

Research Article



Investigating the Correlation Between Body Mass Index and Insulin Resistance among Women Diagnosed with Gestational Diabetes

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Abstract | Gestational diabetes mellitus is becoming a more common problem during pregnancy and is on the rise around the world. Screening for and treating gestational diabetes mellitus is a way to stop its consequences. An abnormal body mass index can lead to many problems during pregnancy. It is also one of the main risk factors for pregnancy that can be changed. Knowing and evaluating the relationship of body mass index with insulin resistance in women with gestational diabetes. This case-control study included 50 pregnant women suffering from gestational diabetes who were diagnosed by doctors at Maysan Children's and Maternity Hospital for the period from 5/11/2023 to 5/20/2024, along with 50 pregnant women who did not have gestational diabetes and 50 non-pregnant women who did not have gestational diabetes as a healthy control group. The study groups were divided according to body mass index into a normal weight group, an overweight group, and an obese group. Ethical approval was taken from all research participants, 5 ml was withdrawn from all participants and placed in a gel tube and left at room temperature for 15 minutes until coagulation, after which it was separated using Centrifuge for 15 minutes, and the serum was stored at a temperature of -20 Celsius until use. Fasting glucose levels were measured using a spectrophotometer, and HBA1c and insulin levels were measured using Cobas e411. Lipid profile, their levels were measured using spectrophotometer. The results showed a significant increase in cholesterol levels in the case group compared to the control group with a normal body mass index. While cholesterol and LDL levels increased in the case group of overweight women. While the results showed a significant increase in cholesterol, HDL and DL levels in the obese case group. While insulin, fasting sugar, and HBA1c levels increased in all condition groups depending on the body mass index. High blood sugar, HBA1c and insulin levels in women with gestational diabetes underscore the importance of insulin resistance, especially with differences in lipid levels according to body mass index. These differences indicate the influence of cellular lipid metabolism on glucose levels and insulin resistance.

Keywords: Body Mass Index, Insulin Resistance, Gestational Diabetes, Dyslipidemia, Overweigh and Obesity

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INTRODUCTION

A frequent metabolic consequence of pregnancy, gestational diabetes mellitus (GDM) is characterized by glucose intolerance that is first noted during pregnancy. Preterm delivery, cesarean section, macrosomia, postpartum type 2 diabetes mellitus, and metabolic disorders in offspring are among the negative pregnancy outcomes that raise the risk (Wang et al., 2021; Tobias et al., 2017). Together with changing lifestyles, rising obesity rates, and older pregnant women, the prevalence of GDM is rising

quickly globally (Shepherd et al., 2017; Ferrara., 2007). Presently affecting 3–25% of pregnancies globally, it is a major global healthcare burden. A meta-analysis study indicates that 14.8% of Chinese people have GDM overall. The data on universal screening for GDM in Tianjin, China, shows that it rose about 3.5-fold between 1999 and 2012 (Gao et al., 2019; Popova et al., 2021). Genetic and environmental forces both work together to make it happen. A lot of possible risk factors for GDM have been found through studies that have already been done. Some of these are getting older, having a higher body mass index

(BMI) before pregnancy, having more children, having a baby with macrosomia before, having a family history of diabetes or polycystic ovary syndrome (PCOS), and smoking a lot. Getting rid of and managing GDM should get more attention (Leng et al., 2015; Wu et al., 2018). Making changes to your lifestyle is an important part of managing GDM. Medical nutrition therapy (MNT), along with weight loss and exercise, is the most important part of treating GDM. Taking these steps can help improve glucose and insulin levels and lead to better pregnancy results (Gou et al., 2019; Almeida et al., 2021). This impact may be related to the lifestyle changes made at the start of pregnancy that lower the gestational weight gain (GWG) before the mid-second trimester. Several studies have shown that diet and activity treatments during pregnancy could lower the risk of GDM. Still, there are a lot of arguments nowadays, even about the existing evidence (Wang et al., 2017; Assaf et al., 2017). Women go through a number of physiological and metabolic changes and adjustments throughout pregnancy that are intimately linked to pre pregnancy nutritional status and GWG and are intended to safeguard the development of the fetuses. The institute of medicine (IOM) considered the detrimental effects of both too much and too little GWG on the outcomes for the mother and fetus and created universal recommendations for the ideal GWG depending on pre pregnancy BMI categories (Goldstein et al., 2017; Rasmussen et al., 2009). It was 21% below the GWG rules in the US, 18% in Europe, and 31% in Asia. It was 51% above the guidelines in those same three places. Asian women may be more likely to be hurt by having too much GWG. It is agreed that regional BMI categories work better than WHO, BMI categories when applying IOM and GWG standards to people in Asia (Goldstein et al., 2017). GWG is a risk factor that can be changed for bad pregnancy results. Taking a woman's weight during the first and second trimesters can help find, stop, and fix problems before they happen during pregnancy. GDM is linked to a mother's BMI and may be to GWG, but the links could not be tested because of differences in evaluation and treatment, as well as the fact that GDM treatment might have an effect on GWG (Black et al., 2013; Enomoto et al., 2016). Many studies confirm that a higher risk of developing GDM is linked to overweight and obesity before pregnancy, as well as excessive GWG (Sun et al., 2020; Brunner et al., 2015). Chinese researchers have published a study showing that, compared to non-excessive GWG; women with excessive GWG had a 32.8% higher risk of getting GDM. But according to some US research, women with and without GDM had comparable mean GWG prior to GDM screening. Moreover, another Chinese study has linked the GWG's above recommendations to a reduced incidence of GDM. Consequently, more proof is required to link GWG to the risk of GDM (Hung et al., 2016; Li et al., 2013). BMI is better than body weight because it takes into ac-

count height during the whole pregnancy. The biggest thing that can tell you about GDM is your BMI before you get pregnant. No clear link has been found between the change in BMI during pregnancy and the chance of GDM, though. Previous research has shown that a change in BMI between pregnancies may be linked to a higher risk of problems during labor. So, we focus on the BMI before GDM screening and are committed to coming up with a new way to figure out how energy balance during pregnancy affects health. This just shows how this study has given us new and useful information (Ochsenbein et al., 2007; McClurg DP et al., 2022). The aim of the study is to determine the relationship between body mass index and insulin resistance in pregnant women with gestational diabetes and evaluate the relationship to reduce potential risk factors during pregnancy.

METHODOLOGY

This case-control study included 50 pregnant women suffering from gestational diabetes who were diagnosed by doctors at Maysan Children's and Maternity Hospital for the period from 5/11/2023 to 5/20/2024, along with 50 pregnant women who did not have gestational diabetes and 50 non-pregnant women who did not have gestational diabetes as a healthy control group. The study groups were divided according to body mass index into a normal weight group, an overweight group, and an obese group. Ethical approval was obtained from all research participants. 5 ml was withdrawn from all participants, placed in a gel tube, and left at room temperature for 15 minutes until coagulation, after which it was separated using a centrifuge for 15 minutes, and the serum was stored at a temperature of -20 Celsius until use. Fasting glucose levels were measured using a spectrophotometer, and HBA1c and insulin levels were measured using Cobas e411. Lipid profile, their levels were measured using spectrophotometer.

STATISTICAL ANALYSIS

Statistical analysis is often used to analyze quantitative data and provides methods for data description and simple inference for continuous and categorical data. The procedure involves the collection of data, leading to a test of the relationship between two statistical data sets. In this study, all data are presented as mean $\pm$ standard deviation. The statistical analyses were performed using SPSS (version 26) and using dependent t-tests (two-tailed) and independent t-tests (two-tailed) for normally distributed variables, whereas the Mann-Whitney and Wilcoxon tests were used for those variables that were not normally distributed. $P < 0.05$ was considered statistically significant.

ETHICAL APPROVAL

Before the samples were taken, all of the patients who were going to be part of this study were properly informed and

gave their verbal permission. The Committee on Publication Ethics at the Maysan Maternity Hospital gave its approval to the study.

RESULTS

LIPID PROFILE (TC, TG, HDL, AND LDL) LEVELS OF (18-24.9 KG) NORMAL WEIGHT GESTATIONAL DIABETES MELLITUS PREGNANT, NORMAL PREGNANT AND CONTROL GROUPS.

Results show the mean and standard deviation of lipid profile levels (total cholesterol TC, triglycerides TG, high-density lipoprotein (HDL), low-density lipoprotein (LDL)) for pregnant women with gestational diabetes mellitus (GDM) of normal weight (18 to 24.9 kg) and normal pregnant women. The control group is as follows: For pregnant women with gestational diabetes, the average level of total cholesterol was 200.80 ± 15.55 , triglycerides 213.13 ± 43.06 , high-density lipoprotein 38.08 ± 2.15 , and low-density lipoprotein 118.97 ± 3.42 . In normal pregnant women, total cholesterol was recorded at 194.80 ± 13.22 , triglycerides at 200.50 ± 19.22 , high-density lipoprotein at 37.25 ± 1.54 , and low-density lipoprotein at 116.30 ± 2.00 . In the control group, the average total cholesterol was 190.00 ± 18.13 , triglycerides 178.85 ± 20.59 , high-density lipoprotein 37.49 ± 2.20 , and low-density lipoprotein 117.87 ± 2.48 . When evaluating the statistical P values, statistical significance was found in triglycerides (TG) with a P value of 0.019, while no statistically significant differences appeared in the rest of the parameters, as total cholesterol (TC) recorded a P value of 0.205, high-density lipoprotein (HDL) recorded a P value of 0.567, and low-density lipoprotein (LDL) had a P value of 0.077.

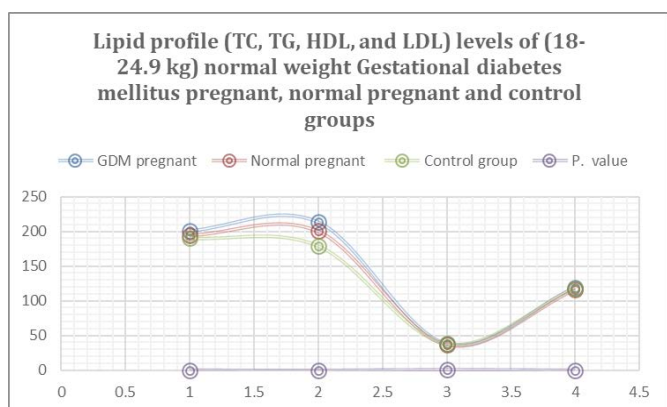


Figure 1: The difference in the lipid profile levels of (18-24.9 kg) normal weight Gestational diabetes mellitus pregnant, normal pregnant and control groups.

Blood sugar profile (HbA1C, FBS and Insulin) levels of (18-24.9 kg) normal weight Gestational diabetes mellitus pregnant, normal pregnant and control groups. Study results show the means and standard deviation of

blood sugar levels (HbA1C, FBS, and insulin) for normal-weight pregnant women with gestational diabetes, normal-weight pregnant women, and a normal-weight control group. The group with gestational diabetes showed higher levels of HbA1C (8.28 ± 0.89), FBS (202.46 ± 48.12), and insulin (12.74 ± 3.80), compared to normal pregnant women (HbA1C: 5.76 ± 1.32 , FBS: 112.10 ± 8.42 , and insulin: 9.50 ± 1.80) and the control group (HbA1C: 5.78 ± 1.60 , FBS: 97.28 ± 12.11 , and insulin: 7.04 ± 1.83). P statistical values showed significant significance (0.000) for all parameters, indicating significant differences between groups.

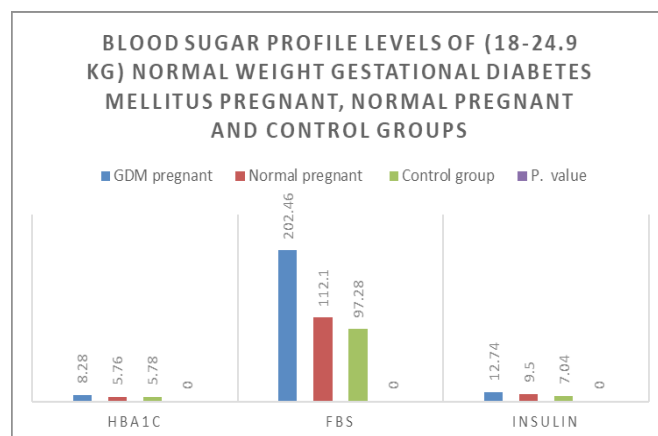


Figure 2: The difference in the blood sugar profile of (18-24.9 kg) normal weight Gestational diabetes mellitus pregnant, normal pregnant and control groups

Lipid profile (TC, TG, HDL, and LDL) levels of (25-29.9 kg) overweight Gestational diabetes mellitus pregnant, normal pregnant and control groups.

Shows the results of the research on the analysis of the mean and standard deviation of lipid profile levels (total cholesterol TC, triglycerides TG, high-density lipoprotein HDL, low-density lipoprotein LDL) for pregnant women with above normal weight (25-29.9 kg) from the groups of pregnant women with gestational diabetes, normal pregnant women, and the control group. The results show the following. In the group of pregnant women with gestational diabetes, total cholesterol was 204.66 ± 20.79 , triglycerides 239.22 ± 63.23 , high-density lipoprotein 37.91 ± 2.03 , and low-density lipoprotein 118.60 ± 3.42 . For normal pregnant women, total cholesterol values were recorded at 188.27 ± 23.22 , triglycerides 195.50 ± 21.29 , high-density lipoprotein 36.07 ± 2.24 , and low-density lipoprotein 116.77 ± 2.36 . In the control group, total cholesterol was 189.00 ± 19.28 , triglycerides 183.70 ± 26.48 , high-density lipoprotein 36.05 ± 2.16 , and low-density lipoprotein 117.13 ± 2.93 . The P-values showed statistically significant differences in triglycerides ($P=0.000$) and high-density lipoprotein ($P=0.015$), while the P-values for total cholesterol (0.037) and low-density lipoprotein (0.151) did not show highly significant differences.

Table 1: Mean $\pm$ SD of lipid profile (TC, TG, HDL, LDL) levels of (18-24.9 kg) normal weight Gestational diabetes mellitus pregnant, normal pregnant and control groups

Parameters	TC	TG	HDL	LDL
GDM pregnant	200.80 $\pm$ 15.55	213.13 $\pm$ 43.06	38.08 $\pm$ 2.15	118.97 $\pm$ 3.42
Normal pregnant	194.80 $\pm$ 13.22	200.50 $\pm$ 19.22	37.25 $\pm$ 1.54	116.30 $\pm$ 2.00
Control group	190.00 $\pm$ 18.13	178.85 $\pm$ 20.59	37.49 $\pm$ 2.20	117.87 $\pm$ 2.48
P. value	0.205	0.019	0.567	0.077

Table 2: Mean $\pm$ SD of blood sugar profile (HbA1C, FBS and insulin) levels of (18-24.9 kg) normal weight Gestational diabetes mellitus pregnant, normal pregnant and control groups

Parameters	HbA1C	FBS	Insulin
GDM pregnant	8.28 $\pm$ 0.89	202.46 $\pm$ 48.12	12.74 $\pm$ 3.80
Normal pregnant	5.76 $\pm$ 1.32	112.10 $\pm$ 8.42	9.50 $\pm$ 1.80
Control group	5.78 $\pm$ 1.60	97.28 $\pm$ 12.11	7.04 $\pm$ 1.83
P. value	0.000	0.000	0.000

Table 3: Mean $\pm$ SD of lipid profile (TC, TG, HDL, LDL) levels of (25-29.9 kg) overweight Gestational diabetes mellitus pregnant, normal pregnant and control groups

Parameters	TC	TG	HDL	LDL
GDM pregnant	204.66 $\pm$ 20.79	239.22 $\pm$ 63.23	37.91 $\pm$ 2.03	118.60 $\pm$ 3.42
Normal pregnant	188.27 $\pm$ 23.22	195.50 $\pm$ 21.29	36.07 $\pm$ 2.24	116.77 $\pm$ 2.36
Control group	189.00 $\pm$ 19.28	183.70 $\pm$ 26.48	36.05 $\pm$ 2.16	117.13 $\pm$ 2.93
P. value	0.037	0.000	0.015	0.151

Table 4: Mean $\pm$ SD of blood sugar profile (HbA1C, FBS and insulin) levels of (25-29.9 kg) overweight Gestational diabetes mellitus pregnant, normal pregnant and control groups

Parameters	HbA1C	FBS	Insulin
GDM pregnant	8.38 $\pm$ 1.02	170.77 $\pm$ 26.37	14.16 $\pm$ 4.64
Normal pregnant	5.39 $\pm$ 1.30	113.33 $\pm$ 6.92	9.00 $\pm$ 1.8
Control group	5.34 $\pm$ 1.02	92.45 $\pm$ 8.30	5.44 $\pm$ 1.42
P. value	0.000	0.000	0.000

Table 5: Mean $\pm$ SD of lipid profile (TC, TG, HDL, and LDL) levels of (30 $\geq$ kg) Obesity Gestational diabetes mellitus pregnant, normal pregnant and control groups

Parameters	TC	TG	HDL	LDL
GDM pregnant	199.76 $\pm$ 16.52	229.41 $\pm$ 36.44	40.09 $\pm$ 2.18	118.89 $\pm$ 3.63
Normal pregnant	199.42 $\pm$ 19.14	187.19 $\pm$ 21.37	35.85 $\pm$ 2.49	116.66 $\pm$ 2.72
Control group	190.68 $\pm$ 18.15	194.93 $\pm$ 27.26	38.11 $\pm$ 2.77	115.77 $\pm$ 3.02
P. value	0.264	0.000	0.000	0.017

Table 6: Mean $\pm$ SD of Blood sugar profile (HbA1C, FBS and insulin) levels of (30 $\geq$ kg) Obesity Gestational diabetes mellitus pregnant, normal pregnant and control groups

Parameters	HbA1C	FBS	Insulin
GDM pregnant	8.31 $\pm$ 0.89	185.23 $\pm$ 32.57	13.66 $\pm$ 5.11
Normal pregnant	5.53 $\pm$ 1.02	111.52 $\pm$ 6.32	9.58 $\pm$ 1.57
Control group	5.18 $\pm$ 0.83	90.37 $\pm$ 9.85	5.85 $\pm$ 1.73
P. value	0.000	0.000	0.000

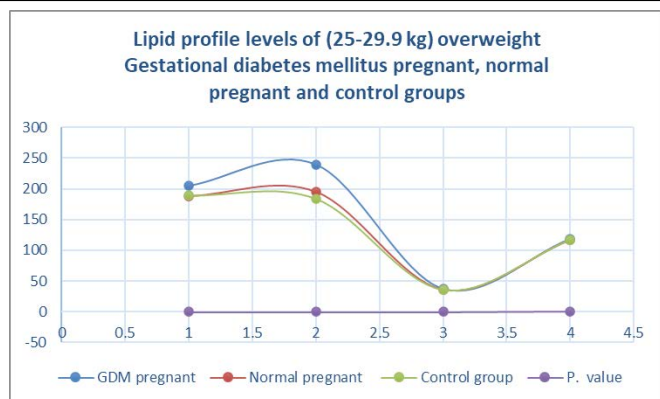


Figure 3: The difference in the lipid profile of (25-29.9 kg) overweight Gestational diabetes mellitus pregnant, normal pregnant and control groups.

BLOOD SUGAR PROFILE (HbA1C, FBS AND INSULIN) LEVELS OF (25-29.9 KG) OVERWEIGHT GESTATIONAL DIABETES MELLITUS PREGNANT, NORMAL PREGNANT AND CONTROL GROUPS.

The study, which was conducted on pregnant women weighing between 25-29.9 kg, whether pregnant women with above-normal weight with gestational diabetes, pregnant women with normal weight, or the control group, shows averages and standard deviations for blood sugar profile levels (HbA1C, FBS, and insulin) as follows: In pregnant women with gestational diabetes, the HbA1C is 8.38 ± 1.02 , FBS is 170.77 ± 26.37 , and insulin is 14.16 ± 4.64 . In pregnant women of normal weight, the HbA1C is 5.39 ± 1.30 , FBS is 113.33 ± 6.92 , and insulin is 9.00 ± 1.8 . In the control group, the HbA1C was 5.34 ± 1.02 , FBS was 92.45 ± 8.30 , and insulin was 5.44 ± 1.42 . The differences in levels between the groups are statistically significant, with P values equal to 0.000 for all parameters (HbA1C, FBS, and insulin), indicating that there are significant differences between the group of pregnant women with gestational diabetes compared to pregnant women with normal weight and the control group.

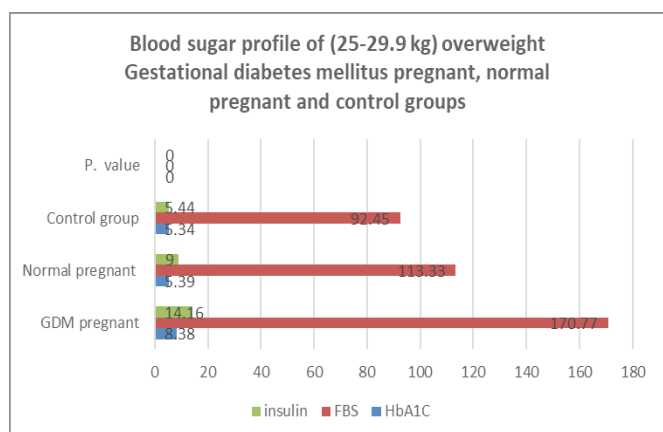


Figure 4: The difference in the blood sugar profile of (25-29.9 kg) overweight Gestational diabetes mellitus pregnant, normal pregnant and control groups

Lipid profile (TC, TG, HDL, and LDL) levels of (30≥ kg) Obesity Gestational diabetes mellitus pregnant, normal pregnant and control groups.

The lipid profile values (total cholesterol (TC), triglycerides (TG), high-density lipoprotein (HDL), and low-density lipoprotein (LDL)) were compared in obese pregnant women (weight 30 kg or more) with gestational diabetes, normal pregnant women, and a control group. The gestational diabetic pregnant women had rates of total cholesterol 199.76 ± 16.52 , triglycerides 229.41 ± 36.44 , HDL 40.09 ± 2.18 , and LDL 118.89 ± 3.63 . While in normal pregnant women the rates were TC 199.42 ± 19.14 , TG 187.19 ± 21.37 , HDL 35.85 ± 2.49 , LDL 116.66 ± 2.72 , and in the control group the rates were TC 190.68 ± 18.15 , TG 194.93 ± 27.26 , and HDL 38.11 ± 2.77 . 115.77 ± 3.02 . Statistical P values showed statistical significance in triglycerides, HDL (P = 0.000 for both), and LDL (P = 0.017), indicating significant differences between groups in these parameters, while no significance appeared in total cholesterol (P = 0.264).

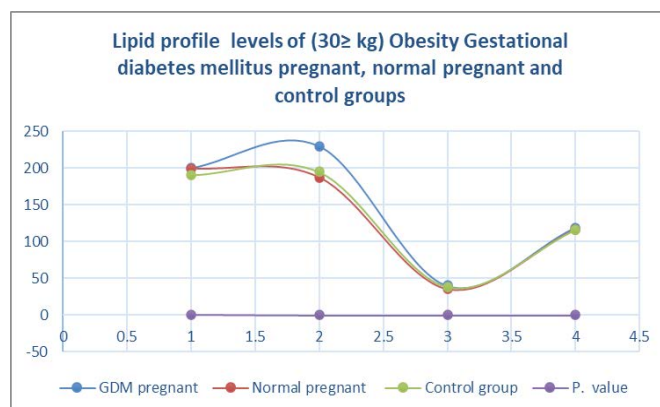


Figure 5: The difference in the Lipid profile of (30≥ kg) Obesity Gestational diabetes mellitus pregnant, normal pregnant and control groups

Blood sugar profile (HbA1C, FBS and insulin) levels of (30≥kg) Obesity Gestational diabetes mellitus pregnant, normal pregnant and control groups.

The results of the blood sugar profile (HbA1C, FBS, and insulin) for obese women (weight 30 kg or more) with gestational diabetes, pregnant women with normal weight, and the control group showed the following values: In the gestational diabetes group, HbA1C was 8.31 ± 0.89 , FBS 185.23 ± 32.57 , and insulin 13.66 ± 5.11 ; while in normal pregnant women, the values of HbA1C were 5.53 ± 1.02 , FBS 111.52 ± 6.32 , and insulin 9.58 ± 1.57 ; for the control group, HbA1C was 5.18 ± 0.83 , FBS 90.37 ± 9.85 , and insulin 5.85 ± 1.73 . The differences between the groups were statistically significant (P = 0.000) in HbA1C, FBS, and insulin levels, confirming the presence of significant differences between pregnant women with gestational diabetes and both normal pregnant women and the control group.

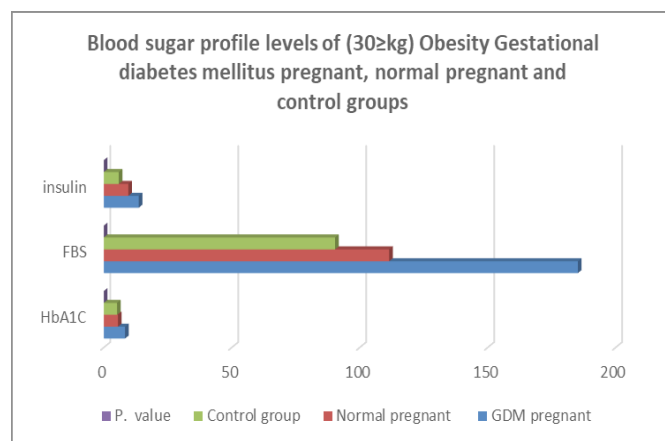


Figure 6: The difference in the blood sugar profile of (30≥kg) Obesity Gestational diabetes mellitus pregnant, normal pregnant and control groups

DISCUSSION

On the other hand, the mother with gestational diabetes mellitus (GDM) and her baby would be more likely to later acquire type 2 diabetes, metabolic syndrome, and cardiovascular problems. Any system should be concerned about GDM given the growing use of health and care resources and the negative effects, many of which can be prevented with early diagnosis and treatment (Sudasinghe et al., 2018). Changes in the lipid profile brought about by physiological anomalies associated with pregnancy are associated with gestational diabetes mellitus (GDM). The lipid profile quantifies directly the amounts of triglyceride (TG), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), and very low-density lipoprotein cholesterol (VLDL-C) (Wang et al., 2019). Insulin promotes the buildup of fat tissue in the uterus during the initial stages of pregnancy. Subsequently, there is an escalation in the breakdown of adipose tissue and the occurrence of hypertriglyceridemia, predominantly due to the effects of estrogen and insulin resistance. There are several factors that are known to affect lipid levels in patients with GDM. This is because lipid metabolism is directly regulated by carbohydrate metabolism. The link between lipid profile and GDM continues to be a subject of ongoing controversy (Antwi et al., 2018). Although there has been a significant amount of research dedicated to lipid levels during pregnancy, conflicting results continue to exist in this field. In addition, there has been limited research investigating potential variations in obesity patterns among pregnant women with gestational diabetes mellitus (GDM) in the initial trimester (Herrera et al., 2016). When comparing the group of pregnant women with gestational diabetes, the results showed that cholesterol showed statistical significance, while in the overweight group, the results showed no statistical significance in the lipid profile. For the obesity group, the results showed sta-

tistical significance in the levels of triglycerides, HDL, and LDL. As for the group suffering from hypertension, the results showed a statistical significance in the levels of triglycerides. As for the group that does not suffer from hypertension, the results showed statistical significance for triglycerides, HDL, and LDL (Wang et al., 2019; Herrera et al., 2016). These results are consistent with (Wang et al., 2019). During pregnancy, the metabolism of lipoproteins in the liver and adipose tissue undergoes changes that lead to alterations in the levels of phospholipids, fatty acids, triglycerides (TG), and cholesterol in the bloodstream. Maternal metabolism during pregnancy is often marked by a normal and natural increase in lipid levels. After Following an initial decline during the initial eight weeks of pregnancy, lipoprotein levels, particularly TG levels, increase steadily [28]. GDM is frequently accompanied by elevated blood lipid levels compared to a typical pregnancy, although this assertion lacks universal confirmation across studies (Layton et al., 2019). Most studies indicate that pregnant women who are obese and diabetic have abnormal lipid profiles, characterized by high levels of triglycerides, very low-density lipoprotein, and low levels of HDL-C. These lipid abnormalities are typically accompanied by high levels of insulin in the blood (Blades et al., 2021). Similar to the symptoms of metabolic syndrome. In our study, we found that women diagnosed with gestational diabetes mellitus had the highest levels of metabolic syndrome indicators, including BMI, waist circumference, C-peptide level, and TG. On the other hand, women who were in excellent health and not pregnant had the lowest levels of these indicators. The body mass index (BMI) of pregnant women without diabetes was seen to be lower as compared to those with gestational diabetes mellitus (GDM), which aligns with the aforementioned statement. Although the levels of TG (triglycerides) were elevated in pregnant women with GDM (gestational diabetes mellitus) compared to those without GDM, the observed difference did not reach statistical significance. In addition, pregnant women with gestational diabetes mellitus (GDM) exhibited decreased levels of high-density lipoprotein cholesterol (HDL-C) compared to those without GDM. According to an earlier study, women who have been diagnosed with gestational diabetes mellitus (GDM) have lower levels of high-density lipoprotein cholesterol (HDL-C) during pregnancy than women who do not have GDM. There is a big rise in HDL-C levels during pregnancy, with the highest amounts happening in the second trimester (Meng et al., 2020; Koukkou et al., 2021). There are many issues about the levels of TG (and, as a result, LDL-C) during pregnancy. In our study, pregnant women, whether they had gestational diabetes mellitus (GDM) or not, exhibited higher levels of triglycerides (TG) and low-density lipoprotein cholesterol (LDL-C) compared to non-pregnant women. Conclusively, there was no discernible difference between pregnant women with and without gestational diabetes mellitus

(GDM). A study conducted by Koukkou et al. found that women with GDM had elevated amounts of TG but decreased concentrations of LDL-C in their serum compared to the control group during the third trimester of pregnancy. There were no significant differences in the levels of TC, HDL-C, and apolipoprotein between pregnant women with and without GDM (Toescu et al., 2014). Toescu et al. achieved similar outcomes for women without diabetes and those with diabetes, despite the progressive increase in TC and TG levels throughout pregnancy. In contrast to the previous study, these authors found that diabetic women had higher levels of LDL in each trimester of pregnancy compared to non-diabetic controls (Blumer et al., 2016). Pregnancy-induced changes in lipid metabolism play a critical role in the early and mid-pregnancy buildup of maternal fat stores and the latter stages of pregnancy, when fat is mobilized more rapidly. In the anabolic phase of early pregnancy, there is an increase in lipogenesis and the accumulation of fat. This is crucial for priming the embryo for its accelerated growth during the latter stages of pregnancy. Elevated amounts of insulin, progesterone, and estrogen increase lipid accumulation and decrease lipolysis. The placenta relies on cholesterol for steroid synthesis, while fatty acids are used for placental oxidation and the creation of membranes (Agarwal et al., 2010). Pregnancy is associated with hyperinsulinemia and insulin resistance (IR), which can potentially elevate the likelihood of diabetes in specific women. Gestational diabetes is a condition characterized by the presence of glucose intolerance that is either observed or identified for the first time during pregnancy. The current definition does not exclude the possibility that there was undetected glucose intolerance before the pregnancy. As a result, the Endocrine Society has suggested using the phrase “hyperglycemia in pregnancy” as a more appropriate alternative. When hyperglycemia is first detected during pregnancy, the International Association of Diabetes and Pregnancy Study Groups (IADPSG) categorizes it as either gestational diabetes mellitus (GDM) or “overt diabetes.” Three In 2013, the World Health Organization (WHO) made a proposal about how to classify high blood sugar levels that are first detected during pregnancy. They suggested using either the term “diabetes mellitus (DM) in pregnancy” or “gestational diabetes mellitus (GDM)” (Barbour et al., 2007). The study groups, consisting of women with gestational diabetes who were classified as normal weight, overweight, obese, or having high blood pressure, showed a substantial increase in fasting sugar, cumulative sugar, and insulin levels compared to the control group. The findings are consistent with (Solomon et al., 1997). A progressive intrauterine growth restriction (IR) occurs during a regular pregnancy, starting around the middle of the pregnancy and progressing throughout the third trimester. Potential factors contributing to insulin resistance (IR) during pregnancy encompass hormones and adipokines released by

the placenta, such as human placental lactogen, human placental growth hormone, and tumor necrosis factor (TNF)- α . Elevated levels of progesterone, estrogen, and cortisol additionally contribute to a disruption in the equilibrium between glucose and insulin during pregnancy. During pregnancy, the pancreas increases its secretion of insulin in response to peripheral insulin resistance. Gestational diabetes mellitus (GDM) occurs when a woman's pancreas is unable to produce enough insulin to meet the metabolic needs caused by internal resistance. Moreover, this condition of relatively reduced ability to process glucose is worsened by higher caloric consumption, reduced physical activity, and greater accumulation of fat in the mother's body (Rajput et al., 2016). During the initial phases of pregnancy, there is an increase in the secretion of insulin, while the sensitivity to insulin either remains constant, declines, or possibly increases. Insulin sensitivity steadily decreases during the middle of pregnancy and continues to diminish until the late third trimester, when it reaches its maximum level of decline. The placenta rebounds upon delivery. As a result, gestational diabetes mellitus (GDM) usually appears during the later part of the second trimester of pregnancy and disappears right after childbirth (Solomon et al., 1997; Rajput et al., 2016). There are multiple risk factors that are associated with the development of GDM. The most common risk factors for type 2 diabetes mellitus include obesity, advanced maternal age, a strong family history of diabetes mellitus, chronic glucosuria, belonging to an ethnic group with a high incidence of the disease, and older maternal age. Other risk factors for gestational diabetes mellitus (GDM) include a medical history of giving birth to kids with a birth weight of 4000 g or more, multiple miscarriages, unexplained fetal deaths, and essential hypertension or pregnancy-induced hypertension [38]. Rajput evaluated the diagnostic accuracy of HbA1C levels taken during the 24th and 28th weeks of pregnancy in 607 women to detect gestational diabetes mellitus. The diagnosis of GDM was determined based on the discovery that HbA1C, with a threshold value of 5.95%, had an accuracy of 80.5%, a sensitivity of 28.6%, and a specificity of 97.2% (Hiramatsu et al., 2012). Furthermore, when the cutoff point for HbA1C was established at 5.45% or above, the sensitivity for detecting GDM was 85.7% and the specificity was 61.1%. A threshold of 5.35% for HbA1C levels in the first trimester and 5.75% between 20 and 24 weeks of pregnancy has been established as the most effective in detecting gestational diabetes mellitus at 24-28 weeks. Comparing the two studies indicates that HbA1C threshold points may rise as gestational age increases. This observation is reasonable considering that insulin resistance tends to develop throughout pregnancy, resulting in a higher average HbA1C level, as indicated in our study (Plows et al., 2018). It is crucial to take into account that the normal occurrence of physiological anemia and raised blood plasma levels

during pregnancy may lead to a lower HbA1C level in early pregnancy compared to non-pregnant women. The 2012 study conducted by Hiramutsu et al. found a similar result, showing a decrease in HbA1C levels during the second trimester of pregnancy and an increase during the third trimester (Ying et al., 2020). This underscores the need for determining a specific HbA1C threshold for each trimester, as evidenced by our study, where we identified two unique thresholds: one for early screening in the first trimester and another between 20 and 24 weeks of pregnancy. The exact mechanism that causes the abnormal physiological processes in gestational diabetes mellitus (GDM) is not well comprehended. However, this syndrome is often caused by prolonged insulin resistance during pregnancy, resulting in impaired function of pancreatic β -cells. β -cells perform the primary task of storing and releasing insulin in response to the buildup of glucose in the bloodstream (Kampmann et al., 2019). Insulin sensitivity varies throughout pregnancy because the growing baby requires energy to fulfill its metabolic demands. Early in pregnancy, there is increased insulin sensitivity, which facilitates better glucose absorption into fat cells. This gets the body ready for the later in pregnancy higher energy demands. Long term fuel excess is thought to be the main cause of β -cell dysfunction, which is typified by uncontrolled insulin production. Elevation of several hormones, including as estrogen, progesterone, leptin, cortisol, placental lactogen, and placental growth hormone, as the pregnancy progresses, facilitates insulin resistance (Kampmann et al., 2019). Any point along the insulin signaling cascade, including post-translational modifications, β -cell formation, and gene changes linked to insulin signaling, can result in β -cell changes [40]. Changed insulin signaling makes it more difficult for GLUT4, the main glucose molecule transporter, to cross the plasma membrane of the cell. Pregnancies, including gestational diabetes mellitus (GDM), have a 54% slower rate of insulin stimulation of glucose absorption into cells than do healthy pregnancies (Ying et al., 2020). Over the first to third trimesters of pregnancy, progesterone levels rise progressively. These levels block the movement and absorption of glucose made possible by GLUT4 and reduce the synthesis of IRS-1, therefore impeding the phosphoinositol-3 kinase (PI3K) pathway (Ying et al., 2020). During pregnancy, estrogen levels rise significantly, which is linked to insulin not working as well. The substance human placental lactogen (hPL) can do two things: it can mimic insulin and block insulin. High amounts of the chemical are linked to pregnancy, which makes it easier for the mother to absorb glucose and make glycogen (Baz et al., 2016). Pituitary growth hormone and human placental growth hormone raise blood sugar levels too high, mess up the control of liver gluconeogenesis, and lower the body's ability to absorb glucose and make glycogen. These hormonal changes make diabetes more likely to happen (Ara et al., 2022). An excessive amount of pro-in-

flammatory cytokines and adipokines builds up in fatty tissues during pregnancy. This makes the body inflamed, which makes leptin come out and insulin resistance happen. Too much production of leptin sets off the hypothalamus, which makes people eat too little and causes high blood sugar during pregnancy (Pérez et al., 2020).

CONFLICT OF INTEREST

There are no conflict of interests.

AUTHORS CONTRIBUTION

All authors contributed equally.

CONCLUSION

The high levels of fasting blood sugar, HbA1c, and insulin levels in women with gestational diabetes depending on the body mass index indicate the important role played by insulin resistance in this group, in addition to the differences in fat levels depending on the body mass index, which has an effective role in influencing insulin resistance and causing gestational diabetes, as the imbalance of fats in women with different body mass indexes reflects the positive outlook on the effect of cellular fat metabolism on sugar levels and insulin resistance.

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