The Effect of Dietary Intake of Vitamin D on Gestational Diabetes Mellitus

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ABSTRACT: Diabetes mellitus (DM) is a growing health issue that has been reaching epidemic proportions in the recent years. Low intake of some nutrients like vitamin D may increase the risk of gestational diabetes mellitus (GDM). This study was to investigate the association between the dietary intake of Vitamin D and GDM among women in the Eastern Region of Saudi Arabia. A case-control study was conducted in a sample of 121 women, among those 72 were with GDM and 49 were controls. Vitamin D was estimated using food frequency questionnaire. Also, the 24-h's dietary recall was carried out for 3 days to determine the nutrient intake as well as biochemical analysis for blood glucose level. In this study, GDM subjects were consuming significantly more eggs ($P = .040$). Vitamin D and vitamin C intakes in GDM and control pregnant women were lower than recommended dietary allowances (RDA). It was also found that low-fat milk, full-fat milk, fortified yogurt, and fortified orange juice were significantly associated with GDM ($P < 0.05$). Saudi women with GDM need a well-organized dietary counseling before, during pregnancy, and after delivery especially for vitamin D sources.

KEYWORDS: Gestational diabetes, Vitamin D, sunlight exposure, Saudi Arabia

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Introduction

Diabetes mellitus (DM) is a common chronic endocrine disorder caused by acquired or genetic deficiency in insulin production by the pancreas, or by the inefficiency of the insulin produced. Recent prevalence of DM is around 150 million people worldwide, and by 2025 this number may well be doubled.[1] Diabetes mellitus can be classified into, Type 1 diabetes, Type 2 diabetes, gestational diabetes mellitus (GDM), and specific types of diabetes due to other causes.[2]

Gestational diabetes mellitus a heterogeneous disorder usually is defined as "*any degree of glucose intolerance onset or first recognition during pregnancy*."[3] Gestational diabetes mellitus (diabetes diagnosed in the second or third trimester of pregnancy that was not clearly overt diabetes prior to gestation).[2] The prevalence of GDM among Saudi women in Riyadh 2013 was found to be 13.8%,[4] which is higher than the prevalence in 2000. The major risk factor of (GDM) includes old age in pregnancy, family history of diabetes, obesity, and multiple pregnancy.[5]

Vitamin D generally refers to two fat-soluble prohormones, ergocalciferol (vitamin D_2), and cholecalciferol (vitamin D_3).[6] Vitamin D or calciferol is one of the most important fat-soluble vitamins, which has two major form vitamin D2 (ergocalciferol) and vitamin D3 (cholecalciferol).[7] Both of them are inactive prehormone and become active in the form of calciferol (1,25-dihydroxy vitamin D) when hydroxylated twice, first in liver and then in kidney. The synthesis location of the calciferol is in the kidney and regulated by parathyroid hormone. According to Burris and Camargo[8] maintaining bone health, and homeostasis of calcium and phosphate level are some of the important roles of calciferol. Vitamin D affects the glucose metabolism by influencing insulin sensitivity.[9] However, there are only a few foods that are naturally rich in vitamin D; good sources include liver and fatty fish such as salmon, mackerel, and sardines, whereas other foods such as red meat and eggs provide marginal amounts.[10] In recent year, hypovitaminosis D has been increasingly recognized as one of the many reasons of developed GDM.[11]

Vitamin D and gestational diabetes mechanism, vitamin D deficiency is linked to impaired glucose and insulin metabolism. The receptors of vitamin D (1,25 [OH] D) is located in the beta-cells of the pancreas, which could affect the function of theses insulin producing cells.[9] There are a lot of researches that studied the association between GDM and hypovitaminosis D. The result of one of these studies showed that low levels of vitamin D are an independent risk factor for developing GDM at first trimester.[12]

In another research, Meinilä et al, concluded that pregnant women at high risk of GDM have insufficient intakes of folate and vitamin D. Therefore, pregnant women need supplementation.[13] Moreover, Al-Faris[14] examined vitamin D deficiency prevalence among pregnant women in Saudi Arabia and related risk factors. The researcher concluded that vitamin D deficiency was common in pregnant women who live in Riyadh. Also, suggested that steps should be taken to address the current situation, including consumption of fatty fish, vitamin D supplements, and increased sunlight exposure. Therefore, we conduct this research to find out the effect of dietary vitamin D intake on pregnant women with GDM in eastern region of Saudi Arabia.

Materials and Methods

Study design and data collection

Totally, 72 were cases and 49 controls were included in this case-control study. The subjects for this study were recruited using convenience sampling from King Fahad University Hospital, Maternal and Children Hospital and Family Medicine of Imam Abdulrahman Bin Faisal University.

Inclusion criteria for control group was pregnant women without GDM age from 19 to 45 years old. But for GDM group was with GDM (fasting glucose ⩾ 126 mg/dL) according to Diagnosis and Classification of Diabetes Mellitus,[15] in second or third trimester, between the ages of 19 and 45 years, body mass index (BMI) greater than 30 kg/m^2 in first trimester and family history of gestational diabetes Exclusion criteria: women with pre-existing diabetes or disease affecting glucose metabolism, active infection, chronic illness (any gastrointestinal trace malabsorption and thyroid and parathyroid diseases) and GDM women taken vitamin D supplementation. Institutional Review Board (IRB) approval for the study was granted (serial number: UGS-2017-03-032) by Imam Abdulrahman Bin Faisal University. All participants were given a consent form and informed about the aim of the study. All records had collected by data sheet.

Assessment of dietary and biochemical variables

After obtaining the informed consent, both groups (Control and GDM) were interviewed regarding their socio-demographic background, anthropometric indices (body weight and height) were measured, BMI was calculated using the following equation: BMI = weight (kg)/height (m^2), questionnaire about food habits, family history, and their knowledge was collected from all participants, and food frequency questionnaire (FFQ) based on vitamin D content of different food items[16] (United States Department of Agriculture USDA 2017) was used. Intake values were divided into 3 groups and consist of 22 food items (High [250-1360 IU with 5 food items], medium [85-171 IU with 9 food items], and low [16-61 IU with 8 food items]) vitamin D content. A 24-h's dietary recall for 3 days (2 weekdays and 1 weekend day) were collected then analyzed by using Saudi Food Composition Table to calculate the amount of each macro-nutrients (protein, carbohydrate, and fats) and micronutrients (vitamin D and vitamin C) also, energy intake compared to recommended dietary allowances (RDA). Biochemical measurements for fasting and random blood glucose levels were determined by the hexokinase method which was available from the patient medical record (Glucoquant, Roche Diagnostics, Mannheim, Germany).

Statistical analysis

The collected data were analyzed using SPSS, version 20. Continuous variables were presented as mean ± standard deviation (SD) and compared among the GDM and controls using independent samples *t* test. Boxplot is used for the graphical representation. Chi-square test was used for the comparison of food habits between the GDM and controls; logistic regression analysis was used to find the significant risk factors of GDM. P value < 0.05 is considered as statistically significant.[17]

Results

Table 1 showed that the average pre-pregnancy BMI for GDM was significantly higher than the control group (32.1 ± 3.9 vs 23.8 ± 2.5 kg/m^2; $P < .001$). It also reveals that the average fasting blood glucose level for GDM women was (132.94 ± 24.37 mg/dL). On the other hand, the fasting blood glucose level for control was (82 ± 7.93 mg/dL). The mean of randomizes blood glucose levels for GDM women and control pregnant are (188.01 ± 25.56 mg/dL) and (109.35 ± 20.14 mg/dL), respectively, which consider statistically significant (*P* value < .001) in both tests.

Table 2 provided the association between the demographic characteristics and the GDM status, and the data did not prove any significant association.

Table 3 illustrated that (31.9%) of GDM group and (36.7%) of control group are skipping breakfast. Furthermore, (55.6%) of GDM group are drinking low-fat milk and (61.1%) are eating full-fat cheese. Almost 97.2% of GDM are consuming eggs while among controls only 87.8% were consuming eggs, which is less than case group and which is statistically significant also (*P* value = .04). In addition, (47.2%) are taking medium fat meat and (52.8%) are eating fried fish. On the other hand, the majority of control group (67.3%), (75.5%), (87.8%), (55.1%), and (61.2%) are drinking full-fat milk, eating full-fat cheese, eggs, high-fat meat and fried fish, respectively. Moreover, 51.4% of GDM group do not consume soft drinks but (44.4%) are consuming soft drinks at least once a day. Also, the percentage is the same (36.7%) between control group who are consuming and not consuming soft drinks. There are almost similar percentage among both groups in consuming fast foods, GDM (75%) and control group (75.5%).

Table 4 reveals that difference in vitamin D intake between GDM and control group is represented using Boxplot in Figure 1. Vitamin D dietary intake is higher among controls compared to GDM group.

Table 1. Comparison of study groups based on their anthropometric measurements and clinical variables.

VARIABLES	CONTROL (N=49)	GDM (N=72)	*P* VALUE*
	MEAN ± SD		
Age (years)	29.9 ± 5.5	32.40 ± 5.6	.200
Pre-**pregnancy weight (kg)**	59.6 ± 7.2	80.4 ± 13.8	<.001
Height (cm)	158.4 ± 5.5	157.7 ± 6.5	.550
Pre-pregnancy BMI (kg/m²)	23.8 ± 2.5	32.1 ± 3.9	<.001
Fasting glucose (mg/dL)	82.0 ± 7.9	132.9 ± 24.4	<.001
Randomize glucose mg/dL)	109.4 ± 20.1	188.0 ± 25.6	<.001

Abbreviations: BMI, body mass index (kg/m²); GDM, gestational diabetes mellitus; SD, standard deviation.
*Chi-square test.

Table 5 demonstrated that both groups are aware about the dietary sources of vitamin D with a percentage of 58.3% for GDM group and 61.2% for control group. In addition, (65.3%) of GDM and (57.1%) of control group are not taking vitamin D supplementation.

Table 6 showed no correlation between sun exposure and family history of GDM in both groups.

Table 7 showed highly significant correlation between skin color and GDM. There is no correlation between sun exposure, time of sun exposure, way of exposure, duration of sun exposure, frequency of sun exposure per week, body parts exposed to sunlight, and sunscreen usage and GDM.

Table 8 showed no correlation between the participants' knowledge about the association between vitamin D deficiency and gestational diabetes.

The analysis was done to find the categories of intake of foods were collapsed into three categories as follows: (1) Low—Not eaten, rarely and 1 to 3 times a month; (2) Medium—once a week and 2 to 4 times per week; and (3) High—5—6 times per week and 1-3 times per day.

It is clear that the subjects with higher amount of low-fat milk consumption had a significantly higher risk for GDM (Table 9). Subjects who had medium or high amount of full-fat milk consumption had a significantly less risk for GDM in this study ($P < .05$). Consumption of medium to high level of fortified yogurt is also showing a higher risk, that is 3 times higher risk as compared to low consumption ($P < .05$), which is also statistically significant. Consumption of Egg was also indicating a 3 to 4 times higher risk for GDM, but not statistically. Consumption of tuna indicates a protective effect on GDM, however not statistically significant at 5% level. Cod liver oil may also have protective effect and this is also not significant. Fortified orange juice consumption shows a higher significant risk for GDM.

Discussion

Gestational diabetes mellitus defined as any degree of glucose intolerance with onset during pregnancy, its prevalence ranges between 7% and 14% worldwide.[15] Gestational diabetes mellitus risk factors are high maternal age, family history of T2DM, obesity, prior history of GDM, and poor vitamin D status.[18] The prevalence of Vitamin D deficiency is around 60% among Saudi Arabian population.[19] Dietary intake during pregnancy play an important role in the progress of GDM. This study was conducted to find out the association between the dietary consumption of vitamin D and GDM among women in eastern region of Saudi Arabia.

This study demonstrated that, 31.9% of GDM are skipping breakfast which is agreed with another study conducted in 2013,[20] who tried to highlight the role of food pattern and habits on GDM and found that none of the studied subjects eat less than three meals per day and most of them eat three meals (51.3%) or more (48.7%). Although 69.7% eat breakfast regularly but still considerable percentage, 30.3% used to skip it.

The study showed that most of GDM (97.2%) consumed eggs as[21] mentioned that the high consumption of eggs during pregnancy increase the risk of developing GDM. The mechanisms by which high egg and cholesterol consumption might influence glucose homeostasis and diabetes risks are largely unknown. Investigators have speculated that observed associations may be attributable to the hyperglycemic and hyperinsulinemic influence of diets high in cholesterol and animal.[22] Others have speculated that oxysterols, a family of 27-carbon cholesterol oxidation derivatives, are potentially involved in the initiation and progression of cardiometabolic disorders, including diabetes.[23]

Many studies have examined the role of diet in increasing or decreasing the risk of GDM. Focusing more on red meat[22] revealed that dietary patterns in pre-pregnancy may contribute

Table 2. Association between the demographic variables and the GDM status.

DEMOGRAPHIC CHARACTERISTICS	CATEGORIES	GDM (N = 72)		CONTROL (N = 49)		*P* VALUE*
		N	%	N	%	
Education	Uneducated	1	33.3	2	66.7	.532
	Primary education	3	75.0	1	25.0	
	Intermediate education	2	66.7	1	33.3	
	Secondary education	24	66.7	12	33.3	
	Diploma	3	33.3	6	66.7	
	Undergraduate degree	36	58.1	26	41.9	
	Post graduate	3	75.0	1	25.0	
Occupation	House wife	44	65.7	23	34.3	.583
	Nurse	4	44.4	5	55.6	
	Teacher	5	55.6	4	44.4	
	Employee with intermediate level	4	66.7	2	33.3	
	Employee with high level	9	42.9	12	57.1	
	Doctor	2	66.7	1	33.3	
	Other	4	66.7	2	33.3	
Husband education	Uneducated	1	33.3	2	66.7	.176
	Primary Education	3	75.0	1	25.0	
	Intermediate education	8	57.1	6	42.9	
	Secondary education	22	78.6	6	21.4	
	Diploma	6	37.5	10	62.5	
	Undergraduate degree	27	56.2	21	43.8	
	Postgraduate	5	62.5	3	37.5	
Husband occupation	Manager	39	60.0	26	40.0	.499
	Retired	3	75.0	1	25.0	
	Technician	4	66.7	2	33.3	
	Seller	1	50.0	1	50.0	
	Military	4	44.4	5	55.6	
	Teacher	7	63.6	4	36.4	
	Engineer	7	70.0	3	30.0	
	Doctor	1	16.7	5	83.3	
	Other	6	75.0	2	25.0	
Income	<5000 SR	16	69.6	7	30.4	.588
	5000-10 000 SR	21	52.5	19	47.5	
	10 000-15 000 SR	22	57.9	16	42.1	
	>15 000 SR	13	65.0	7	35.0	

*Chi-square test.
Abbreviation: GDM, gestational diabetes mellitus.

Table 3. Food consumption habits among controls and GDM subjects.

VARIABLES	CONTROL 1 (N=49)		GDM (N=72)		*P* VALUE*
	N	%	N	%	
Skipping meals					
Breakfast	18	36.7	23	31.9	.53
Lunch	4	8.2	12	16.7	
Dinner	15	30.6	18	25	
No meal skipped	12	24.5	19	26.4	
Egg consumption					
Yes	43	87.8	70	97.2	.04
No	6	12.2	2	2.8	
Type of milk consumed					
Full fat	33	67.3	27	37.5	.08
Low fat	12	24.5	40	55.6	
Skimmed	1	2	1	1.4	
Not taken	3	6.1	4	5.6	
Type of cheese consumed					
Full fat	37	75.5	44	61.1	.81
Low fat	10	20.4	26	36.1	
Skimmed	0	0	1	1.4	
Not taken	2	4.1	2	1.4	
Type of red meat consumed					
High fat	27	55.1	23	31.9	.85
Medium fat	15	30.6	34	47.2	
Lean	4	8.2	10	13.9	
Not taken	3	6.1	5	6.9	
Cooking method of fish consumed					
Broth	3	6.1	3	4.2	.69
Fried	30	61.2	38	52.8	
Grilled	11	22.4	22	30.6	
Not taken	5	10.2	9	12.5	
Soft drinks consumption					
Yes	18	36.7	18	25	.24
Sometimes	13	26.5	17	23.6	
No	18	36.7	37	51.4	
Number of soft drinks cans consumed daily					
1/day	29	59.2	32	44.1	.89
2/day	1	2	2	2.8	

(Continued)

Table 3. (Continued)

VARIABLES	CONTROL 1 (N=49)		GDM (N=72)		*P* VALUE*
	N	%	N	%	
3/day	1	2	1	1.4	
Not taken	18	36.7	37	51.4	
Fast food consumption					
Yes	15	30.6	25	34.7	.86
Sometimes	22	44.9	29	40.3	
No	12	24.5	18	25	

Abbreviation: GDM, gestational diabetes mellitus.
*Chi-square test.

in the increase the risk of having GDM. A diet high in red and processed meat were associated with elevated risk of GDM significantly. Our study showed that 93% of GDM were consuming red meat.

Moreover, 51.4% of GDM group do not consume soft drinks but 44.4% are consuming soft drinks at least once a day. Also, the percentage is the same (36.7%) between control group who are consuming and not consuming soft drinks. There are almost similar percentage among both groups in consuming fast foods, GDM (75%) and control group (75.5%).

In this study, 51.4% of GDM group do not consume soft drinks but 44.4% are consuming soft drinks at least once a day. Also, the percentage of control group who are consuming and not consuming soft drinks is the same (36.7%). This results in the same line with Chen et al,[24] who reported that, higher consumption of sugar sweetened cola (⩾5 servings/week) in pre-pregnancy was associated with an elevated risk of GDM.

In addition, fast food consumption contributes to weight gain and many health risks. Consequently, pregnant women who consume fast foods are at a high risk for GDM. In this study, GDM group (40.3%) and control group (44.9%) are consuming fast foods sometimes once a week (43.1%), twice a week (18.1%), three times a week (9.7%), and more than three times a week (4.2 %) for GDM and (53.1%) for control group. Moreover, (97.2%) of GDM and (98%) of control group are believing that fast foods are harmful. These results are in agreement with Dominguez et al[25] who concluded that higher consumption of fast foods in pre-pregnancy is considered as an independent risk factor for developing gestational diabetes.

Our results showed that vitamin D is higher among controls than GDM group. This results in the same line with those reported by Meinilä et al[13] and Zhang et al,[26] who have linked insufficient intake of vitamin D with high risk of GDM.

Another study mentioned that having high-fat dairy products had a protective effect against GDM which is supported by our study as well.[27] Women with medium or high intake of

Table 4. Comparison of energy, carbohydrates intake, vitamin C, and vitamin D according to RDA between GDM and control group using 24h dietary recall.

	CONTROLS	GDM	*P* VALUE*
	MEDIAN (IQR)	MEDIAN (IQR)	
Energy (Kcal)	1431 (1142, 1803)	1380 (1741, 1108)	.540
Carbohydrates (g)	196 (144, 252)	186 (146, 239)	.492
Vitamin D (IU)	79 (32, 154)	54 (28, 81)	.021
Vitamin C (mg)	11 (5, 26)	31 (7, 57)	.004

Abbreviations: GDM, gestational diabetes mellitus; IQR, interquartile range; RDA, recommended dietary allowance.
*Mann Whitney U-test.

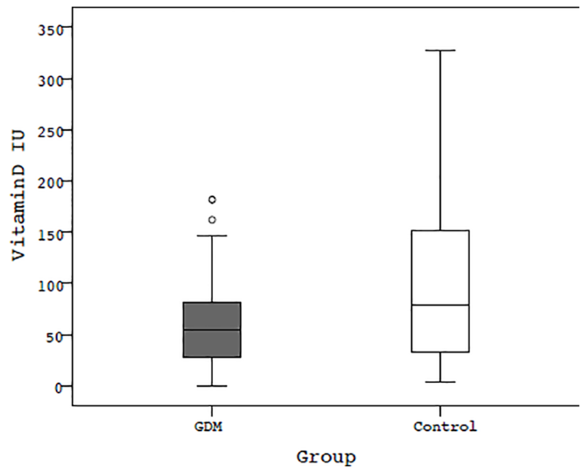

Figure 1. Vitamin D dietary intake among control and GDM groups. GDM indicate gestational diabetes mellitus.

full-fat milk had a significantly lower risk for GDM and higher amount of low-fat milk consumption had a significantly higher risk for GDM.

According to Li and Xing[28] in a double-blinded clinical trial found that the consumption of yogurt fortified with vitamin D improved the insulin resistance in women with GDM, which contradicted our findings with a majority of control group who did not eat fortified yogurt with a percentage of 32.7% compared to 15.3% of GDM group. The results of our study found that 83.3% of GDM pregnant women were not consuming fatty fish like canned tuna, which is in the same line as with those reported by Al-Faris[14] who suggested the consumption of fatty fish because fatty fish such as salmon, tuna, and sardines provide 200–350 IU of vitamin D per 100g.

The findings of Valkama et al[29] suggested that an increased intake of low-fat but not full-fat cheese between pre and early pregnancy is associated with a lower risk of GDM in high-risk women. These results agree with current study; 61.1% of GDM pregnant women consumed full-fat cheese. Majority of GDM pregnant women (91.8%) are not taking cod liver oil. The result of Ostadrahimi et al,[30] illustrated that no evidence supports effectiveness of using fish oil supplement during pregnancy in preventing or treating GDM.

Zhou et al[31] demonstrated that consumption of low carbohydrate and high-protein diet associated with high risk of GDM. On the other hand, Zhang et al[32] found that excessive consumption of carbohydrates increases the incidence of GDM. While our results revealed that control (118%) and GDM (111.6%) groups carbohydrates intakes were higher than the RDA. Looman et al[33] concluded that the intake of fruit and fruit juice in high amounts were protective against GDM, which conflicts with this study that found fortified orange juice consumption shows a higher significant risk for GDM this might be due to a cofactor like high sugar content in orange juice.

The study results reveal that most of GDM pregnant women (48.6%) not exposed to sunlight. But the 29.2% of GDM exposed to sunlight at period of (9-10 a.m). Alamri[34] presented that the optimum time to expose to sunlight from 8:30 to 10:00 a.m and 1:00 to 2:30p.m in Dammam that effective in prevent vitamin D deficiency. About 51.4% of GDM and 77.6 control had a light brown skin color which consider risk for vitamin D deficiency. Martin et al[35] found that the immigrants with dark skin from Middle East region are at high risk for vitamin D deficiency. Moreover, Richard et al[36] concluded that vitamin D deficiency was statistically significant in dark skin pregnant women compared to light skin color. We found that 33.3% of GDM and 38.8% of control women used sunscreen. In contrast, a study done by Kearney et al[37] on 121 Saudi pregnant women showed that 53.7% used sunscreen which mean there is an increase in using sunscreen in pregnant women in the last 2years in Saudi Arabia that lead to increase prevalence of vitamin D deficiency.

Overall, low vitamin D intake, high intakes of eggs, fortified yogurt and low-fat milk intake significantly increased the risk of GDM while, full-fat milk was protective. However, skipping breakfast, consuming red meats and processed meat may be associated with increasing the risk of GDM and canned tuna in water can be protective. Moreover, carbohydrate intake was higher than the RDA in both groups and the amount is still conflicting in managing GDM.

This study had several limitations; sample size did not reach the target of the number of participants; biochemical analysis

Table 5. Awareness about the dietary sources of vitamin D and supplementation intake.

VARIABLES		CONTROL		GDM		*P* VALUE*
		N	%	N	%	
Awareness about the dietary sources of vitamin D	Yes	30	61.2	42	58.3	0.46
	No	19	38.8	30	41.7	
Vitamin D supplementation intake	Yes	15	30.6	16	22.2	0.44
	No	28	57.1	47	65.3	
	Sometimes	6	12.2	9	12.5	

Abbreviation: GDM, gestational diabetes mellitus.
*Chi-square test.

Table 6. Family history of GDM and sun exposure.

VARIABLES		GDM GROUP						P VALUE	CONTROL GROUP						*P* VALUE*
		SUN EXPOSURE							SUN EXPOSURE						
		YES, N	%	SOMETIMES, N	%	NO., N	%		YES, N	%	SOMETIMES, N	%	NO., N	%	
Family history of GDM	Yes	7	13	20	37	27	50	.891	8	23	15	43	12	34	.281
	No	3	17	7	39	8	44		3	21	3	21	8	57	

Abbreviation: GDM, gestational diabetes mellitus.

Table 7. Association between sun exposure and GDM among the study subjects.

VARIABLES		GROUP				*P* VALUE
		GDM		CONTROL		
		N	%	N	%	
Sun exposure	Yes	10	47.6	11	52.4	.444
	Sometimes	27	60.0	18	40.0	
	No	35	63.6	20	36.4	
Time of sun exposure	9 am-11 am	24	60.0	16	40.0	.518
	11 am-1 pm	5	50.0	5	50.0	
	1 pm-3 pm	7	43.8	9	56.3	
Way of exposure	Regular	2	40.0	3	60.0	.452
	Irregular	35	57.4	26	42.6	
Duration of sun exposure	$\leqslant$15 mins	31	57.4	23	42.6	.640
	>15 mins	6	50.0	6	50.0	
Frequency of sun exposure per week	Once	9	64.3	5	35.7	.305
	Twice	8	53.3	7	46.7	
	Thrice	6	37.5	10	62.5	
	3 times	14	66.7	7	33.3	
Body parts exposed to sunlight	Hands	22	52.4	20	47.6	.426
	Face	15	62.5	9	37.5	
Sunscreen usage	Yes	24	55.8	19	44.2	.057
	Sometimes	11	91.7	1	8.3	
	No	37	56.1	29	43.9	
Skin color	White	28	80.0	7	20.0	.009
	Brown	37	49.3	38	50.7	
	Black	7	63.6	4	36.4	

Abbreviation: GDM, gestational diabetes mellitus.

Table 8. Knowledge on vitamin D and GDM and its association on GDM among the study subjects.

VARIABLES		GROUP				*P* VALUE
		GDM		CONTROL		
		N	%	N	%	
Do you think that vitamin D deficiency and GDM are correlated?	Strongly agree	3	60.0	2	40.0	.196
	Agree	16	72.7	6	27.3	
	Neither agree nor disagree	33	58.9	23	41.1	
	Disagree	20	57.1	15	42.9	
	Strongly disagree	0	0.0	3	100.0	
Do you know the sources of vitamin D	Yes	42	59.2	29	40.8	.926
	No	30	60	20	40	
Vitamin D supplements	Yes	16	51.6	15	48.4	.573
	Sometimes	9	60.0	6	40.0	
	No	47	62.7	28	37.3	

Abbreviation: GDM, gestational diabetes mellitus.

Table 9. Logistic regression analysis results for finding the significant factors for GDM.

	GDM N	%	CONTROL N	%	OR	95% CI	*P* VALUE
Low-fat milk							
Low	29	40.3	37	75.5	Reference		
Medium	18	25	2	4.1	11.5	2.5, 53.5	.002
High	25	34.7	10	20.4	3.2	1.3, 7.7	.01
Full-fat milk							
Low	45	62.5	18	36.7	Reference		
Medium	9	12.5	11	22.4	0.3	.1, .9	.035
High	18	25	20	40.8	0.4	.2, .8	.017
Fortified yogurt							
Low	12	16.7	19	38.8	Reference		
Medium	41	56.9	20	40.8	3.3	1.3, 8.0	.01
High	19	26.4	10	20.4	3	1.1, 8.6	.04
Egg							
Low	3	4.2	7	14.3	Reference		
Medium	57	79.2	33	67.3	4	.9, 16.7	.054
High	12	16.7	9	18.4	3.1	.6, 15.5	.166
Canned tuna in water							
Low	64	88.9	37	75.5	Reference		
Medium	8	11.1	12	24.5	0.4	.1, 1.03	.057

(Continued)

Table 9. (Continued)

	GDM N	%	CONTROL N	%	OR	95% CI	*P* VALUE
Cod liver Oil							
Low	70	97.2	47	95.9	Reference		
Medium	2	2.8	2	4.1	0.7	.1, 4.9	.695
Fortified orange Juice							
Low	8	11.1	12	24.5	Reference		
Medium	51	70.8	24	49	3.2	1.2, 8.8	.026
High	13	18.1	13	26.5	1.5	.5, 4.9	.5

Abbreviations: CI, confidence interval; GDM, gestational diabetes mellitus; OR, odds ratio.

of vitamin D was not available to confirm a deficiency. Diabetic control marker A1C was also not available.

Recommendations

Saudi women with GDM need a well-organized dietary counseling before, during pregnancy and after delivery especially for vitamin D sources because it may protect against GDM.

Author Contributions

AA supported the proposal writing, data analysis and writing of the article. HH supported the proposal writing, data collection and writing of the article. WA supported the proposal writing, data analysis and writing of the article. OA supported the proposal writing and writing of the article. NQ supported the proposal writing, data collection and writing of the article. TS supported the statistical analysis and writing of the article. RM supported the proposal writing and writing of the article. Also, RM was responsible for performing all stages of the study. All authors read and approved the final manuscript.

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