increases glucose autoxidation [7], yielding to the formation of the superoxide radical (O_2), precursor of hydrogen peroxide (H_2O_2) [8], and the subsequent ROS production, thus causing oxidative stress (OS) [9]. As a result, enzymatic antioxidant defenses, including superoxide dismutase (SOD), glutathione peroxidases (GPx) and catalase (CAT), become

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diminished [10]. This imbalance of the oxidant/antioxidant system exacerbates insulin resistance (IR) [11], prompting metabolic and inflammatory disturbances characterized by excessive production of proinflammatory cytokines such as interleukin-1 (IL-1), interleukin-6 (IL-6), tumor necrosis factor alpha (TNF-α), resistin, leptin and adiponectin [12]. Thus, humoral immunity undergoes alteration, bearing harmful consequences for the short- and long-term health of both the mother and fetus [13].

Diet plays a key role, particularly the type and amount of consumed CHOs, which impact on blood glucose levels and control [14]. Elevated intake of SCHOs such as sucrose, table sugar, processed foods and sugar-sweetened beverages [15] during pregnancy contributes to accelerated gestational weight gain, uncontrolled blood glucose and the development of complications including GDM, preeclampsia and preterm delivery [16]. Despite this, the association between CHO consumption—especially sucrose—and its impact on the antioxidant defense system and OS in patients with GDM remains unstudied. Therefore, this study aims to identify the influence of CHO intake on oxidative status among women with and without GDM.

MATERIALS AND METHODS

Study design and population

A cross-sectional, observational and comparative study was carried out at Hospital Materno Perinatal "Mónica Pretelini Sáenz" in Toluca, Mexico, from January to December 2022. A non-probability convenience sampling method was employed. A total of 100 patients who attended medical and nutritional consultations for the first time, referred by their community health centers, were invited to participate. A total of 42 pregnant women agreed to take part in the study, signed the informed consent form and met the inclusion criteria. Two groups were formed: a) group of pregnant women without GDM (Gw/oGDM, *n* = 21) and b) group of pregnant women with GDM (GwGDM, *n* = 21). The inclusion criteria were: age 18–41 years, gestational week (GW) 22 to 34 and pregestational body mass index (BMI) ≤ 30. The presence or absence of GDM was confirmed by a fasting glucose tolerance test performed in the hospital laboratory. American Diabetes Association (ADA) guidelines [17] and fasting plasma glucose ≥ 95 mg/dL were taken into account. The exclusion criteria were: diagnosis of type 1 diabetes mellitus (T1DM) or T2DM prior to pregnancy, hypertension, diseases diagnosed prior to pregnancy, pregestational BMI > 30, age younger than 18 and older than 41 years.

Variables and measurements

Dependent variables: CAT, SOD, total antioxidant capacity (TAC), malondialdehyde (MDA). Independent variable: CHO intake. Sociodemographic independent variables: Age, BMI, GW, education, occupation, marital status.

Once the patients agreed to participate in the study and signed their informed consent form, data were collected through the following methods:

Medical history: Sociodemographic data; family history (FH); personal pathological, non-pathological and obstetric history by direct questioning of each participant.

Anthropometric data: Body weight and height were measured. Weight was measured using a Tanita® scale, model BWB-800A, class III (Tokyo, Japan) and height with a Seca 206 mechanical wall-mounted stadiometer (Hamburg, Germany). These data were employed to calculate the gestational BMI using the following formula: BMI = weight (kg) / height (m^2).

Biochemical data and oxidative and antioxidant markers: Before the consultation, blood glucose, total cholesterol (TC) and triglycerides (TG) tests were performed, with results obtained from the medical consultation record. The sample for oxidative and antioxidant markers was collected during the medical consultation after an 8-hour fast. Standardized hospital personnel collected 5 mL of whole blood in a 6-mL anticoagulant-free Vacutainer® tube, labeled with an identifiable folio number for each participant. The samples were centrifuged at 3,000 rpm for 10 minutes to isolate serum, stored in 1.5 mL microtubes and frozen at –80 °C until further analysis.

Processing of oxidant and antioxidant markers: From the obtained sera, the following parameters were quantified by enzyme-linked immunosorbent assay (ELISA) and according to the supplier's specifications: CAT (EnzyChrom™ Catalase Assay Kit, Cat. No. ECAT-100, California, USA), SOD (EnzyChrom™ Superoxide Dismutase Assay Kit, Cat. No. ESOD-100, California, USA), TAC (QuantiChrom™ Antioxidant Assay Kit, Cat. No. DTAC-100, California, USA) and MDA (QuantiChrom™ TBARS Assay Kit, Cat. No. DTBA-100, California, USA) to determine thiobarbituric acid reactive substances. All kits used in this study were from the commercial brand BioAssay Systems. Sample readings were performed using a BioTek ELx800™ ELISA reader (BioTek Instruments, Friedrichshall, Germany), which operates within an absorbance range of 400 to 750 nm.

Dietary evaluation: Conducted through direct questioning by qualified and trained personnel in nutritional profiling (nutritionists) who are part of the team, using a 24-hour reminder. The amounts of food portions in cups and grams were recorded to categorize them using the Mexican Food Equivalence System (SMAE) [18]. For diet analysis and daily consumption quantification, the NutriKcal VO program [19] was used with the following variables: total kilocalories per day (kcal/day), total carbohydrates (TCHOs), simple carbohydrates (SCHOs), complex carbohydrates (CCHOs), lipids and proteins in grams. For calculating SCHOs per day, the list of foods with sucrose content per 100 grams, used

by the SME, was employed. Foods with high sucrose content were categorized in grams as follows: a) 21 to 40 g sucrose, b) 11 to 20 g sucrose, c) 5 to 10 g sucrose and d) < 5 g sucrose.

Statistical analysis

Data were presented as mean ± standard deviation and median. The normality of the data was assessed using the Shapiro-Wilk test. Differences between homogeneous groups were compared using Student's *t* test for independent samples and Mann-Whitney *U* test for non-homogeneous variables. Spearman correlation analysis was also applied. All analyses were performed with the Statistical Package for the Social Sciences (SPSS, version 19.0; SPSS Inc., Chicago, IL, USA). A *p*-value ≤ 0.05 was considered statistically significant.

Ethical considerations

The study was approved by the Research Ethics Committee of the School of Medicine at Universidad Autónoma del Estado de México and by the Research Committee and Research Ethics Committee of the hospital (Reg. No. 2019-09-652). The authors affirmed their commitment to maintaining confidentiality and protecting the information collected during the research.

RESULTS

Sociodemographic and anthropometric data

The GwGDM showed a significantly higher mean age compared with the Gw/oGDM, as illustrated in Figure 1. In the Gw/oGDM, patients predominantly had basic education, were homemakers, lived in common-law marriages, lived in rural areas and owned their homes. Conversely, patients in the GwGDM had a medium level of education, were also homemakers, lived in rural areas, owned their homes and most were married. The obstetric history of the Gw/oGDM revealed that a high percentage of patients were primiparous, had no history of previous abortions/miscarriages and had no personal history of GDM (PHGDM). In contrast, patients in the GwGDM were multiparous, had no significant history of previous abortions/miscarriages and a small percentage had a PHGDM. Regarding the FH, the GwGDM had a high percentage of T2DM, obesity, hypertension and dyslipidemias compared to the Gw/oGDM (Figure 1).

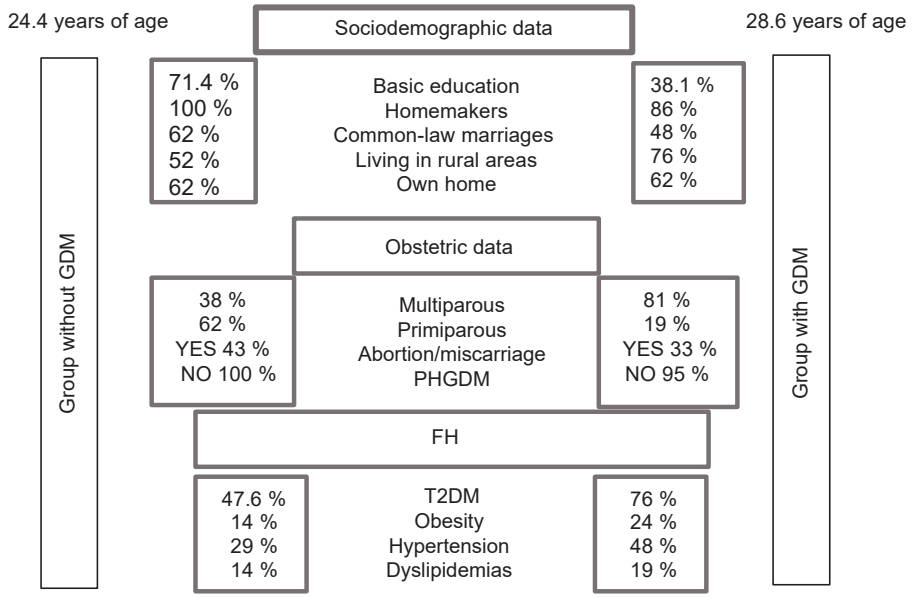

Figure 1. Comparison of sociodemographic data, obstetric data and FH of patients with and without GDM. Data represent the percentage of each group, with *n* = 21 per group of pregnant women with and without GDM.

There were no significant differences in GWs at the diagnosis of GDM between the groups ($p > 0.903$), with a mean of 29 ± 4 weeks for the Gw/oGDM and 30 ± 4 weeks for the GwGDM. However, patients' pregestational and gestational weight, as well as pregestational and gestational BMI, were significantly higher in the GwGDM compared to the Gw/oGDM (Table 1).

Table 1. Anthropometric and biochemical characteristics of pregnant women with and without GDM at Hospital Materno Perinatal "Mónica Pretelini Sáenz"

	Gw/oGDM[a] Mean ± SD (*n* = 21)	GwGDM[b] Mean ± SD (*n* = 21)	*p*-value
Age (years)	24.4 ± 4	28.6 ± 6	0.026*
Pregestational weight (kg)	55.8 ± 7.5	61.5 ± 6.2	0.011*
Gestational weight (kg)	63.4 ± 8	69.5 ± 8	0.020*
Pregestational BMI[c] (kg/m²)	22.5 ± 2.6	26.2 ± 2.6	0.001*
Gestational BMI (kg/m²)	25.6 ± 2.6	29.6 ± 2.6	0.001*
Gestational blood glucose (mg/dL)	76.7 ± 6	121.7 ± 14.3	0.001*
	Median	**Median**	
TC (mg/dL)	210	201	0.039*
TG (mg/dL)	195	221	0.029*

[a] Group without GDM.
[b] Group with GDM.
[c] Body mass index.

The values represent the mean ± SD and median of the anthropometric and biochemical data of pregnant women with and without GDM at Hospital Materno Perinatal "Mónica Pretelini Sáenz." Group comparisons were conducted using Student's *t* test for independent samples and Mann-Whitney *U* test for non-homogeneous data (TC and TG). Differences were considered significant at $p < 0.05$.

Biochemical data

Blood glucose, TC and TG

Blood glucose and TG were significantly elevated in the GwGDM compared to the Gw/oGDM. In contrast, TC concentrations were lower in the Gw/oGDM compared to the GwGDM (Table 1).

Evaluation of oxidant/antioxidant status

In terms of antioxidant status, the only parameter that exhibited no difference between groups was TAC (Table 2). However, significantly higher values were observed for CAT and SOD in the GwGDM compared to the Gw/oGDM. Similarly, elevated concentrations of lipid oxidation markers were noted in the GwGDM relative to the Gw/oGDM (Table 2).

Table 2. Oxidant/antioxidant markers in serum of pregnant women with and without GDM at Hospital Materno Perinatal "Mónica Pretelini Sáenz"

	Gw/oGDM[a] Median (*n* = 21)	GwGDM[b] Median (*n* = 21)	*p*-value
TAC (µM)	0.055	0.062	0.414
SOD (U/mL)	0.068	0.082	0.013*
CAT (U/L)	344	357	0.011*
MDA (µM)	22.49	23.68	0.039*

[a] Group without GDM.
[b] Group with GDM.

The values represent the median of serum oxidant and antioxidant markers in pregnant women at Hospital Materno Perinatal "Mónica Pretelini Sáenz." To compare the groups, differences were analyzed using the Mann-Whitney *U* test, with significance set at $p < 0.05$.

Dietary assessment and carbohydrate intake

Concerning the dietary assessment, the Gw/oGDM consumed significantly more calories, water, TCHOs at the expense of CCHOs. Conversely, the GwGDM exhibited lower consumption, except for SCHOs, where intake was higher compared to that of the Gw/oGDM. There were no differences between the groups in protein and lipid consumption (Table 3).

Table 3. Dietary assessment of pregnant women with and without DMG at Hospital Materno Perinatal "Mónica Pretelini Sáenz"

	Gw/oGDM[a] Mean ± SD (*n* = 21)	GwGDM[b] Mean ± SD (*n* = 21)	*p*-value
kcal/day	1.932 ± 5.2	1.700 ± 21	0.047*
Water (mL/day)	1.633 ± 47	1.302 ± 25	0.017*
	Median	**Median**	
TCHO (g/day)	254	226	0.032*
CCHO[c]/day (g/day)	208	168	0.015*
SCHO[d]/day (g/day)	39	62	0.028*
% SCHO/day	16	23	0.001*
Proteins (g/day)	77	66	0.061
Lipids (g/day)	69	56	0.232

[a] Group without GDM.
[b] Group with GDM.
[c] Complex carbohydrates per day.
[d] Simple carbohydrates per day.

The values represent the mean ± SD and median intake of macronutrients in pregnant women with and without GDM. Group comparisons were conducted using Student's *t* test for independent samples and homogeneous variables and the Mann-Whitney *U* test for non-homogeneous variables. Differences were considered significant at $p < 0.05$.

Regarding the source of sucrose intake, the GwGDM consumed a greater amount of carbonated and flavored soft drinks, milk, flavored water, table sugar and sweet bread compared to the Gw/oGDM. Overall, the GwGDM consumed 773.9 g of sucrose per day, in contrast to the 600.1 g consumed by the Gw/oGDM (Table 4).

Table 4. Sucrose consumption in grams per day among pregnant women with and without GDM at Hospital Materno Perinatal "Mónica Pretelini Sáenz"

Food	Sucrose (g) Gw/oGDM[a]	GwGDM[b]	Food	Sucrose (g) Gw/oGDM	GwGDM
	21 to > 40 g sucrose			11 to 20 g sucrose	
Carbonated drink (350 mL)	0	105	Yogurt (240 mL)	33	11
Flavored soft drink (350 mL)	30	30	Banana (1 pc.)	153	85
Cookies (100 g)	22	0	Papaya (100 g)	44	33
			Cocoa powder (1 tbsp.)	13	13
			Milk	0	101
Total	**52**	**135**	**Total**	**243**	**243**

Food	Sucrose (g) Gw/oGDM[a]	GwGDM[b]	Food	Sucrose (g) Gw/oGDM	GwGDM
	21 to > 40 g sucrose			11 to 20 g sucrose	
			5 to 10 g sucrose		
Orange (1 pc.)	14	43	Jam (1 tbsp.)	8	0
Mango (1 pc.)	0	8	Table sugar	134	151
Tangerine (1 pc.)	17	17	Sweet bread (100 g)	57	78
Total	**31 g**	**68 g**	**Total**	**199 g**	**229 g**
			< 5 g sucrose		
Oaxaca cheese (100 g)	5	15	Spinach (100 g)	0	0
Apple (1 pc.)	26	18	Avocado (100 g)	0.07	0
Watermelon (35 g)	0	2	Peas (100 g)	5	10
Pear (1 pc.)	2	1	Cooked pasta soup (50 g)	0.86	0.97
Chicken egg (1 pc.)	0.21	0.48	Oatmeal (100 g)	0.8	0
Bacon (20 g)	0	0.45	Cornflakes (50 g)	10	14
Rice (150 g)	1	4	Cream (1 tsp.)	0.1	0
Potato or sweet potato (1 pc.)	5	3	Mayonnaise (1 tsp.)	0.06	0
Carrot (50 g)	0	11	Tortilla (1 pc.)	19	19
Total	**39.21 g**	**54.93 g**	**Total**	**35.89 g**	**43.97 g**
Total	**122.21**	**257.93**	**Total**	**477.89**	**515.97**
Total	**Gw/oGDM**	**600.1 g**	**Total**	**GwGDM**	**773.9 g**

[a] Group without GDM.
[b] Group with GDM.

The table represents the sucrose consumption in grams or servings per day, based on food consumption frequency, of pregnant women with and without GDM at Hospital Materno Perinatal "Mónica Pretelini Sáenz." Measurement units: piece (pc.), teaspoon (tsp.), tablespoon (tbsp.), cup (240 mL).

The frequency and quantity of sucrose consumption in the GwGDM were at the expense of oranges, flavored water, table sugar, sweet bread, Oaxaca cheese, eggs, rice, carrots, peas, pasta soup, corn flakes, milk and tortillas. In contrast, the Gw/oGDM consumed more sucrose from foods like yogurt, bananas, papayas, jam, apples, pears, potatoes or sweet potatoes, oatmeal, cream and mayonnaise.

Correlations were conducted between TCHO, SCHO and CCHO consumption and the study variables. The Gw/oGDM showed significant correlations with TG, kcal, lipids and proteins. In contrast, in the GwGDM, significant correlations were only observed with variables such as kcal, proteins and TAC, as shown in Table 5. There were no statistically significant correlations between daily consumption of TCHO, SCHO and CCHO and levels of SOD, TAC and MDA (Table 5).

Table 5. Positive correlations between groups of pregnant women with and without GDM

	Gw/oGDM[a]			GwGDM[b]		
	TCHO[c]	CCHO[d]	SCHO[e]	TCHO	CCHO	SCHO
TG	0.031	0.020	--	--	--	--
kcal/day	0.001	0.001	0.006	0.001	0.009	0.003
Lipids	0.017	0.029	--	--	--	--
Proteins	0.005	0.010	0.037	0.023	--	0.008
TAC[f]	--	--	--	--	--	0.029

[a] Group without GDM.
[b] Group with GDM.
[c] Total carbohydrates.
[d] Complex carbohydrates.
[e] Simple carbohydrates.
[f] Total antioxidant capacity.

Spearman's rank correlation coefficient was calculated, with the results in the table representing the positive correlations between the variables of pregnant women with and without GDM and the consumption of TCHO, CCHO and SCHO. Differences were considered significant at $p < 0.05$.

DISCUSSION

GDM manifests as transient, spontaneous hyperglycemia of varying severity during pregnancy [20]. Its pathophysiology and etiology, though not fully understood, involve hormonal fluctuations affecting insulin sensitivity and pancreatic ß-cell function [21]. Risk factors include ethnicity, age, pregestational BMI, and personal and family history of diabetes [22]. In this study, women with GDM were from rural areas, indicating low economic status, were aged ≥ 28 years, and exhibited higher weight and pregestational BMI (Table 1, Figure 1), in contrast to those without GDM. The GwGDM had a FH of T2DM, obesity and hypertension, with elevated TG and low TC (Table 1), which is consistent with the scientific literature [23,24].

Monitoring of nutrient intake and caloric content in patients with GDM before diagnosis and pregnancy is limited. The Gw/oGDM consumed higher quantities of kcal, water, TCHOs and CCHOs, protein and lipids compared to the GwGDM (Table 3). Metabolically, dietary quality influences individual health; for example, the type of CHO affects glycemic control [25]. In this study, the Gw/oGDM consumed higher amounts of TCHO and CCHO than the GwGDM, who consumed a higher percentage of SCHO such as sucrose but a lower amount of protein per day. This consumption routine predisposes individuals and their offspring to metabolic diseases [26]. Ideally, the World Health Organization (WHO) recommends SCHO intake to be less than 10 % of total kcal/day [27]. However, in this study, both groups exceeded this recommendation, with SCHO consumption of 16 % (Gw/oGDM) and 23 % (GwGDM) of total kcal (Table 3).

Optimal glycemic control and prevention of maternal and fetal complications [28] need a higher proportion of CCHO with a low glycemic index and lower SCHO intake, a regimen not observed in these patients.

Status of enzymatic antioxidants and prooxidants in GDM

Achieving a balance between ROS, oxidants and antioxidants is crucial to sustain an optimal environment for both the fetus and maternal health [29]. However, under certain conditions, this physiological balance can be disrupted, leading to an imbalance characterized by increased ROS and decreased antioxidant system [30,31]. In pregnant women with a family and personal history of DM, particularly those with more than three risk factors for GDM, this fragile balance is disrupted, precipitating the onset of the disease [32]. Antioxidant activity plays a vital role in regulating oxygen levels in the placenta. Diminished antioxidant capacity due to inadequate intake or supplementation can result in cellular damage and OS [33]. Although GwGDM patients consumed more antioxidant-rich foods (carrots, oranges and mangoes) than Gw/oGDM patients, the levels were insufficient. Moreover, the GwGDM did not report taking any supplements—whether vitamin supplements, folic acid, etc.—at least during the study period. The compromised antioxidant activity during placental development leads to increased lipid peroxidation, endothelial damage and heightened MDA production [34]. GwGDM patients showed elevated concentrations of TAC, SOD, CAT and MDA. Elevated TAC levels, typically rising during the second and third trimesters of pregnancy [35], were observed alongside

elevated SOD levels in this study. Reduced TAC levels during pregnancy have been linked to decreased SOD activity [36]. Conversely, diminished SOD activity is correlated with lower plasma TG, TC and LDL levels [37]. However, in this study, while SOD levels were elevated, TC was decreased, but no significant change was noted in TG levels (Table 1). This indicates the presence of OS with increased SOD and MDA levels in these patients from the second trimester of pregnancy. Antioxidant deficiency in early pregnancy may contribute to the onset of GDM in the short term [13]. This agrees with reports of pregnant women supplemented in early GW with vitamins, antioxidants and minerals, where CAT and TAC activity was improved, thus reducing OS [38]. Moreover, in pregnant women, IR, oxidant/antioxidant imbalance with occurrence of OS and maternal inflammation with fetal damage are exacerbated [39]. Glucose autooxidation in the altered metabolic state leads to the formation of O_2, a precursor of H_2O_2, contributing to increased MDA levels [40]. In this study, MDA levels were elevated in the GwGDM, indicating heightened lipid peroxidation (MDA) and, consequently, higher OS (Table 2). Additionally, increased plasma CAT activity was observed in the GwGDM, suggesting increased H_2O_2 production that stimulates the activation of the enzyme to eliminate it; however, this production exceeds the enzyme's capacity, leading to OS [39]. Previous studies have shown that increased MDA levels are accompanied by decreased CAT enzyme activity [41], consistent with the findings of this study. Nonetheless, during pregnancy, physiological generation of ROS plays a pivotal role in various developmental processes, ranging from oocyte maturation to luteolysis and embryo implantation [42].

This study provides insights into the association that GDM and OS have with other nonphysiological variables such as SCHO and CCHO consumption. In the GwGDM, sucrose intake exhibited a positive correlation ($r = 0.476$, $p < 0.05$) with TAC values, suggesting that higher daily sucrose intake may have elevated serum TAC levels in this population.

A comparative study on TAC values in pregnant women with and without GDM revealed significantly lower antioxidant concentrations among women with GDM compared to healthy pregnant women [43], which is consistent with the findings of this study. Despite this, GwGDM participants exhibited higher TAC levels, perhaps reflecting a physiological mechanism aimed to preserve the balance between oxidants and antioxidants [42], thereby mitigating oxidative damage associated with GDM.

Chronic and habitual consumption of SCHO such as sucrose may contribute to the elevation of antioxidant enzyme levels, serving as a compensatory mechanism to maintain balance with oxidants in GDM.

Figure 2 illustrates the interaction between the variables in this study across the GwGDM and Gw/oGDM.

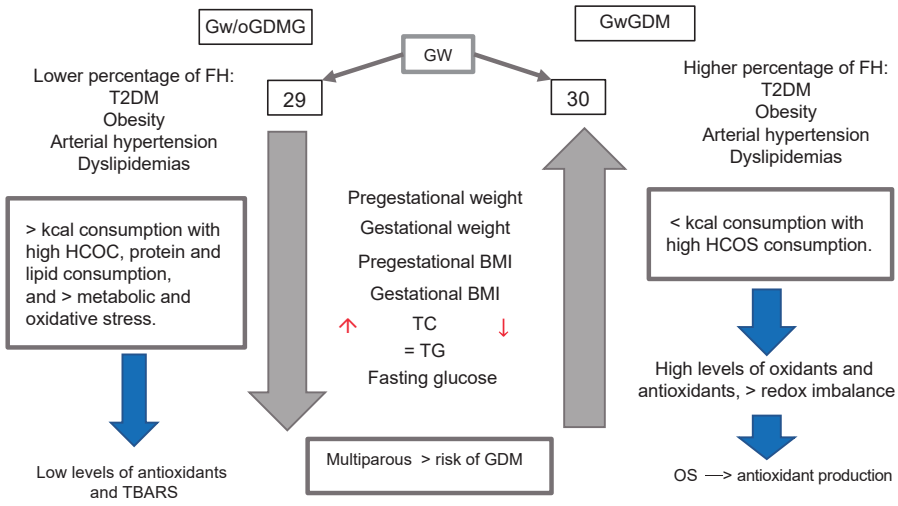

Figure 2. Comparison of sociodemographic, anthropometric, biochemical, oxidant/antioxidant and GW variables between the GwGDM and Gw/oGDM

The limitations of this study primarily stem from the restricted sample size and the reliance solely on a 24-hour reminder, because the study was conducted during the COVID-19 pandemic. Therefore, it was not possible to increase the number of participants or to contact them subsequently. Many of them did not have a contact number, lived in rural areas with sparse internet connectivity, and most of them had scheduled a medical appointment only for the time of delivery.

To minimize memory bias during the dietary assessments, images and references of food portions in cups and grams were used for recording during the 24-hour reminder. Additionally, the questioning was carried out early in the morning. Another factor to consider was controlling the environment and, to avoid bias, the questioning took place in a quiet, distraction-free setting. However, the study findings were interesting and relevant for the type of study proposed. This opens the door for further research studies using alternative dietary assessment methods, such as food records, food frequency questionnaires or more than two 24-hour reminders to establish correlations with OS markers in GDM.

In conclusion, the GwGDM exhibited risk factors for GDM; therefore, childbearing and pregnant women should adopt healthy lifestyles, including regular physical activity, a balanced diet and consumption of exogenous antioxidants. Such lifestyle changes will prevent and mitigate the increase in MDA levels, as well as restore the balance between oxidant and antioxidant production. The GwGDM showed an imbalance in the oxidant/antioxidant status, characterized by elevated levels of CAT, SOD, TAC and MDA, compared to the Gw/oGDM. Further research on the relationship between sucrose and other inflammatory variables in patients with GDM is necessary.

It is noteworthy that the GwGDM consumed fewer total kcal at the expense of SCHO consumption with higher sucrose content. In contrast, the Gw/oGDM consumed more total kcal at the expense of CCHO consumption with lower sucrose content. The chronic and regular consumption of SCHO such as sucrose was associated with increased antioxidant enzymes and MDA levels in the Gw/oGDM.

Author contributions: JGA participated in research implementation, data collection, analysis and manuscript writing. BEMC worked on research conceptualization, methodology, funding acquisition, supervision, and the writing, revising and editing of the manuscript. HMZ supervised clinical data collection from the clinical records, formal data analysis and manuscript review. RAJL performed sample analysis, database development and data collection. ISGS collected the sample, anthropometric and biochemical data, and conducted their analysis. IMAM contributed to the processing and analysis of OS samples. All authors reviewed the article and previous versions of the paper.

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