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Original Article

Influence of physical activity and body mass index to gestational diabetes risk: A cross-sectional observational study

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Abstract:
The incidence of gestational diabetes mellitus (GDM) has risen globally. While various factors contribute to GDM risk, modifiable factors such as lifestyle and weight control play crucial roles in prevention strategies. Therefore, this study aimed to assess the association between physical activity level (PAL), body mass index (BMI), and the odds ratio of gestational diabetes mellitus (GDM). A cross-sectional observational study was performed during routine examinations at a Primary Care Unit of the Unified Health System (SUS). The sample consisted of 68 women with up to 28 weeks of pregnancy and aged between 18 and 43 years. Measurements: Data on age, duration of pregnancy, morbidity, blood pressure, and laboratory tests (fasting glucose, HbA1c%, and lipid profile) were obtained. BMI and PAL data were obtained for the period before and after the current pregnancy. A high prevalence of GDM (39.7%), sedentary lifestyle (50.0% prior to pregnancy; 70.6% current), and obesity (36.8% prior to pregnancy; 39.7% current) was observed in the sample. There was a significant increase in sedentary time and a reduction in walking time after the beginning of pregnancy. There was a significant association between obesity and the presence of GDM. Increased sitting time and BMI are related to an increased likelihood of GDM. Sitting time and BMI explain 27.1% of the variation in the probability of GDM in the pre-pregnancy period and 26.5% in the current period. The high prevalence of obesity and a sedentary lifestyle may be related to the high prevalence of GDM observed in the sample. The prescription of physical activity and reduction of obesity before pregnancy may reduce the risk of GDM.
Keywords: Gestational Diabetes, Diabetes mellitus, Pregnancy, Exercise, Physical Activity Level, Pregnancy Complications.

Introduction

Gestational diabetes mellitus (GDM) is defined as any carbohydrate intolerance level resulting in varying severity of hyperglycemia, with onset or diagnosis during pregnancy. The elevation of insulin counter-regulatory hormones explain its pathophysiology, the physiological stress imposed by pregnancy, and predetermining factors (genetic or environmental). GDM is most frequently diagnosed from the second trimester of pregnancy onwards in the absence of overt pregnancy diabetes. The increase in the incidence of GDM in recent years has led to greater concern about identifying the most prevalent risk factors, such as obesity and a sedentary lifestyle (Phelan et al., 2023; Retnakaran et al., 2023; X. Song et al., 2023).

GDM is considered one of the main risk factors for type 2 DM (DM2) in women. In addition, it increases the child's risk of developing obesity, metabolic syndrome, and DM in later life. The prevalence of hyperglycemia during pregnancy can range from 1 to 37.7%, depending on the diagnostic criteria and the population studied. In Brazil, population estimates of hyperglycemia during pregnancy are conflicting. However, some studies estimated that the prevalence of GDM is approximately 18% (Chandler-Laney et al., 2023; Organização Pan-Americana da Saúde. Ministério da Saúde. Federação Brasileira das Associações de Ginecologia e Obstetrícia. Sociedade Brasileira de Diabetes, 2019; Scheidl et al., 2023).

Although there are discussions about the diagnostic criteria, the Brazilian Society of Diabetes (SBD) recommends that the screening must be performed in all pregnant women. Fasting blood glucose values ≥ 92 mg/dL diagnose GDM, and values ≥ 126 mg/dL diagnosis of diabetes mellitus (DM) during pregnancy. However, in both situations, it is recommended to repeat the blood glucose test for confirmation and, when possible, to perform the oral glucose tolerance test (OGTT) due to its greater sensitivity and specificity for diagnosing GDM (Raets et al., 2023; Zajdenverg et al., 2022). Thus, it is recommended that all pregnant women with normal blood glucose at the first appointment in the first trimester undergo the OGTT between 24 and 28 weeks of gestation (ElSayed et al., 2023).

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The main risk factors for GDM are increased body mass index (BMI) (overweight and obesity) and hypothyroidism. Other risk factors before and during pregnancy, such as advanced maternal age, family history of diabetes, previous GDM, having had a macrosomic baby, non-Caucasian race/ethnicity, and smoking, may be considered. However, modifiable risk factors, such as diet and lifestyle, are important protective factors for GDM and have a significant therapeutic impact (Bruno et al., 2023; Zhang et al., 2022).

DMG increases the risk of cesarean section by 30% and gestational hypertension by 50%. In addition, it increases the risk of prematurity by 70% and is strongly associated with a higher risk of childhood adiposity, insulin resistance and adverse neurodevelopmental outcomes (Egan et al., 2020). Therefore, the treatment of GDM is directly related to adequate and early diagnosis, with immediate start of therapeutic intervention and strict glycemic control. Thus, self-monitoring of capillary blood glucose several times a day, accompanied by changes in diet, adequacy of physical activity, and, when necessary, use of insulin, represent the main intervention strategies (Field et al., 2023).

It was observed that any physical activity level (PAL) before or at the beginning of pregnancy can reduce the chance of GDM by 21 to 30%, respectively, compared to a sedentary condition. However, in women who perform more than 90 minutes per week of leisure-time physical activity before pregnancy, the reduction in the risk of GDM is 46% (Mijatovic-vukas et al., 2018). Thus, in addition to drug intervention, glycemic control, dietary adequacy, and maintenance of an adequate physical activity pattern are determinants in the therapeutic success of GDM and DM during pregnancy (American Diabetes Association ADA, 2021).

However, the degree of protection that the increase in the level of activity has in reducing the risk of GDM and in the values of glycemia in the OGTT at the end of the second semester of pregnancy in sedentary women before pregnancy has not yet been completely clarified, mainly in non-systematized activities represented by a wide range of displacements, occupational, leisure and daily activities (Di Biase et al., 2019). Although there are some restrictions on physical exercise during pregnancy, an adequate prescription has positive repercussions on the health of the pregnant woman and the fetus. However, late interventions lifestyle are related to lower adherence and effectiveness in the prevention and treatment of GDM, as well as its complications (Moholdt & Hawley, 2020).

Excess weight or obesity during pregnancy has been identified as an important risk factor for metabolic changes during pregnancy, including GDM. However, the global burden of obesity has increased in recent decades across the world, particularly in women of childbearing age. The repercussions of GDM and maternal obesity go beyond the pregnant woman's health problems, as these factors have been attributed to neurodevelopment problems in the newborn (Saros et al., 2023). Considering the impact of obesity on the health of the pregnant woman and the fetus, early stratification of the risk of GDM in pregnant women with obesity and intervention aimed at lifestyle changes and blood glucose control have been recommended(Quotah et al., 2022).

There is evidence that socioeconomic aspects may influence the incidence of GDM. Although studies present conflicting results, it has been observed that women with lower socioeconomic status are at greater risk of GDM (Roustaei et al., 2023). The effect of lower socioeconomic conditions on the risk of GDM is related to greater difficulty in accessing health services andncorporating lifestyle changes in relation to physical activity and healthy eating habits (Bittner et al., 2023).

In a study carried out in Brazil to evaluate risk factors for GDM in a population served by the SUS, it was found that the main risk factors were maternal age and excess weight (Dos Santos et al., 2020). In Brazil, the SUS represents the main place for health care for the population with lower socioeconomic conditions. However, few studies have been developed in this environment, especially regarding risk factors for GDM. Thus, the study's objective was to investigate the relationship between the PAL before and during pregnancy, as well as nutritional status and weight gain, and the chance of GDM or DM during pregnancy in women who attended prenatal consultations up to 28 weeks in the SUS.

Material & methods

Study design

This is an observational and cross-sectional study. Data were obtained during a routine consultation for prenatal examination at a Primary Care Unit (UBS) of the Unified Health System (SUS). During the consultation, all pregnant women with up to 28 weeks of gestation who sought the gynecology and obstetrics service for prenatal consultation underwent anthropometric measurements, determination of the gestational status, a survey of routine biochemical data, including data from screening for GDM or DM during pregnancy, in addition to evaluating the PAL before and during pregnancy through the international physical activity questionnaire (IPAQ). As exclusion criteria patients who had a gestation period greater than 28 weeks, had a previous diagnosis of DM2, and had a physical disability with malfunction or paralysis of the lower limbs that prevented walking were considered.

Sample The sample was of the non-probabilistic convenience type. However, the minimum sample size was estimated at 39 sample elements in the G*Power software, version 3.1.9.2 (Franz Faul, UniversitätKiel, Germany) to analyze the association of PAL and DMG, considering a large effect size (0.5) (Yong et al., 2020), a type I margin of error (α) of 5%, a study power of 80% and 2 degrees of freedom. Data collection took place between August 2021 and August 2022. During the study period, only 68 women agreed to participate and signed the informed consent form.

Ethical aspects

The procedures used in this research obeyed the Ethical Criteria for Research with Human Beings. The researchers involved in this project signed the Confidentiality Terms, committing themselves to keep the data made available by the study participants confidential. The project was approved by the Ethics and Research Committee of the University of Marília (protocol: 4.934.839/ 2021). Data were obtained with the patient's authorization after reading and signing the Free and Informed Consent Form.

Study variables

Clinical data were obtained as part of routine consultations, including anthropometric measurements (weight and height), age, length of pregnancy, morbidities, blood pressure, and laboratory tests (fasting blood glucose, glycated hemoglobin (HbA1c), insulin, total cholesterol, HDL-cholesterol (HDL-c), triglycerides, and LDL-cholesterol (LDL-c)). Pregnancy weeks were categorized into the first trimester (up to 13 weeks) and the second trimester (14 to 28 weeks). Anthropometric weight and height data were used to calculate the BMI, which was classified according to the weeks of gestation (Surita et al., 2023), underweight, eutrophy, overweight, and obesity. Body weight values before pregnancy and on the day of the consultation were used to calculate the rate of weight gain per week (Kac et al., 2021).

PAL was determined by the IPAQ considering walking time, time of moderate-intensity physical exercise, and time of vigorous-intensity physical activity (intense) in minutes per week (min/week), with results classified as sedentary, insufficiently active, active, and very active (Mielke et al., 2021). Sedentary behavior was estimated by the time spent sitting and lying down, as well as the sum of both for the total sedentary time (Franco et al., 2021).

Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were also measured. Blood pressure values were categorized as: normotensive when SBP < 140 (mmHg) and DBP <90 (mmHg); gestational hypertension when SBP ≥140 (mmHg) and/or DBP ≥90 (mmHg), or both; and in severe gestational hypertension when SBP ≥160 (mmHg) and/or DBP ≥110 (mmHg), or both (Barroso et al., 2020). The diagnosis of dyslipidemia (isolated or mixed) was determined when one of the lipid fractions was altered considering values of LDL-c ≥ 130 mg/dL; triglycerides (TG) ≥ 150 mg/dL; total cholesterol (TC) ≥ 190 mg/dL; and/or HDL-c < 50 mg/dL(Faludi et al., 2017).

The diagnosis of GDM up to 23 weeks of gestation was assigned to pregnant women with fasting blood glucose values ≥ 92 mg/dL and values ≥ 126 mg/dL diagnosed DM during pregnancy. For pregnant women in the second trimester, with 24 to 28 weeks of gestation, in addition to measuring fasting blood glucose, the OGTT was performed, and the diagnostic criterion for GDM was blood glucose values ≥ 180 mg/dL after 1 hour or ≥ 153 mg/dL and < 200 mg/dL after 2 hours. Blood glucose values ≥ 200 mg/dL after 2 hours were considered for the diagnosis of DM during pregnancy. HbA1c% values were classified as <5.7% normal, 5.7 to 6.4% risk of GDM, and ≥ 6.5% diagnosis of DM during pregnancy (Zajdenverg et al., 2022). OGTT data were used only for diagnostic criteria and were not analyzed in the results.

Statistical analysis

Qualitative variables were described by absolute (f) and relative (%) frequency distribution, and their associations were analyzed using Fisher's exact test. Quantitative variables were described by mean and standard deviation. A comparison between means was performed using the mixed ANOVA test for repeated measures, and post-hoc comparisons were made using the Bonferroni test. Correlations were explored using Spearman's non-parametric test. The probability of DMG was analyzed using the binary logistic regression model using the Enter method and analysis of Wald statistics (independent variables) and Omnibus (model). The binary logistic regression model analyzed the odds ratio (Odds). The explanation factor of the binary logistic regression model was analyzed using R^2 Nagelkerke's. The SPSS software version 24.0 for Windows was used for all analyses, with a significance level of 5%.

Results

The sample consisted of 68 women with a mean age ± standard deviation of 28.8±6.0 years, with a minimum age of 18 years and a maximum age of 43 years. All pregnant women had negative results for Venereal Disease Research Laboratory, serology for HVI, Toxoplasmosis, and Anti-HCV. There was no association between the presence of GDM and clinical aspects of routine prenatal consultations. The largest proportion of the sample was in the first semester of pregnancy and the first pregnancy, but without a significant association with GDM (Table 1).

Table 1: Distribution of absolute and relative frequency (%) of clinical aspects of routine prenatal consultations in the sample compared to pregnant women without and with Gestational Diabetes (GDM).

		GDM		Total	p-value
		No	Yes		
Gestation	1 pregnancy	16 (39.0)	10 (37.0)	26 (38.2)	0.691
	2 pregnancy	11 (26.8)	6 (22.2)	16 (25.0)	
	> 3 gestation	14 (34.1)	11 (40.7)	25 (36.8)	
Gestational trimester	1st trimester	26 (63.4)	22 (81.5)	48 (70.6)	0.112
	2nd trimester	15 (36.6)	5 (18.5)	20 (29.4)	
Blood typing	A	10 (24.4)	8 (29.6)	18 (26.5)	0.833
	AB	3 (7.3)	1 (3.7)	4 (59)	
	B	3 (7.3)	3 (11.1)	6 (8.8)	
	O	25 (61.0)	15 (55.6)	40 (58.8)	
Rh factor	Positive	35 (87.5)	26 (96.3)	61 (91.0)	0.389
	Negative	5 (12.5)	1 (3.7)	6 (9.0)	
Urine I/ Urine culture	Negative	37 (92.5)	21 (77.8)	58 (86.6)	0.142
	Positive	3 (7.5)	6 (22.2)	9 (13.4)	
Serology (Toxoplasma)	Susceptible	28 (68.3)	15 (55.6)	43 (63.2)	0.290
	Immune	13 (31.7)	12 (44.4)	25 (36.8)	
Papanicolaou class II	Light	16 (66.7)	14 (77.9)	30 (71.4)	0.506
	Moderate	8 (33.3)	4 (22.2)	12 (28.6)	

The p-value was calculated using Fisher's exact test for association.

In the sample, the mean fasting blood glucose ± standard deviation was 87.7 ± 8.6 mg/dL, with a minimum value of 72 and a maximum of 111 mg/dL and 27 women (39.7%) were diagnosed with GDM. No patient was diagnosed with DM during pregnancy, although HbA1c values ≥ 6.5% were observed in one patient. No association was observed between the presence of GDM and changes in blood pressure, total cholesterol and fractions, and HbA1c (Table 2).

Table 2: Distribution of absolute and relative frequency (%) of the classes of blood pressure, total cholesterol and fractions, and HbA1C in the sample in the comparison between pregnant women without and with Gestational Diabetes (GDM).

		GDM		Total	p-value
		No	Yes		
Hypertension	No	39 (95.1)	25 (92.6)	64 (94.1)	0.667
	Yes	2 (4.9)	2 (7.4)	4 (5.9)	
SBP	Normotensive	36 (87.8)	24 (88.8)	60 (88.2)	0.414
	Hypertension	5 (12.2)	2 (7.4)	7 (10.3)	
	Severe hypertension	0 (0.0)	1 (3.7)	1 (1.5)	
DBP	Normotensive	38 (92.7)	23 (85.2)	61 (89.7)	0.423
	Hypertension	3 (7.3)	4 (14.8)	7 (10.3)	
TC	Normal	24 (61.5)	17 (65.4)	41 (63.1)	0.755
	Altered	15 (38.5)	8 (34)	24 (36.9)	
TG	Normal	30 (78.9)	19 (73.1)	49 (76.6)	0.589
	Altered	8 (21.1)	7 (26.9)	15 (23.4)	
LDL-c	Normal	37 (94.9)	26 (100.0)	63 (96.9)	0.513
	Altered	2 (5.1)	0 (0.0)	2 (3.1)	
HDL-c	Normal	30 (75.0)	18 (66.7)	48 (71.6)	0.461
	Altered	10 (25.0)	9 (33.3)	19 (28.4)	
HbA1c%	Normal (<5.7%)	35 (92.1)	21 (80.8)	56 (87.5)	0.304
	DMG risk (5.7 a 6.4%)	3 (7.9)	4 (15.4)	7 (10.9)	
	DM during pregnancy (≥6,5%)	0 (0.0)	1 (3.8)	1 (1.6)	

The p-value was calculated by Fisher's exact test for association. SBP: systolic blood pressure; DBP: diastolic blood pressure; TC: total cholesterol; TG: triglycerides; HbA1c: glycated hemoglobin.

A significant association was observed between GDM and nutritional status through the BMI classification. A higher proportion of obese women was observed among pregnant women with GDM both for BMI prior to pregnancy and for current BMI, which suggests that obesity before pregnancy increases the chance of GDM. As for PAL, no significant association was observed with GDM, but a high prevalence of sedentary lifestyle was observed in the total sample, limiting the association analysis's power (Table 3).

It was observed that pregnancy contributed to the reduction of PAL and increased prevalence of a sedentary lifestyle. Prior to pregnancy, 30.9% (95% CI: 20.6 - 42.6%) of the pregnant women showed active behavior, but after the beginning of pregnancy, a significant reduction in active behavior was observed for 10.3% (95% CI:4.4 – 16.6%). Considering the high prevalence of GDM (39.7%) and sedentary lifestyle prior to pregnancy (50.0%), it is possible to suggest that a sedentary lifestyle may contribute to the increased chance of GDM (Table 3).

Table 3: Distribution of absolute and relative frequency (%) of nutritional status by body mass index (BMI) and physical activity level (PAL) of the sample in the comparison between pregnant women without and with Gestational Diabetes (GDM) for the moment before pregnancy and current.

		GDM		Total	p-value
		No	Yes		
BMI before pregnancy	Low weight	1 (2.4)	0 (0.0)	1 (1.5)	0.020*
	Eutrophic	15a (36.6)	3b (11.1)	18 (26.5)	
	Overweight	15 (36.6)	9 (33.3)	24 (35.3)	
	Obese	10a (24.4)	15b (55.6)	25 (36.8)	
Current BMI	Low weight	1 (2.4)	0 (0.0)	1 (1.5)	0.006*
	Eutrophic	15a (36.6)	3b (11.1)	18 (26.5)	
	Overweight	15 (36.6)	7 (25.9)	22 (32.4)	
	Obese	10a (24.4)	17b (63.0)	27 (39.7)	
PAL before pregnancy	Sedentary	22 (53.7)	12 (44.4)	34 (50.0)	0.545
	Irregularly active	7 (17.1)	6 (22.2)	13 (19.1)	
	Active	12 (29.3)	9 (33.3)	21 (30.9)	
Current PAL	Sedentary	31 (75.6)	17 (63.0)	48 (70.6)	0.491
	Irregularly active	7 (17.1)	6 (22.2)	13 (19.1)	
	Active	3 (7.3)	4 (14.8)	7 (10.3)	

*indicates significant association with GDM by Fisher's exact test for p-value ≤ 0.050. Different letters indicate significant differences between columns in the row by Bonferroni's adjustment test for p-value ≤ 0.050.

Considering the results in Table 4, walking was the main form of physical activity performed in the period prior to pregnancy, but it showed a significant reduction during pregnancy, especially for the GDM group. Both groups presented reduced time of moderate and vigorous intensity physical exercise in the period before pregnancy. During pregnancy, neither group practiced moderate or vigorous physical exercise. On the other hand, an increase in sedentary time was observed, especially in relation to the time lying down in both groups. On the other hand, an increase in sedentary time was observed, especially in relation to the time lying down in both groups. The group with GDM had higher sedentary time during the current pregnancy period.

As for walking physical activity (min/week), a significant reduction was observed in the current period compared to the period before pregnancy only in the group with GDM. Although the group with GDM showed a longer walking time before pregnancy compared to the group without GDM, this difference was not statistically significant, possibly due to the great variability of walking time in the group with GDM (Table 4).

Regarding the time of moderate-intensity physical exercise, only the group without GDM reported performing this type of physical activity before pregnancy (Table 4). These results suggest that moderate-intensity physical activity may reduce the chance of GDM. As for vigorous-intensity physical activity, only the group with GDM reported performing this type of PA before pregnancy, with a reduced average of minutes per week. In the analysis of the total physical exercise time, both groups presented a significant reduction in the current period concerning the period before pregnancy. In the current period, none of the groups reported performing physical exercise of moderate or vigorous intensity, indicating a trend toward a reduction in the pattern of physical activity during pregnancy (Table 4).

As for sedentary behavior, the group with GDM had a longer sedentary time compared to the group without GDM, especially in the current period, indicating a trend towards longer sedentary time in pregnant women with GDM. However, both groups showed a significant increase in sedentary time during pregnancy. Regarding sitting time, no significant effect was observed, although the group with GDM showed higher values in both periods (Table 4).

As for sitting time for transport, only the group with GDM showed a significant reduction in the current period compared to the period before pregnancy and lower values than the group without GDM in the current period. For the time lying down, a significant increase was observed in both groups in the current period compared to the period before pregnancy (Table 4). Although the time spent sitting in transport is also related to sedentary behavior, a reduction in this aspect of PA may be related to a decrease in work activities and daily activities outside the home environment.

Table 4: Comparison of the mean and standard deviation (SD) of the physical activity parameters between pregnant women with and without Gestational Diabetes (GDM) for the moment before pregnancy and the current one.

Group	No DMG (n=41)				DMG (n=27)				Anova		
Time	Before		Current		Before		Current		p-value		
Variables	Mean	DP	Mean	DP	Mean	DP	Mean	DP	Group	Time	Interaction
Walk (min/wk)	77.3	141.7	42.9	114.0	134.8	282.2	51.4ƚƚ	88.3	0.328	0.014ƚ	0.300
Moderate physical exercise (min/wk)	68.0	183.8	0.0ƚƚ	0.0	0.0	0.0	0.0	0.0		ENC	
Vigorous physical exercise (min/wk)	0.0	0.0	0.0	0.0	23.3	92.0	0.0ƚƚ	0.0		ENC	
Sitting time (min/wk)	1682	1026	1728	988	2108	1191	2132	1088	0.077	0.783	0.930
Lying time (min/wk)	3369	729	3785ƚƚ	1058	3502	658	4157ƚƚ	1195	0.195	0.001ƚ	0.349
Sedentary time (minutes/week)	5235	1371	5659**ƚƚ	1278	5816	1362	6328ƚƚ	1143	0.027*	0.006ƚ	0.789
Total physical activity (min/wk)	145.4	240.7	42.9ƚƚ	114.0	158.1	291.0	51.4ƚƚ	88.3	0.784	0.001ƚ	0.945

* indicates significant group effect by repeated measures ANOVA for p-value ≤ 0.050; ** indicates a significant difference in relation to the DMG group by time (before and current) by the Post-Hoc Bonferroni test for p-value ≤ 0.050; ƚ indicates a significant effect of time by the Anova of repeated measures for p-value ≤ 0.050; ƚƚ indicates a significant difference in relation to the period before pregnancy within each group by the Post-Hoc Bonferroni test for p-value ≤ 0.050; ǂ indicates significant interaction effect between group and time by the Anova of repeated measures for p-value ≤ 0.050; Statistics not calculated due to lack of moderate and vigorous physical exercise (NCE). Min: minutes; Wk: week.

Exploratory Spearman correlation analysis was performed to identify quantitative variables that could explain the variation in the chance of GDM. BMI (current and prior to pregnancy), moderate physical exercise prior to pregnancy, PAL (current and prior to pregnancy), and sedentary time (present and before pregnancy) were included in the regression model. The regression model was complemented with age, length of pregnancy, and the number of pregnancies. Table 5 shows only the variables significantly affecting the binary logistic regression analysis. In model 1 (Table 5), the parameters prior to pregnancy were explored. The increase in BMI and sitting time before pregnancy was found to increase the likelihood of GDM. A 1 kg/m2 increase in BMI before pregnancy increases the chance (odds ratio) of GDM by 1.18 times. An increase of 1 minute per week in sitting time before pregnancy increases the chance (odds ratio) of GDM by 1.00054 times. These variables together explain 27.1% (R^2 Nalgelkerke) of the variation in the probability of GDM.

In model 2 (table 5), the current pregnancy parameters were explored. It was found that the increase in BMI and sitting time during pregnancy increased the likelihood of GDM; however, sitting time did not have a significant isolated effect. These variables together explain 26.5% (R^2 Nalgelkerke) of the variation in the probability of GDM. A 1 kg/m2 increase in the current BMI during pregnancy increases the chance (odds ratio) of GDM by 1.19 times.

Table 5: Binary logistic regression analysis for the effect of weight, body mass index, time of moderate physical exercise, and sedentary time before pregnancy on the probability of Gestational Diabetes (GDM).

Variables: Dependent	Variables: Independent	B	p-value (a)	Odds Ratio	IC95% (Odds): LI	IC95% (Odds): LS	Model: p-value (b)	Model: R^2 Nalgelkerke
DMG (model 1)	BMI before pregnancy (kg/m^2)	0.17277	0.001*	1.1885	1.06987	1.32048	0.001ł	0.271
	Sitting time before pregnancy (min/week)	0.00054	0.041*	1.00054	1.00002	1.00107		
	Constant	-6.5797	<0.001*	0.00139				
DMG (model 2)	Current BMI (kg/m2)	0.17436	0.002*	1.19048	1.06870	1.32614	0.001ł	0.265
	Current sitting time (min/wk)	0.00054	0.054	1.00054	0.99999	1.00108		
	Constant	-6.6909	<0.001*	0.00124				

Regression coefficient (B); * indicates a significant effect of the independent variable on the probability of GDM by the Wald test for p-value (a) ≤ 0.050; odds ratio (Odds); 95% confidence interval (95%CI); lower limit (LI); upper limit (LS); ł indicates a significant effect of the model on the probability of GDM by the Omnibus test for p-value (b) ≤ 0.050; explanation factor that indicates the percentage of variation in the probability of GDM explained by the variation of the independent variables (R^2 Nalgelkerke).

Discussion

In general terms, our results show that the increase in sedentary time and BMI increases the chance of GDM. The high prevalence of obesity and sedentary lifestyles in women may be related to the high prevalence of GDM observed in our sample. Pregnancy-related conditions are well-known to increase morbidity and mortality in mothers significantly. DM and GDM are included in these conditions and can be associated with maternal postpartum metabolic and cardiovascular morbidity. For these reasons, studies are necessary to identify this clinical condition as early as possible (Li et al., 2022; Z. Song et al., 2022).

Recent findings suggest that about a quarter of the risk of pregnancy complications may be attributed to the mother's overweight or obesity, preterm premature rupture of membranes, cesarean delivery, hemorrhage, and preeclampsia (Zhang et al., 2022). Song et al (Z. Song et al., 2022) investigated complications and outcomes in pregnancy of obese women or with GDM in more than 15,000 mothers. They found that overweight or obesity was responsible for 16% and 4% of the total population, respectively. The incidence of GDM was 12.3%. The authors also observed that overweight and obese subjects (BMI ≥ 24 kg/m2) were at a higher risk for GDM.

Being overweight and obese can be related to short and long-term undesirable outcomes for mothers and children. An increase in BMI before pregnancy also increases the risk of GDM and cesarean section rate. The presence of overweight, obesity, and GDM presents independent actions on neonatal obesity and increases the risk of long-term obesity, metabolic syndrome, and increased cardiovascular disease risk. A sedentary lifestyle contributes to being overweight and having deviations in blood glucose, thus contributing to obesity. Moreover, the increased BMI before excessive weight gain during pregnancy can also result in higher adverse pregnancy outcomes (Babu et al., 2019; Fan et al., 2022; Ogburn, 2016; Pagotto et al., 2020; Rehder et al., 2021; Shen et al., 2018).

GDM also represents undesirable outcomes since it is related to several delivery problems and perinatal outcomes. In a cohort study with almost 700 pregnant women, the authors showed that, compared to normal pregnant subjects, the women with GDM presented a higher risk of adverse outcomes such as hypertension, hemorrhage, and preterm rupture of membranes (Muche et al., 2020; Osuagwu et al., 2020).

In a randomized clinical trial with 260 pregnant women, Uria-Minguito et al (Uria-Minguito et al., 2022) used an online supervised exercise program in subjects without obstetric contra-indications. The exercise program was performed from 8-10 to 38-39 weeks of pregnancy (one group worked as a control, and the other performed physical activity). The results did not show significant differences in maternal characteristics at baseline. However, some outcomes presented a favorable trend in the group that performed physical activity, such as a lower number and percentage of GDM cases in the group that performed physical exercises. Also, in this group, a reduced number of women gained excessive body weight.

In a systematic review followed by a meta-analysis, Behnam et al (Behnam et al., 2022) evaluated the effects of lifestyle interventions in overweight and obese pregnant women. The authors identified twenty-eight randomized controlled trials and found that among the primary outcomes, just hypertension was significantly reduced by physical activity in the total group (1324 participants/odds ratio 0.52 / 95% confidence interval 0.28 to 0.96). If combined interventions supported behavioral therapies, the mother's weight gain and neonatal birth weight significantly decreased in the whole group. A higher frequency of physical activity improved the results. Moreover, the authors found that behavioral therapy can help prevent the adverse effects of maternal obesity if associated with lifestyle intervention. Notwithstanding, the authors of this study reported high heterogeneity of the included studies. For these reasons, future studies are required to explain better the effects of increased intensities of physical activity in pregnant women.

Many studies have shown that pregnant women voluntarily choose a reduction in training volume and/or intensity since there is a lack of information about the real outcomes of physical practice during pregnancy (Almquist et al., 2022; Davenport et al., 2022; Sigurdardottir et al., 2019; Solli & Sandbakk, 2018). In a scoping review, Wieloch et al (Wieloch et al., 2022) investigated the available evidence related to physical activity volume and intensity and the possible effects on pregnancy outcomes in athlete women and found that there were no adverse effects on maternal or fetal outcomes in this group. However, some fetuses' heart rates decelerated during performance tests in acute intensive exercise in which the woman exercised at more than 90% of her maximal heart rate. It is well-known that the practice of physical exercise effectively prevents or reduces obesity and DM. These benefits are extended to pregnant women. The beneficial effects of physical exercise can be related to the adaptation to many different tissues, such as the liver, skeletal muscle, and adipose tissues (Barbalho, Flato, et al., 2020). Some authors have shown that exercising induces adaptation to the white adipose tissue of humans or rodents, including augmented mitochondrial activity and a decrease in the pro-inflammatory and endocrine profiles contributing to metabolic homeostasis. The practice of exercise can improve obesity-induced activation of the pro-inflammatory signaling cascades, such as Nuclear factor -κB (NF-κB) and Mitogen-activated protein kinase (MAPKs), in the adipose tissue, suggesting an improvement in the inflammatory response. Furthermore, exercise potentializes the oxidation of fatty acids, resulting in reducedat, decreased oxidative stress, and improved antioxidant defenses (Golbidi & Laher, 2014; Tsuzuki et al., 2022).

During the execution of moderate exercises, myokines are released, which are related to numerous metabolic actions with systemic repercussions. Among these, we can mention the regulation of hepatic glycolysis, glycogenesis, and gluconeogenesis, helping in glycemic homeostasis. In addition, there is an increase in glucose uptake by peripheral tissues and an increase in the release of Glucagon-like peptide-1 (GLP-1), which helps control hunger and insulin action. Another interesting effect is the browning of the white adipose tissue, which can increase thermogenesis, aiding in weight loss or body weight regulation. In addition, effects on the brain are also observed, reducing anxiety (Barbalho, Prado Neto, et al., 2020).

The actions of moderate and regular exercise practice during pregnancy help mothers to gain less body weight and can decrease the risk of pregnancy-related DM, hypertension, preeclampsia, and higher tolerance to stress tolerance and earlier neonatal neuro-behavioral maturity (Asante et al., 2022; Muktabhant et al., 2015; Sitzberger et al., 2020). In our study, the high prevalence of physical inactivity prior to pregnancy may have contributed to the high prevalence of GDM. Minatovic-Vukas et al (Mijatovic-vukas et al., 2018) observed that carrying out any activity before or at the beginning of pregnancy could reduce the chance of GDM by between 21 and 30% and that in those with more than 90 minutes per week of leisure-time physical activity, the reduction in the risk of GDM could reach to 46%. Although we did not find a significant effect of physical exercise in reducing the chance of GDM, Sitzberger et al (Sitzberger et al., 2020) observed that women who were physically inactive before pregnancy had a three times greater risk of developing GDM compared to active women. The main type of physical activity observed in the sample was related to light-intensity walking, which was performed in a non-systematic way for commuting to work and daily activities. The absence of the effect of physical exercise on the risk of GDM in our sample may be related to the low involvement in moderate to vigorous physical exercise intensity.

Conclusions

Pregnancy is related to a reduction in the physical activity pattern and an increase in sedentary time. In addition, the high prevalence of physical inactivity and obesity before pregnancy may be related to the high prevalence of GDM observed in the sample. Sedentary time in the sitting position before and during pregnancy was an essential indicator of the chance of GDM. Light-intensity physical activity related to walking did not show a protective effect on the chance of GDM. However, the increase in body mass index (BMI), both before and during pregnancy, was the factor that had the greatest impact on increasing the chance of GDM. However, the high prevalence of a sedentary lifestyle in the sample is considered an important factor that limits the identification of the real impact of physical exercise on the chance of GDM.

Considering the results of the present study regarding the high prevalence of GDM, obesity, and sedentary behavior in the pregnant population attended by the SUS, we highlight the need to develop educational actions on healthy eating and an active lifestyle, both for the population of women of childbearing age, as well as the health team that provides care to this population.

Conflicts of interest - If the authors have any conflicts of interest to declare.

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