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| RESEARCH ARTICLE

Comparison of Anthropometric Measurements of Infants Born to Bahraini Mothers with and Without Gestational Diabetes Mellitus (GDM)

Dr. Ali Haider Ali[1] ✉ Dr. Esam Nedhal Mahdawi[2], Dr. Minoosh Nasef[3], Professor Emad Shatla[4] and Dr. Arun Nair[5]

[12]Intern at King Hamad University Hospital, Busaiteen, Kingdom of Bahrain
[34]Consultant Neonatologist in King Hamad University Hospital, Busaiteen, Kingdom of Bahrain.
[5]Medical graduate from Royal College of Surgeons Ireland (Bahrain campus), Busaiteen, Kingdom of Bahrain
Corresponding Author: Dr. Ali Haider Ali, **E-mail**: Alihaiderali97@outlook.com

| ABSTRACT
Gestational Diabetes Mellitus is a major cause of morbidity and mortality to both mother and fetus. It is defined as the development of hyperglycemia during pregnancy in women who were not previously diagnosed with Diabetes Mellitus (DM) (1). Diagnosis usually occurs during the 24th to 28th weeks of gestation (1). The prevalence of GDM varies worldwide and was reported to be in Bahrain in 2012 at 10.1% of pregnancies, which was increased from 7.2% in 2002 (6). For this study, a total sample of 10,865 patients was used, dating from May 2016 to January 2020. The sample size is set in King Hamad University Hospital (KHUH), Kingdom of Bahrain. They were chosen based on inclusion and exclusion criteria. The data collected included the GDM status of the mother (GDM or Non-GDM), gestational age of the fetus (weeks), birth weight (grams) of the fetus, length (centimeters) of the fetus, head circumference (centimeters) of the fetus and placental weight (grams) upon delivery. In our study, the results showed an increase in anthropometric measurements in infants born to GDM mothers. 10 out of 200 (5%) neonates had a macrocosmic birth weight in GDM infants. However, when comparing to the birth weight, p= 0.940 was found, showing a non-significant difference between both groups. There was a faster acceleration in head circumference in neonates born to mothers with GDM, and there was no significant difference in average head circumference between both groups. Moreover, 153 out of 200 (76%) of the GDM group had a placental weight of more than 500 grams, whereas 179 out of 200 (89.5%) of the non-GDM group had a placental weight of more than 500 grams. GDM is a common yet serious complication encountered throughout pregnancy, most commonly via routine screening. One of the commonly observed outcomes of GDM in pregnancy is increased fetal growth through various mechanisms, which can result in an increased risk of neonatal morbidity and mortality. This study helps to reaffirm that routine screening of GDM is required, and perhaps placental weight is another factor to be taken into consideration after further study as an indicator of fetal growth and GDM progression.

| KEYWORDS

"Gestational Diabetes", "Macrosomia", "Anthropometric Measurements", "Placental Weight"

| ARTICLE INFORMATION

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1. Introduction

Gestational diabetes mellitus (GDM) is a prevalent complication encountered during pregnancy and is characterized by the development of hyperglycemia during pregnancy (1). GDM is diagnosed via routine screening between the 24th and 28th week of gestation. The screening tools used include the:

- 50-gram 1-hour oral glucose challenge test.
- 100-gram 3-hour oral glucose tolerance test.

The global prevalence of GDM is estimated to be between 7% to 10% worldwide (3), although variations of prevalence have been reported in multiple studies. In 2019, it was reported in an article by the International Diabetes Federation that out of 20 million births worldwide that involved hyperglycemia in the intrapartum period, an estimated 84% were due to GDM (4). The prevalence of GDM in the Middle East was estimated to be close to 7.5%, with 1,871,313 live births affected in 2019 (5). The latest incidence report of GDM in Bahrain was reported in 2012 to be 10.1% of pregnancies, which increased from 7.2% in 2002 (6).

Risk factors for developing GDM include advanced maternal age, maternal obesity, ethnicity, family history of DM, and previous history of GDM (7). It also carries a significant health burden for the neonate born, including macrosomia, increased likelihood of a cesarean section delivery, preterm birth, an increased probability of the development of cardiovascular disease, and type II DM in the infant (7). In a study conducted in 2020 by Jaffe A. et al., it was shown that mean body mass index (BMI) rates and morbid obesity were shown to be highest among women from Arab countries (8). Another study conducted in Saudi Arabia by AlFadhli et al. in 2015 showed that the prevalence of GDM in Saudi Arabia was reported to be 16.2% (9).

During the progression of pregnancy, due to the increase in hormones such as placental lactogen, placental growth hormone, estrogen, progesterone, cortisol, and leptin, there is increased resistance to insulin, leading to hyperglycemia. Glucose can enter the fetal circulation through the placenta, resulting in fetal hyperinsulinemia and subsequent neonatal hypoglycemia (1). One of the well-known fetal complications of GDM is accelerated growth, resulting in macrosomia, further increasing neonatal morbidity. It is suggested that the accelerated fetal growth is due to the hyperinsulinemia in the fetus, resulting in increased adipose tissue and total body size (10). In a study conducted by Hammoud et al. in 2013, it was shown that all neonates born to mothers with type I DM, type II DM, and GDM had disproportionate growth patterns.

Sub-sections of growth parameters, including head circumference, birth weight, and crown heel length, were found to be significantly higher in neonates born to mothers with any form of DM during pregnancy (11). Interestingly, a study conducted by Edu et al. in 2016 explained that placental size and weight had significantly increased values in patients with GDM compared to those without. It has been proposed that increased placental sizes seen between 24 to 28 weeks of gestation can indicate a potential diagnosis of GDM (12).

2. Aim:

This study aims to investigate the differences in anthropometric measurements of neonates born to mothers with and without GDM. We hypothesize that from the pre-existing knowledge of how GDM affects growth, anthropometric measurements will have a significant increase in neonates born to mothers with GDM.

3. Methods

For this study, a total sample of 10,865 patients was used, dating from May 2016 to January 2020. The sample size is set in King Hamad University Hospital (KHUH), Kingdom of Bahrain, and this study was approved by the institutional review board (IRB) at KHUH. The inclusion and exclusion criteria were implemented to acquire a sample of the target population. The target population for this study were neonates born to Bahraini mothers with and without GDM.

The inclusion criteria for this study were as follows:

- Neonates born to Bahraini mothers with and without GDM.

The exclusion criteria for this study were as follows:

- Neonates born to mothers not of Bahraini origin.
- Files of patients that did not contain all of the required variables are listed below.

The mother's data was accessed to determine the ethnicity and to discern the following variables required for our study:

- GDM status of the patient's mother (GDM or Non-GDM)
- Gestational age of the fetus (weeks).
- Birth weight (grams) of fetus
- Length (centimeters) of fetus
- Head circumference (centimeters) of fetus

- Placental weight (grams) upon delivery.

The sample size was calculated through the sample size formula to be 385 in total. The collaborators in this research decided to obtain 200 patients born to mothers with GDM and 200 patients born to mothers without. This was randomly obtained by searching through each ID number of the patient from January 2020 and backwards. The first 400 patients who satisfied the inclusion criteria for both the GDM and non- GDM group were included in the study; for both the GDM and non-GDM groups, 200 patients were allocated accordingly.

Once the data was collected, it was organized in a tabular form, separating the GDM and non-GDM groups. The mean values of each of the variables mentioned above were obtained with a standard deviation, and a t-test was conducted to analyze the values from the variables. A p-value for each of the variables is used to ascertain the statistical significance of the values calculated for each variable. A p-value less than 0.05 was considered significant.

4. Results:

Table 1 – Comparison of Birth Weight of Neonates born to mothers with and without GDM, organized by week of gestation

Gestational Age (weeks)	GDM Neonates Birth Weight (g)	Non-GDM Neonates Birth Weight (g)	Difference in Weight (g)
29-35	1968.8	2091.7	-122.9
36	2880.9	2828.6	52.3
37	3154.8	2935.6	219.2
38	3167.6	3139.8	27.8
39	3266.4	3220.2	46.2
40	3422.2	3380.3	41.9
41 and above	3361	3386.4	-25.4

- This demonstrates that there is an increment in birth weight in both groups; however, figure 1 demonstrates that beginning at 36 weeks and onwards, the GDM group, on average, had an increased birth weight than the non-GDM group. The most significant difference is seen at 37 weeks, where the average birth weight for a baby born to a mother with GDM was 3154.8 grams, and a baby born to a mother without GDM had an average birth weight of 2935.6 grams. In Figure 2, between 29-35 weeks, it is noted that neonates born to mothers without GDM had an increased birth weight at 2091.7 grams compared to neonates born to mothers with GDM who, on average, had a birth weight of 1968.8 grams.

Table 2 – Comparison of head circumference of neonates born to mothers with and without GDM, organized by week of gestation

Gestational Age (weeks)	GDM Neonates Head Circumference (cm)	Non-GDM Neonates Head Circumference (cm)	Difference in Head Circumference (cm)
29-35	30.9	30.1	0.8
36	33.6	33.1	0.5
37	34	33.6	0.4
38	34.2	34.2	0
39	34.5	34.2	0.3
40	35	34.4	0.6
41 and above	35.8	35.1	0.7

- Demonstrate the expected increase in head circumference in both groups as the gestational age increased. However, it can be noted in Figure 2 that in each gestational age group, the GDM group had significantly increased head

circumference at a faster pace compared to the non-GDM group. The most significant difference is seen at 29 to 35 weeks with a difference of 0.8 where, interestingly, it is noted that at 38 weeks of gestation, there is no difference regarded.

Table 3 – Comparison of Length of Neonates born to mothers with and without GDM, organized by weeks of gestation

Gestational Age (weeks)	GDM Neonates Length (cm)	Non-GDM Neonates Length (cm)	Difference in Length (cm)
29-35	44.5	45.3	-0.8
36	50.9	50.3	0.6
37	51.9	51.1	0.8
38	51.4	51.7	-0.3
39	53.2	52	1.2
40	54.3	53.5	0.8
41 and above	54.5	53.6	0.9

- Demonstrate the comparison in the development of birth length in neonates born to mothers with and without GDM. As expected, there is a general increase in birth length in both groups as the gestational age increases. However, it can be seen that unlike the birth weight and head circumference, a substantial difference in length between both groups is not seen.

Table 4 – Comparison of the placental weight of neonates born to mothers with and without GDM, organized by weeks of gestation.

Gestational Age (Weeks)	GDM Neonates Placental Weight (grams)	Non-GDM Neonates Placental Weight (grams)	Difference in Placental Weight (grams)
29-35 weeks	388.9	552.9	-164
36 weeks	692.1	565	127.1
37 weeks	597.9	658.3	-60.4
38 weeks	606.9	632.9	-26
39 weeks	626.6	625	1.6
40 weeks	624.1	662.2	-38.1
41 weeks and above	597.5	676.9	-79.4

- Demonstrate the difference in placental weight at different gestational ages in neonates born to mothers with and without GDM. Unlike the birth weight, head circumference, and length, there is a different trend in placental weight between both groups, as shown above. In all categories except 36 weeks and slightly in 39 weeks, placental weight is increased in the non-GDM group compared to the GDM group. The largest difference in placental weight can be seen at 29-35 weeks, where the average placental weight in mothers with GDM was 388.9 grams and in mothers without GDM was 552.9 grams. In contrast, at 36 weeks, the placental weight was higher in the control group at an average placental weight of 692.1 grams compared to 565 in the non-GDM group.

Table 5 - Associations between GDM and non-GDM mothers with several parameters of childbirth: gestational age at birth, birth weight, length, head circumference, and placental weight.

Factors	GDM (n=200)	NON-GDM (n=200)	P Value
Gestational Age at Birth (weeks)	38.5 ± 1.5	39.0 ± 2.1	.015
Birth Weight (grams)	3139.8 ± 564.8	3144.0 ± 545.4	.940
Length (cm)	52.0 ± 3.5	51.9 ± 3.3	.613
Head Circumference (cm)	34.2 ± 1.6	34.0 ± 1.8	.281
Placental Weight (grams)	607.3 ± 143.4	638.2 ± 133.3	.026

*Values are shown as mean ± SD
**p-values in bold are statistically significant at the 0.05 level

- Demonstrates the overall association of the tested variables between the GDM group and the non-GDM group with results obtained by a t-test.
  The difference in placental weight, as shown from the data analysis, was of particular interest, as it was shown to be lower in mothers with GDM compared to mothers without GDM.
- On further inspection, it can also be noted that there are small differences in the average birth weight, length, and head circumference of both groups. However, the average values for these variables did not reach statistical significance, possibly due to other confounding variables such as maternal BMI, maternal co-morbidities such as pre-eclampsia, and smoking status.
- The values for the gestational age at birth and placental weight were statistically significant in this study.

5. Discussion

GDM is a commonly encountered clinical condition with significant morbidity in mothers and neonates. The intrapartum effect of GDM on fetal growth has been documented well by multiple studies, and the post-natal morbidity and mortality have been closely examined as well. However, one of the noteworthy aspects of the effects of GDM on fetal growth is to determine how the anthropometric measurements of neonates born to mothers with and without GDM differ among different ethnicities. This paper has focused on Bahraini women and neonates and has examined the aforementioned differences.

According to a study by Kamana et al. in 2015 reviewed the underlying mechanism of increased birth weight in neonates born to mothers with GDM (13). As the placental size increases during the progression of pregnancy, there is an increase in pregnancy-related hormones such as placental lactogen, estrogen, progesterone, cortisol, and insulin in the mother. In a normal course of pregnancy, insulin resistance decreases as the placental hormone production ceases. However, there is a strong suggestion that the continued release of these hormones promotes continuous insulin resistance, leading to GDM. The resulting maternal hyperglycemia causes fetal hyperinsulinemia. Fetal insulin has been shown to have a role as a growth factor as well as an anabolic hormone, which leads to the development of fetal adiposity.

Macrosomia, which is defined as a birth weight of more than 4,000 grams, was examined in detail in a study conducted by Najafian et al. in 2012 in Saudi Arabia (14). It was found that maternal diabetes rates in neonates born with macrosomia were 39.5%, whereas in the control group, 6.1% of babies were identified as being macrosomic. In our study, only 5 out of 200 (2.5%) neonates born to mothers without GDM had a macrocosmic birth weight, and in the GDM group, 10 out of 200 (5%) neonates had a macrocosmic birth weight. There is a significant difference, as the probability of macrosomia doubles in GDM women than in non-GDM women. However, when examining the average birth weight of all neonates in both groups, there isn't a significant difference (p= 0.940) [Table 5]. Similarly, in a study conducted by Byström et al. in 2014, a comparison study of different potential variables affected by GDM was examined as a retrospective cohort study (15). Significant differences were noticed in the birth weight, birth length, and head circumference of neonates born to mothers with GDM compared to those born to mothers without GDM. In our study, however, there was a faster acceleration in head circumference in neonates born to mothers with GDM, as described in Table 2. Table 5 demonstrates that there was no significant difference in average head circumference between both groups.

In contrast, our study showed that 153 out of 200 (76%) of the GDM group had a placental weight of more than 500 grams, whereas 179 out of 200 (89.5%) of the non-GDM group had a placental weight of more than 500 grams. Our study also reported an average placental weight of 607.3 grams (± 143.4) in the GDM group and 638.2 grams (± 133.3) with a p-value of 0.026. The

underlying pathophysiology of how GDM causes increased placental weight is particularly remarkable. In a study conducted by El Sawy et al. in 2018, which examined the histopathological features of the placenta in mothers with and without GDM, it was found that in mothers with insulin resistance, evidence of neo-angiogenesis was seen[18]. These new blood vessels were classified as immature and were found to have thrombi. Vessels in the placenta of the GDM group were noted to be thicker due to this thick barrier, suggesting that there was impaired oxygen and nutrient transfer to the fetus. This evidence of a denser meshwork of vessels and thickened membranes is believed to be the cause of a heavier placenta in mothers with GDM. The results in our study, although statistically significant, are contradictory to this study. Our study indicates that, on average, the placental weight was found to be lower in the GDM group compared to the non-GDM group. The only gestational week where the placental weight was increased in the GDM group was during the 36th week, as shown in Figure 4, but otherwise, the non-GDM group had an increased placental weight. After a thorough search for existing literature regarding any evidence of decreased placental weight in mothers with GDM, we were unable to find any evidence for such phenomena.

GDM is a condition that can have detrimental effects on both the mother and the neonate. This study has attempted to compare the anthropometric measurements of neonates born to mothers with and without GDM to assess the effect of GDM on fetal growth. From our study, we recommend further investigation into the use of placental weight as a potential marker for growth during a GDM pregnancy. Interestingly, the results and analysis of the placental weight in this study, albeit statistically significant, were different compared to the existing literature and warrant further research and study.

6. Conclusion

GDM is a common yet serious complication encountered throughout pregnancy, most commonly via routine screening. One of the commonly observed outcomes of GDM in pregnancy is increased fetal growth through various mechanisms, which can result in an increased risk of neonatal morbidity and mortality. This study helps to reaffirm that routine screening of GDM is required, and perhaps placental weight is another factor to be taken into consideration after further study as an indicator of fetal growth and GDM progression.

Statements and Declarations

This research received no external funding, and the authors declare no conflict of interest. All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organization or those of the publisher, the editors, and the reviewers. Authors are required to state whether ethical approval was sought or not for the present study, especially if the study is a clinical trial or animal experiment. The authors took verbal consent from all participants to use the data.

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