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The effect of fruit consumption time on glucose regulation in pregnancy with gestational diabetes

O efeito do tempo de consumo de fruta na regulação da glicose na gravidez com diabetes gestacional

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ABSTRACT

Objective
This study aims to determine the effect of fruit consumption time on blood glucose regulation in pregnant women with gestational diabetes.

Methods
The study was carried out with 64 volunteer participants diagnosed with gestational diabetes. Participants who were directed to the Department of Nutrition and Dietetics were divided into two groups according to the order of application; Group 1 was included in the nutrition treatment program for a week, consuming fruit for the main meal and Group 2 for the snack. During this process, the participants were applied a personalized nutrition plan that was adjusted equally for macronutrients of all meals containing isocaloric 3 main and 4 snacks. In this process, blood glucose values were measured six times a day by the participants and the blood glucose results of both groups before starting the nutrition therapy and on the seventh day after starting the medical nutrition therapy were compared.

Results
The mean age of the women participating in the study was 33.50±4.95 years and 32.28±5.18 years for the 1st and 2nd groups, respectively, and the groups were similar in terms of anthropometric measurements. The post-diet average of postprandial blood glucose levels in the morning within each group dropped from 180mg/d to 115mg/dL (p<0,001) for Group 1 and from 185mg/dL to 110mg/dL (p<0,001) for Group 2. There was a decrease in the fasting plasma glucose and postprandial blood glucose levels measured in the morning, noon and evening before and after the medical nutrition therapy of the groups, but no statistically significant difference was found between the groups (p>0.05). All participants on the gestational diabetes diet had normal blood sugar levels without the need for insulin. A statistically significant decrease was observed in the postprandial blood glucose-fasting plasma glucose difference

levels of the pregnant women in the group that consumed fruit for snacks (Group 2) on the seventh day of the study (p<0,001). There was no significant difference in the pre-diet and post-diet morning fasting plasma glucose values of both groups (p>0,05).

Conclusion

This study found that medical nutrition therapy in pregnant women with gestational diabetes led to a decrease in blood glucose levels, but consuming fruits as a snack or at the main meal did not make a significant difference on fasting plasma glucose and postprandial blood glucose. It was concluded that the type and amount of carbohydrates consumed daily in gestational diabetes are determinative on blood glucose level.

Keywords: Diabetes, gestational. Fructose. Fruit. Glycemic index.

RESUMO

Objetivo

O objetivo deste estudo é determinar o efeito do tempo de consumo de fruta na regulação da glucose no sangue em mulheres grávidas com diabetes gestacional.

Métodos

Este estudo foi realizado com 64 participantes voluntários diagnosticados com diabetes gestacional. Os participantes que foram encaminhados para o Departamento de Nutrição e Dietética foram divididos em dois grupos, de acordo com a ordem da sua aplicação. O grupo 1 foi incluído no programa de tratamento médico nutricional durante uma semana, consumindo fruta para a refeição principal e o grupo 2 para os lanches. Neste processo, foi aplicado aos participantes um plano de nutrição personalizado, com isocalórico, 3 refeições principais e 4 lanches, os macronutrientes de todas as refeições foram ajustados igualmente.

Neste processo, os valores de glicemia foram medidos seis vezes por dia pelos participantes, e foram comparados os resultados da glicemia de ambos os grupos antes de se iniciar a terapia nutricional médica e no sétimo dia após o início da terapia nutricional médica.

Resultados

A idade média das mulheres que participaram no estudo foi de 33,50±4,95 e 32,28±5,18 anos para o 1º e 2º grupos, respetivamente, e não houve diferença entre os grupos em termos de medidas antropométricas. A glicemia média pós-prandial de manhã após terapia nutricional médica dentro dos grupos variou entre 180mg/d a 115mg/dL (p<0,001) para o Grupo 1, e de 185mg/dL a 110mg/dL para o Grupo 2 (p<0,001). Houve uma diminuição nos níveis de glicemia em jejum e glicemia média pós-prandial medidos de manhã, meio-dia e noite antes e depois da terapia nutricional médica dos grupos, mas não houve diferença estatisticamente significativa entre os grupos (p>0,05). Os níveis de açúcar no sangue de todos os participantes na dieta diabetes gestacional baixaram para níveis normais sem necessidade de terapia com insulina. Uma diminuição estatisticamente significativa foi observada no sétimo dia do estudo nos níveis de diferença do glicemia média pós-prandial-glicemia em jejum das mulheres grávidas do grupo que consumiram fruta como aperitivo (Grupo 2). (p<0.001). Não houve diferença significativa nos valores de glicemia em jejum matinal de ambos os grupos antes e depois da dieta (p>0,05).

Conclusão

Como resultado deste estudo, verificou-se que a terapia nutricional levou a uma diminuição do açúcar no sangue em mulheres grávidas com diabetes gestacional, mas o consumo de fruta como lanche ou refeição principal não fez uma diferença significativa no jejum e na glucose do sangue pós-prandial. Concluiu-se que o tipo e a quantidade de hidratos de carbono consumidos diariamente na diabetes gestacional são determinantes para o nível de glicose no sangue.

***Palavras-chave**: Diabetes gestacional. Frutose. Frutas. Índice glicêmico.*

INTRODUCTION

Gestational Diabetes is defined as glucose intolerance with onset or is first diagnosed during pregnancy leading to hyperglycemia at different levels [1]. It usually occurs in the second trimester of pregnancy, with increased blood glucose levels between weeks 24-28 [2].

Nutrition therapy provided during pregnancy and lifestyle changes lie at the heart of treating gestational diabetes [3]. The purpose of nutrition therapy for GDM are to reduce the blood glucose level to reference range, to ensure the continuity of blood glucose regulation, to prevent fasting ketosis and to provide all nutritional sources mother and fetus need [4].

Oxidative stress is an important cause and most important therapeutic target of GDM. Fruits are rich sources of natural antioxidants and among the bioactive compounds determined to have anti-diabetic activities, phenolic compounds, polysaccharides, vitamin C contents are rich. Most of them have antioxidant activity. Therefore, fruits are a good source of anti-diabetic nutrients and a balanced diet rich in different fruits is recommended for diabetic patients and pre-diabetic population. For this feature of fruits, varieties and consumption amounts are important. Especially the red, crimson, purple or black colored ones are good natural anti-diabetic foods [5]. However, fruits contain high sugar levels, including fructose, glucose and sucrose. Also, the sugar content in fruits can cause a high post-meal insulin level that predisposes individuals to diabetes, and can increase uric acid production, which is associated with high insulin resistance. Fruit intake without substituting other foods leads to increased energy intake and weight gain, leading to higher blood sugar levels [6]. Firstly, a large number of reactive oxygen species and free radicals are produced during pregnancy, especially during the first trimester, due to the high metabolism of the placenta. There is evidence to demonstrate that the consumption of certain berries and fruits was associated with increased plasma antioxidant capacity. Secondly, the anti-inflammatory effects of polyphenols are reported through a variety of molecular targets [7].

The type and amount of carbohydrates consumed in nutritional therapy and the Glycemic Index (GI) and portion of the fruit are significant determinants on blood glucose level [8]. Excessive fruit consumption and consumption of fruits with high GI, especially in the second trimester of pregnancy, increase the risk of GDM [9]. Some studies found that daily consumption of 460 grams of fruit did not make any difference in the first and second trimesters of pregnancy, but it increased the risk of GDM in the third trimester of pregnancy. However, the low GI and high polypherol ingredient of fruits were reported as factors that reduce the risk of GDM [9-11].

In a study, pregnant women with similar anthropometric measurements were divided into three groups. First group was given 120 grams of apple before the main meal, second group was given the same amount after the main meal, and the control group was given no fruit. While the energy consumption of the group that consumed fruit before the main meal decreased by 18.5% compared to the control group, it was observed that there was a significant increase in the Glucagon-Like Peptide-1 (GLP-1) levels compared to the group that consumed fruit after the main meal. There was no significant difference found in blood glucose levels of the groups. It was stated that further studies were needed to determine the effect of fruit consumption time on blood glucose levels [12].

The effect of fruit consumption, type of the consumed fruit, amount of the consumed fruit and consumption of fruit at certain meals or times on blood glucose regulation in pregnant women with GDM *Mellitus* is unclear. This study aims to investigate the effect of fruit consumption time on blood glucose regulation in pregnant women diagnosed with GDM *Mellitus*. In the presence of a Nutrition and Dietetics Specialist, with the application of a one-week nutrition therapy that is appropriate for GDM on pregnant women diagnosed with GDM, significant decreases were expected in the Fasting Plasma Glucose (FPG) and Postprandial Glucose (PPG) levels of all participants. It was predicted that the total amount and type of carbohydrates consumed would effect the blood glucose, not the consumption of fruit at the snack time or with the main meal.

MATERIAL AND METHODS

Research design

In a private hospital in Istanbul, 80 pregnant women who met the research criteria applied for the research between 15.06.2018 and 15.02.2020.5 of the pregnant women were not included in the study for they did not meet all the research criteria. The study was approved number of (2017-KAEK-120)/40 by Istinye University Clinical Research Ethics Committee. 75 pregnant women who met the criteria were informed about the study and the experimental period started after they signed the consent form stating that they were willing to participate in the research. During the study, 5 of the pregnant women got excluded because they did not comply with the nutrition therapy, and 6 of them because they did not measure their blood glucose for the required number of times. The research was completed with a total of 64 participants. Participants who met the criteria were divided into two groups according to the order of application: The group consuming fruit at the main meal (Group 1: 32 people) and the group consuming fruit at the snack time (Group 2: 32 people). Study's design demonstrates the flowchart of the research (Figure 1).

The daily energy intake of the participants in both groups was arranged isocaloric ally as seven meals a day (3 main – 4 snacks). In both groups, daily macro element elements and energy contents were planned equally and individually. The daily energy, protein, fat and carbohydrate amounts of the groups were respectively as 1st group 1955.2 kcal/d 20%, 35%, 45%, 2nd group 2009.5 kcal/d 20%, 36%, 44%. All daily snacks of both groups contain equal carbohydrates. Although the trial period of medical nutrition therapy depends on the gestational week and glucose levels, the trial period of the study was planned as one week due to the convenience of being one or two weeks at the most [13].

As recommended for individuals with diabetes, 45-50% of daily energy of the participants was composed of carbohydrates, 15-20% from proteins and 25-30% from fats [14]. The amount of fructose was adjusted so as not to exceed 10% of the daily carbohydrate intake [1 k]. According to with GDM dietary guidelines fruits with low GI were added (like an apple, orange, mandarin) to the daily nutrition plan as three servings per day composing 10% of the daily carbohydrate intake (200 g).

Patient Population and Randomization

To determine the minimum number of participants to participate in the study, the number of individuals diagnosed with GDM who had applied to a private hospital in Istanbul in the last year was taken as the universe (85 people). Power analysis was carried out in the research to determine the minimum number of participants to represent the universe.

Considering the similar studies in the literature, the expected change in sample size was calculated as 0.53 (with 80% power and 5% margin of error) and 32 participants (Group 1, 16 participants; Group 2, 16 participants) [16]. 64 volunteer pregnant women diagnosed with GDM were included in the study. Participants were randomly selected according to the order of application and divided into two groups: Group 1, 32 participants, and Group 2, 32 participants.

After the research was completed, the power of the research was calculated as 5% margin of error, 100% using the fasting blood glucose change with the PASS 11® package program, and 99.9% using the fasting blood glucose change.

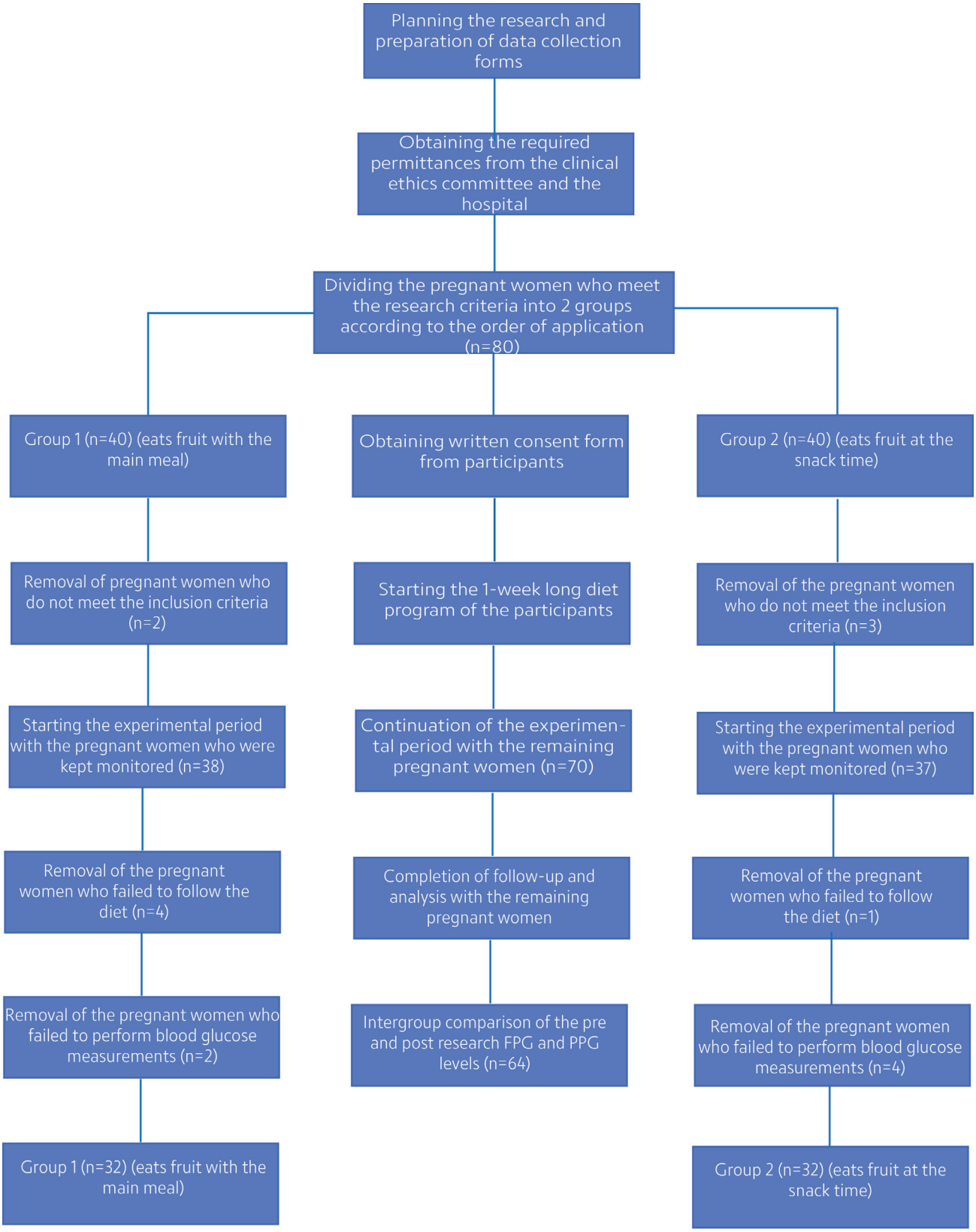

Figure 1 – Research Flowchart.

Volunteer pregnant women of all ages with a singleton pregnancy, not having diagnosed with Diabetes *Mellitus* (DM), Impaired Glucose Tolerance (IGT) or hypoglycemia before pregnancy, not having diagnosed with GDM in previous pregnancies, without any comorbid diseases, with pre-pregnancy body mass index in the range of 20-25 kg/m^2, not using insulin, who gained maximum 10 kg during pregnancy, who have no condition that prevents fruit consumption, who were diagnosed with GDM by the Obstetrics and Gynecology Polyclinic based on the results of the Oral Glucose Tolerance Test performed within the 24-28th week and who were referred to the Nutrition and Dietetics Department were included in the research.

Pregnant women with multiple pregnancies, who did not consume fruit, who had additional diseases other than GDM (such as [type 1 diabetes *Mellitus* (T1DM), T2DM, IGT, hypoglycemia, preeclampsia, hypertension (HT)], kidney diseases), and those using insulin were excluded from the study. In addition, pregnant women who did not comply with the nutrition treatment program prepared during the research period or who failed to track their glucose levels at home were not included in the study.

Data Collection

Participants consist of pregnant women who applied to the Obstetrics and Gynecology Polyclinic, who were in the 24-28th week of their pregnancy, diagnosed with GDM because of the routine OGTT test requested by their physicians and referred to the Nutrition and Dietetics Polyclinic. After the pregnant women who were planned to be included in the study were informed.

Patient Population and Randomization

To determine the minimum number of participants to participate in the study, the number of individuals diagnosed with GDM who had applied to a private hospital in Istanbul in the last year was taken as the universe (85 people). Power analysis was carried out in the research to determine the minimum number of participants to represent the universe.

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After the research was completed, the power of the research was calculated as 5% margin of error, 100% using the fasting blood glucose change with the PASS 11® package program, and 99.9% using the fasting blood glucose change.

Volunteer pregnant women of all ages with a singleton pregnancy, not having diagnosed with DM, IGT or hypoglycemia before pregnancy, not having diagnosed with GDM in previous pregnancies, without any comorbid diseases, with pre-pregnancy body mass index in the range of 20-25 kg/m^2, not using insulin, who gained maximum 10 kg during pregnancy, who have no condition that prevents fruit consumption, who were diagnosed with GDM by the Obstetrics and Gynecology Polyclinic based on the results of the Oral Glucose Tolerance Test performed within the 24-28th week and who were referred to the Nutrition and Dietetics Department were included in the research.

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pregnant women who did not comply with the nutrition treatment program prepared during the research period or who failed to track their glucose levels at home.

Participants consist of pregnant women who applied to the Obstetrics and Gynecology Polyclinic, who were in the 24-28th week of their pregnancy, diagnosed with GDM because of the routine OGTT test requested by their physicians and referred to the Nutrition and Dietetics Polyclinic. After the pregnant women who were planned to be included in the study were informed about the research, each participant signed the Informed Volunteer Consent Form. The participants were asked questions about their sociodemographic information, health condition, information about their pregnancy and dietary habits with the information form prepared by the researcher. After the body analysis of the participants were completed and the researcher prepared their nutrition programs, a daily food and blood glucose record form was given to the participants. They were asked to record the foods they consumed as well as the FPG and PPG results that they would measure at home with a glucometer for a week. The fasting and PPG levels in the morning before and on the seventh day of the study, and the fasting and PPG levels in the morning, noon, and evening on the first and seventh day of the study were compared of the two groups that consumed fruit in the main meal and at snack time.

Statistical analyzes of the data obtained in the study were evaluated using the IBM®SPSS®, version 21 package program. Quantitative variables are demonstrated with mean, standard deviation, median, minimum and maximum values. Qualitative variables are demonstrated with numbers and percentages. Participants consist of two groups: those who consume fruit with the main meal and those who consume fruit at snack time. Chi-square test (Pearson Chi-square test, Fisher's exact test, multi-eyed Chi-square test) was used for the differences between the groups regarding qualitative variables. The convenience of the quantitative variables to the normal distribution was checked using the Shapiro Wilk test. Differences between groups in terms of quantitative variables were examined using the t-test for the variables in which the parametric test assumptions were met, and the Mann Whitney U test for the variables where the parametric test assumptions were not met. The relationship between quantitative variables was evaluated with the help of Spearman Correlation coefficient. The significance level was taken as $p<0.05$.

RESULTS

This part of the study presents the findings obtained from the data analysis collected in the research conducted with 64 pregnant women diagnosed with GDM. Among the pregnant women who participated in the study, a statistically significant difference was found between the groups in terms of smoking habit during pregnancy and having a history of food allergies ($p<0.05$). There was no statistically significant difference between the groups in terms of age, education level, employment status, family history of diabetes, drug use, physical activity level, and smoking habit before pregnancy ($p>0.05$).

There was no statistically significant difference between the groups in terms of anthropometric measurements (height, body mass index, current body weight, weight gains during pregnancy) ($p>0.05$).

When the FPG, PPG and PPG-FPG differences of the participants were examined before the study, no statistically significant difference was found between the groups ($p>0.05$). When the FPG and PPG levels of the pregnant women in Group 1 and Group 2 were measured in the morning before starting the research and in the morning of the seventh day after starting the research were compared, no statistically significant difference was found between the groups ($p>0.05$). A statistically significant decrease was observed in the PPG levels of pregnant women in both Group 1 and Group 2 measured in the morning of the seventh day of the study ($p<0.05$) (Table 1).

Table 1 – Evaluation of the anthropometric measurements of pregnant women and the pre-research fasting plasma glucose, postprandial glucose and postprandial glucose-fasting plasma glucose difference according to the groups.

Variables	Group 1		Group 2		Test value	*p*
	Mean±SD	Median	Mean±SD	Median		
Height (cm)	160.31±4.05	160.00	160.88±5.56	160.00	t=-0.463	0.645
Body weight before pregnancy (kg)	64.06±12.77	62.00	68.70±10.49	67.00	t=-1.589	0.117
Pre-pregnancy BMI (kg/m^2)	25.31±4.15	25.00	26.52±4.22	26.00	z=-1.289	0.197
Current body weight (kg)	71.26±11.87	70.50	77.36±11.81	74.00	z=-1.903	0.057
Weight gained during pregnancy (kg)	7.47±3.36	8.00	7.47±4.39	7.00	z=-0.675	0.500
FPG (mg/dL)	89.22±10.32	88.00	92.09±12.47	90.50	t=-1.005	0.319
PPG (mg/dL)	182.03±18.89	180.00	183.66±20.85	185.50	t=-0.327	0.745
PPG-FPG (Difference)	92.81±20.93	90.00	91.56±23.40	92.50	t=0.225	0.823

Note: Group 1: The group consuming fruit in the main meal. Group 2: The group consuming fruit at the snack time. BMI: Body Mass Index, FPG: Fasting plasma glucose, PPG: Postprandial glucose, z: Mann Whitney U test z statistic; t: t-test statistic, SD: Standard Deviation.

The decrease in the difference between PPG-FPG, measured in the morning on the seventh day of the study of the pregnant women in Group 1 and Group 2 was found to be statistically significant (p<0.05). However, no statistically significant difference was found between the two groups in terms of the change of PPG-FPG difference (p>0.05) (Table 2).

Table 2 – Evaluation of the change of the fasting plasma glucose, postprandial glucose and postprandial glucose-fasting plasma glucose difference of the pregnant women measured before and on the seventh day of the study between groups and within the group.

Measurement time	Variable	Group1			Test value[1]	p^1	Group 2			Test value[2]	p^2	Test value[3]	p^3
		Mean±SD	Median	Min-Max			Mean±SD	Median	Min-Max				
Pre-research	FPG	89.22±10.32	88.00	73-113	-0.935	0.350	92.09±12.47	90.50	72-122	-2.273	0.023	-1.296	0.195
Day 7 of research	FPG	87.28±11.83	87.00	68-115			84.66±11.38	82.00	65-120				
Pre-research	PPG	182.03±18.89	180.00	151-227	-4.937	<0.001	183.66±20.85	185.50	127-220	-4.918	<0.001	-1.074	0.283
Day 7 of research	PPG	115.00±26.06	107.50	73-183			110.34±17.83	110.00	68-139				
Pre-research	PPG-FPG (Difference)	92.81±20.93	90.00	57-137	-4.918	<0.001	91.56±23.40	92.50	17-131	-4.899	<0.001	-0.195	0.846
Day 7 of research	PPG-FPG (Difference)	27.72±121.09	23.00	-7-72			25.69±126.10	25.00	-9-52				

Note: Group 1: the group consuming fruit in the main meal. Group 2: the group consuming fruit at the snack time. p^1: Comparison of the measurements of Group 1 before the study and on the 7th day of the study, p^2: Comparison of the measurements of Group 2 before the study and on the 7th day of the study, p^3: Comparison of pre-research and 7th-day measurements between the two groups. Test value[1] and Test value[2]: Wilcoxon test z statistic. Test value[3]: Mann Whitney U test z statistic. FPG: Fasting plasma glucose, PPG: Postprandial glucose, SD: Standart Deviation.

For women in Group 1, there was a statistically significant difference in the changes in the amount of PPG measured in the morning before the study and in the morning of the seventh day after the start of the study (p<0.05). For women in Group 2, there was a statistically significant difference in the changes in the amount of PPG measured in the morning before the study and in the morning of the seventh day after the start of the study (p<0.05) (Table 3).

There was no linear relationship between the FPG values measured pre-research and in the morning of the seventh day of the study, and the number of meals and anthropometric measurements (p>0.05) (Table 4).

Table 3 – Evaluation of the change of the Fasting plasma glucose, Postprandial glucose, and Postprandial glucose -Fasting plasma glucose difference of the pregnant women measured on the first day of the research and in the morning, noon and evening of the seventh day of the research.

Time / Before-After	Variables	Group 1			Test value[1]	p^1	Group 2			Test value[2]	p^2	Test value[3]	p^3
		Mean±SD	Median	Min-Max			Mean±SD	Median	Min-Max				
Morning													
Day 1	FPG	92.38±15.40	90.00	72-141	-1.764	0.078	88.75±11.66	89.00	60-114	-1.644	0.100	-0.477	0.633
Day 7	FPG	87.28±11.83	87.00	68-115			84.66±11.38	82.00	65-120			-0.907	0.364
Day 1	PPG	124.19±25.42	125.00	69-183	-2.033	0.042	123.03±26.98	116.00	62-185	-2.783	0.005	-0.316	0.752
Day 7	PPG	115.00±26.06	107.50	73-183			110.34±17.83	110.00	68-139			-0.282	0.778
Day 1	PPG-FPG (Difference)	31.81±24.67	34.5	-10-94	-1.147	0.251	34.28±25.78	33	-7-107	-1.986	0.047	-0.141	0.888
Day 7	PPG-FPG (Difference)	27.72±21.09	23	-7-72			25.69±16.10	25	-9-52			-0.665	0.506
Noon													
Day 1	FPG	87.31±14.06	86.00	63-140	-0.314	0.754	87.72±11.53	88.50	58-115	-0.783	0.434	-0.558	0.577
Day 7	FPG	88.28±22.58	86.50	60-181			86.22±11.15	85.50	61-110			-0.269	0.788
Day 1	PPG	116.63±21.99	115.50	67-180	-1.254	0.21	110.81±23.20	110.50	71-150	-0.350	0.727	-0.759	0.448
Day 7	PPG	112.00±18.18	110.00	85-140			109.88±19.29	110.00	79-177			-0.578	0.563
Day 1	PPG-FPG (Difference)	29.31±23.75	31	-30-80	-0.617	0.537	23.09±19.40	24	-18-64	-0.154	0.877	-0.101	0.920
Day 7	PPG-FPG (Difference)	23.72±26.03	24.5	-81-64			23.66±18.28	24	-11-91			-0.806	0.420
Evening													
Day 1	FPG	90.19±12.65	91.00	65-125	-0.206	0.837	93.47±18.95	90.00	71-146	-0.905	0.365	-0.141	0.888
Day 7	FPG	88.94±12.06	89.00	66-115			89.44±10.03	89.00	73-110			-0.108	0.914
Day 1	PPG	114.28±21.48	114.50	68-155	-0.533	0.594	116.34±26.81	113.00	69-196	-1.101	0.271	-0.134	0.893
Day 7	PPG	113.75±19.42	114.50	77-162			106.94±14.65	102.00	85-141			-1.452	0.147
Day 1	PPG-FPG (Difference)	24.09±19.29	23.5	-23-61	-0.118	0.906	22.88±29.26	19.5	-36-125	-0.127	0.899	-1.109	0.267
Day 7	PPG-FPG (Difference)	24.81±17.22	21.5	-4-70			17.50±9.54	15.5	-3-42			-1.756	0.079

Note: Group 1: Those who consume fruit in the main meal. Group 2: Those who consume fruit at snack time. Test value1 and Test value[2]: Wilcoxon test z statistic. Test value[3]: Mann Whitney U test z statistic. p^1: Comparison of the measurements of Group 1 before the study and on the 7th day of the study, p^2: Comparison of the measurements of Group 2 before the study and on the 7th day of the study, p^3: Comparison of pre-research and 7th-day measurements between the two groups, FPG: Fasting plasma glucose PPG: Postprandial glucose, SD: Standart Deviation.

Table 4 – Evaluation of the relationship between the fasting plasma glucose and postprandial glucose values, the number of meals and anthropometric measurements of the pregnant women before the study and on the seventh day of the study within each group.

Variables	Group 1				Group 2			
	Pre-research		Day 7 of research		Pre-research		Day 7 of research	
	r	*p*	r	*p*	r	*p*	r	*p*
FPG								
Number of main meals	-0.186	0.307	-0.138	0.451	-0.246	0.174	-0.149	0.416
Number of snacks	0.126	0.491	-0.309	0.086	-0.132	0.472	-0.078	0.672
Weight gained during pregnancy (kg)	-0.227	0.212	-0.294	0.102	0.108	0.556	-0.086	0.640
Pre-pregnancy body weight (kg)	0.147	0.422	0.319	0.075	0.336	0.060	-0.014	0.939
Pre-pregnancy BMI (kg/m^2)	0.167	0.360	0.272	0.132	0.304	0.090	-0.133	0.467
Current body weight (kg)	0.098	0.594	0.299	0.097	0.323	0.071	-0.045	0.809
PPG								
Number of main meals	-0.110	0.547	-0.072	0.694	-0.012	0.949	-0.255	0.160
Number of snacks	-0.344	0.054	-0.190	0.297	-0.024	0.898	-0.277	0.125
Pre-pregnancy body weight (kg)	-0.168	0.358	0.294	0.103	-0.270	0.134	-0.196	0.282
Pre-pregnancy BMI (kg/m^2)	-0.117	0.525	0.267	0.139	-0.366	0.040	-0.060	0.746
Current body weight (kg)	-0.234	0.197	0.302	0.093	-0.178	0.329	-0.363	0.041
Weight gained during pregnancy (kg)	0.072	0.695	-0.168	0.358	0.028	0.880	-0.281	0.120

Note: Group 1: The group consuming fruit in the main meal. Group 2: The group consuming fruit at the snack time. r: Spearman Correlation Coefficient. BMI: Body Mass Index, FPG: Fasting plasma glucose, PPG: Postprandial glucose.

DISCUSSION

The GDM, which is becoming increasingly common due to the increase in T2DM and obesity, is one of the riskiest pregnancy complications in terms of maternal and fetal health.

The most prominent and most important treatment approach in GDM is nutrition therapy. The type and amount of carbohydrates in pregnant women with GDM are crucial, especially for post-meal glucose control. In pregnant women diagnosed with GDM, carbohydrates should be chosen from foods with a low GI, distributed to the meals in a balanced way and excessive carbohydrate consumption should be limited [18]. For this reason, it is necessary to be mindful about the amount and types of fruits daily consumed [16]. This study aimed to determine the effect of fruit consumption time on blood glucose regulation in pregnant women with GDM.

The PPG is related to the amount of all macronutrients, especially carbohydrates, and the GI level of carbohydrates has the most decisive effect on blood glucose. The daily intake of carbohydrates should be distributed as two or three snacks in addition to the main meals [19]. It has been reported that instead of decreasing the amount of carbohydrates consumed during pregnancy, the balanced distribution of consumed carbohydrates to daily meals and opting for carbohydrates with a low GI and glycemic-load are effective in ensuring the regulation of blood glucose and reducing the need for insulin therapy [20]. In a study by Walsh et al. [21], 140 pregnant women with GDM who had not diagnosed with GDM and were not treated with insulin before were randomly divided into two separate groups (group 1 was given a (66) low GI diet, group 2 was given a (74) normal diet). Both groups were given equal energy and carbohydrate diets, but a low GI diet was followed with one group and a normal diet with the other group. While there was no significant difference between the blood glucose levels of the two groups before the diet, a significant statistical decrease was found in the post-diet blood glucose level of the group consuming a low GI diet [22]. In another study conducted with pregnant women with GDM, low GI foods were given to one group and high GI foods containing the same amount of carbohydrates were given to the other group and their PPG levels were compared. The PPG decreased significantly in the first group, while it increased in the other group [23]. Diets with a low GI have a crucial role in regulating the increase in blood glucose levels in pregnant women with GDM [24]. In a study conducted with pregnant women with GDM, the participants were divided into two groups. A diet containing 40% carbohydrates was given to one group and 55% to the other group, and their blood glucose levels were compared. There was no difference between the two groups in terms of insulin need. It has been suggested that the nutrition treatment protocol in this regard should be modified by carrying out research on different populations [25]. In this study, a nutrition treatment plan that is with a low GI, isocaloric and with snacks containing equal amount of carbohydrates was applied to pregnant women. In this study, no statistically significant difference was found between the pre-research FPG, PPG, and PPG-FPG difference levels of the pregnant women in both groups ($p>0.05$). While there was no statistically significant difference was found between the groups when the FPG levels of the pregnant women in both groups were compared before the study and in the morning on the seventh day of the study ($p>0.05$), a statistically significant decrease was observed in the morning PPG levels of both groups after applying the appropriate nutrition therapy for GDM with low GI ($p<0.05$).

In this study, the effect of fruit consumption time on blood glucose level was investigated in pregnant women with GDM. Thanks to the high level of fiber and vitamins they contain, fruits have positive effects on metabolic diseases. However, the effects of long-term consumption of fresh fruit in terms of diabetes and vascular complications caused by diabetes are unknown. Studies show that

three essential macronutrients should be combined in a meal for an ideal blood glucose. The low GI and high polyphenol content of fruits are among the factors that contribute decreasing the risk of GDM. While daily consumption of 460 grams of fruit does not pose a risk for GDM in the first and second trimesters, it increases the probability of developing GDM in the third trimester [9].

Pregnant women with similar anthropometric measurements were divided into three groups in a study. First group was given 120 grams of apple before the main meal, second group was given the same amount after the main meal, and the control group was given no fruit. While the energy consumption of the group that consumed fruit before the main meal decreased by 18.5% compared to the control group, it was observed that there was a significant increase in the level of GLP-1 levels compared to the group that consumed fruit after the main meal. There was no significant difference found in the blood glucose levels of the groups. It was stated that further studies were needed to determine the effect of fruit consumption time on blood glucose level [12].

In this study, when the measurements of the pregnant women in the group consuming fruit for snacks (Group 2) were compared before the research and on the seventh day after the study, it was observed that the difference between PPG and FPG in the morning decreased significantly ($p<0.05$). For the group that consumes fruit in the main meal (Group 1), the number of carbohydrates at breakfast was planned as 42 grams since fruit was given with the main meals, and in Group 2 it was planned as 30 grams, since fruit was given only at snack time. Following the recommended maximum carbohydrate intake of 30 grams in the morning meal for pregnant women with GDM is the reason for this significant difference [26].

Although there was no statistically significant difference in the PPG-FPG levels of the pregnant women in Group 1 and Group 2, which were measured at noon and evening on the first day of the study and on the seventh day of the study, there was a statistical difference between PPG-FPG measured in the morning ($p<0.05$). The difference between the morning blood glucose is due to hyperglycemia due to gluconeogenesis activation in the morning hours because of excessive secretion of growth hormone, corticosteroids, glucagon and adrenaline hormones during sleep at night in response to the decrease in blood glucose levels late at night, and glucose release from muscle, liver and adipose tissue. Morning PPG levels may be higher in individuals with diabetes [27]. It is seen that the low GI diet compatible with GDM applied to the participants has significantly reduced the level of morning hyperglycemia.

CONCLUSION

This study found that nutrition therapy with a low GI is quite effective in preventing hyperglycemia, but consuming the fruit as a snack or at the main meal has no effect on blood glucose levels. With nutrition treatments in the presence of a dietitian in pregnant women diagnosed with GDM, blood glucose values decrease to target values and insulin therapy is not required. Low GI fruits and their portion sizes as well as the amounts they can consume daily should be explained to pregnant women with GDM, and it should be noted that they should be mindful of the GI and portion size of the fruit rather than the time of consumption. Blood glucose is regulated in pregnant women with GDM *Mellitus* by following a diet with 6-7 meals a day and with low GI foods. In the daily diet of pregnant women with GDM, consuming two or three servings of fruit with a low GI in any meal is convenient for blood glucose regulation.

Since the participants cannot be observed in person during the application of nutrition treatments, collecting the data about compliance to the nutrition treatment and the blood glucose results they measured at home through the daily food and blood glucose registration form may

affect the research results. To investigate the effect of fruit consumption time on blood glucose in more detail, there is a need for further and more comprehensive studies with a multidisciplinary approach in several centers and with many participants.

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CONTRIBUTORS

All authors made substantial contributions to the conception and design data collection and analysis, manuscript revision manuscript writing of this study.