Original Research Article

Saudi Medical Journal of Students (SMJS)
Official Journal of Faculty of Medicine University of Tabuk
ISSN: 1658-8274 (Print version); 1658-8282 (Electronic version)

ASSOCIATION OF PRE-PREGNANCY BODY MASS INDEX AND THE DEVELOPMENT OF GESTATIONAL DIABETES MELLITUS AND RELATED COMPLICATIONS IN THE CENTRAL REGION OF SAUDI ARABIA

Mariam S Alharbi[1], Bassam Abdullah Alharbi[2], Mohammed Tuhaymir Alharbi[2], Aqeel Fuhaid Altuwaiyan[2], Abdullah Saleh Aljudayi[2], Omar Mater Alharbi[2], Nagla Sirageldin Elhag[3]

[1]Department of Internal Medicine, College of Medicine, Qassim University Buraidah, KSA
[2]Student, College of Medicine, Qassim University (QU), KSA.
[3]General physician, King Fahd Specialist Hospital (KFSH), Buraydah, Qassim Health Cluster (QHC), KSA

***Corresponding author:** Bassam Abdullah Alharbi[2], Student, College of Medicine, Qassim University, KSA. Postal code: 52383. Mobile: +996553543742, Email: bassam128899@gmail.com.

ABSTRACT

Background: Gestational diabetes mellitus (GDM) during pregnancy can lead to significant health consequences for mothers and children in the short and long term. However, many countries, including Saudi Arabia, lack comprehensive epidemiological data to inform effective responses. This study aims to investigate the association between pre-pregnancy body mass index (BMI) and the development of GDM and related complications in the central region of Saudi Arabia.

Materials and Methods: This cross-sectional study enrolled 55 pregnant women who visited the Diabetes and Endocrinology Center in Buraydah, Qassim region, and voluntarily participated by completing a written questionnaire. Associations between various exposures and outcomes were evaluated using Statistical Packages for Software Sciences (SPSS) version 26, Armonk, New York, IBM Corporation, and 95% confidence intervals (CIs) were estimated.

Results: Our data suggested that GDM seemed to have a higher impact on women with normal BMI (65.5%) and those who were underweight (1.8%); however, the overall results did not reach statistical significance (p=0.361). Additionally, we found that being a housewife and taking medications influenced pre-pregnancy BMI.

Conclusion: In our study, there was no statistically significant relationship between prepregnancy BMI and GDM but normal and underweight women seemed to be more affected by GDM. Also, our study showed some factors to influence prepregnancy BMI, such as being housewife and taking medications.

Keywords: Gestational diabetes mellites; Pregnancy outcomes; Body mass index; Obesity; Saudi Arabia

To cite this article: Alharbi MS, Alharbi BA, Alharbi MT, Altuwaiyan AF, Aljudayi AS, Alharbi OM, Elhag NS. Association of Pre-Pregnancy Body Mass Index and The Development of Gestational Diabetes Mellitus and Related Complications in The Central Region of Saudi Arabia. Saudi Med J Students. 2023;4(1):20-30

INTRODUCTION

Gestational diabetes mellitus (GDM) refers to glucose intolerance first recognized after 20 weeks of pregnancy [1]. Its prevalence varies globally, with rates reported as 7% in North America, 11.2% in South America, and 15% in South-East Asia [2]. The Middle East and North Africa show the highest GDM prevalence, ranging between 8.4% and 24.5% [2]. In Saudi Arabia, various regions report prevalence rates, such as 19.6% in Jeddah, 16.2% in Medina, and 24.2% in Riyadh [3–5]. Despite often being asymptomatic, GDM poses significant risks during pregnancy and delivery, including preeclampsia, cesarean section, preterm delivery, fetal macrosomia, respiratory distress syndrome, neonatal jaundice, and neonatal ICU admission [6-7]. Moreover, women with a history of GDM face a higher risk of developing type 2 diabetes mellitus (T2DM) [8] and cardiovascular diseases [9].

Various risk factors contribute to GDM, including advanced maternal age, non-white ethnicity, previous GDM history, family history of T2DM, and smoking [10–12]. However, the most significant risk factor is being overweight or obese (pre-pregnancy BMI ≥ 25 kg/m2) [13]. Hence, maintaining a BMI below 25 kg/m2, adopting a healthy diet, engaging in regular exercise, and avoiding smoking before and during pregnancy are recommended preventive measures [14].

Obesity and overweight BMI prevalence among women of childbearing age have been rising globally [15]. Recent studies reveal that over 1.9 billion adults are overweight and 650 million are obese worldwide [16]. In Saudi Arabia, the prevalence of obesity surpasses the global average [17]. Besides contributing to GDM, overweight and obese women face higher risks of adverse pregnancy outcomes, including preeclampsia, cesarean delivery, labor induction, increased postpartum hemorrhage risk, gestational hypertension, cardiovascular diseases, and sleep apnea [18–20]. Additionally, neonatal complications such as shoulder dystocia, stillbirth, hypoglycemia, neonatal jaundice, and macrosomia are more common among offspring of obese or overweight mothers [21].

The escalating incidence of GDM is, in part, attributed to the increasing prevalence of obesity among childbearing women. Women with class three obesity, for instance, have a 14.6% higher risk of developing GDM compared to those with a normal BMI [20]. However, there is limited evidence on the association between GDM and obesity in the central region of Saudi Arabia. Therefore, this cross-sectional study aims to provide data on the relationship between GDM and pre-pregnancy obesity in the central region of Saudi Arabia.

MATERIAL AND METHODS

Ethical approval for the study was obtained from the regional research ethics committee, registered at the National Committee of Bioethics & Medical (NCBE) Registration No. H-04-Q-001 on March 01, 2023.

Study Design and Participants:

This cross-sectional study involved pregnant women (n=55) attending the Diabetes and Endocrinology Center in Buraydah, Qassim region. Participants were recruited based on their willingness to take part in the study and were requested to complete a study-specific written questionnaire during their visit. The questionnaire collected information on sociodemographic characteristics and maternal factors.

Data Collection Instrument:

We utilized a written questionnaire in the Arabic language for data collection (Items of the questionnaire was taken from multiple studies [22-25]). The questionnaire encompassed the following aspects: (1) Sociodemographic data, such as age, level of education, and employment status; (2) Physical activity, including cardio sports practice like walking and running, along with the frequency of these activities; (3) Pre-pregnancy weight, current weight (in Kg), and height (in cm); (4) Family history of diabetes mellitus (DM) and personal medical history, encompassing conditions like hypertension, DM, liver diseases, or kidney diseases; (5) Details of any previous pregnancies, their follow-up history, and duration of the current pregnancy (in weeks); (6) History of complications during the current pregnancy; and (7) Whether current blood sugar measurements meet the recommended glycemic targets, which include a fasting glucose level of ≤95 mg/dL (5.3 mmol/L), a 1-hour postprandial glucose level of ≤140 mg/dL (7.8 mmol/L), and a 2-hour postprandial glucose level of ≤120 mg/dL (6.7 mmol/L). Once validated, the questionnaire was distributed to pregnant women attending the Diabetes and Endocrinology Center in Buraydah.

Statistical Analysis:

Descriptive statistics were used to compute and report frequencies and proportions (%) for categorical variables. The relationship between pre-pregnancy BMI levels and the demographic and clinical characteristics of the patients was analyzed using the Fisher Exact test. Statistical significance was considered at $p<0.05$. Data analysis was performed using Statistical Package for the Social Sciences (SPSS) version 26, Armonk, New York, IBM Corporation.

RESULTS

The study included 55 women, with 47.3% of them aged between 30 to 35 years old, as depicted in Table 1. The majority of participants (83.6%) held a diploma, bachelor's, or higher degree, and approximately 56.4% were employed outside the home. Of the participants, 47.3% reported regular practice of cardio sports, with 57.7% engaging in sports on a weekly basis. Among the women, 60% had a family history of diabetes, with 63.3% of them having type 2 diabetes. Chronic diseases were present in

Table 1: Socio-demographic characteristics of the women (n=55)

Study Data	N (%)
Age group	
• 20 – 29 years	15 (27.3%)
• 30 – 35 years	26 (47.3%)
• >35 years	14 (25.5%)
Level of education	
• Middle	01 (01.8%)
• High school	08 (14.5%)
• Diploma/Bachelor or higher	46 (83.6%)
Nature of work	
• Housewife	21 (38.2%)
• Work from home	03 (05.5%)
• Work outside the house	31 (56.4%)
Do you practice Cardio sports (Walking, running)	
• Yes	26 (47.3%)
• No	29 (52.7%)
If your answer is yes to previous question, How much do you practice it? (n=26)	
• Everyday	05 (19.2%)
• 3-6 Days per Week	06 (23.1%)
• Weekly (less than 3 days per week)	15 (57.7%)
Has any of your 1st-degree relatives (parents, siblings) been diagnosed with Diabetes Mellitus?	
• Yes	33 (60.0%)
• No	22 (40.0%)
Please select the typeof DM (n=33)	
• DM Type 1	12 (36.4%)
• DM Type 2	21 (63.6%)
Have you been diagnosed with any chronic diseases?	
• Yes	10 (18.2%)
• No	45 (81.8%)
Specific chronic disease (n=10)	
• Hypertension	02 (20.0%)
• DM	03 (30.0%)
• Liver Diseases	
• Diabetes and Hypertension	03 (30.0%)
• Unknown	01 (10.0%)
If you were diagnosed with diabetes in the past, please select the type	
• DM type 1	03 (05.5%)
• DM type 2	03 (05.5%)
• I have not been diagnosed with DM	49 (89.0%)

18.2% of the participants, with diabetes (30%) or combined diabetes and hypertension (30%) being the most common conditions. Moreover, 5.5% had a previous diagnosis of type 2 diabetes.

Table 2 provides additional details on the participants. Around 12.7% were taking medications, and 41.8% were pregnant for the first time. Among those with previous pregnancies, 71.9% had three or fewer pregnancies in the past. The majority of

Table 2: Maternal characteristics (n=55)

Variables	N (%)
Are you currently take any medication/drugs?	
• Yes	07 (12.7%)
• No	48 (87.3%)
Is this your first pregnancy?	
• Yes	23 (41.8%)
• No	32 (58.2%)
Number of previous pregnancy (n=32)	
• ≤3	23 (71.9%)
• >3	09 (28.1%)
Duration of current pregnancy	
• ≤22 weeks	24 (43.6%)
• >22 weeks	31 (56.4%)
Are you following with obstetrics physician/gynaecologist	
• Yes	53 (96.4%)
• No	02 (03.6%)
Have you suffered from any complication during current pregnancy?	
• Yes	24 (43.6%)
• No	31 (56.4%)
Type of complication (n=24)	
• Gestational Diabetes Mellitus	18 (75.0%)
• Polyhydramnios	02 (08.3%)
• Oligohydramnios	01 (04.2%)
• Spontaneous Abortion (Miscarriage)	02 (08.3%)
• Other	01 (04.2%)
Last fasting blood sugar measurement (mg/dl)	
• ≤95	34 (61.8%)
• >95	21 (38.2%)
Last 1-hour postprandial blood sugar measurement (mg/dl)	
• ≤140	33 (60.0%)
• >140	22 (40.0%)
Last 2-hour postprandial blood sugar measurement (mg/dl)	
• ≤120	36 (65.5%)
• >120	19 (34.5%)

participants (56.4%) were at 22 weeks of gestation in the current pregnancy, and almost all (96.4%) were under the care of a obstetrician. Maternal complications were reported by 43.6% of the participants, with gestational diabetes being the most common complication (75%). Furthermore, 61.8% had a fasting blood sugar level of 95 mg/dL or less, while 60% had a 1-hour postprandial blood sugar level of 140 mg/dL or less, and 65.5% had a 2-hour postprandial blood sugar level of 120 mg/dL or less.

Figure 1 illustrates changes in BMI during pregnancy. During the current pregnancy, 47.3% of the women became overweight, and the prevalence of obesity increased from 12.7% before pregnancy to 20% during pregnancy.

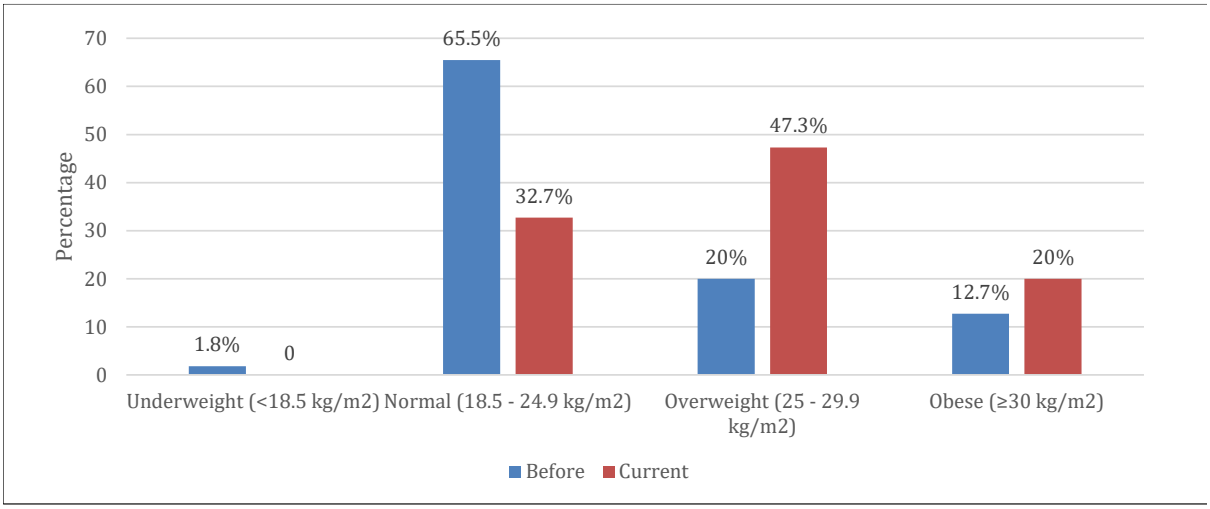
Table 3: Relationship between the level of prepregnancy BMI according to the Socio-demographic and clinical characteristics of the women (n=55)

Factor	Overweight or obese N (%) (n=18)	Normal or underweight N (%) (n=37)	P-value §
Age group			
• 20 – 29 years	03 (16.7%)	12 (32.4%)	
• 30 – 35 years	07 (38.9%)	19 (51.4%)	0.074
• >35 years	08 (44.4%)	06 (16.2%)	
Nature of work			
• Housewife	11 (61.1%)	10 (27.0%)	**0.020 ****
• Working	07 (38.9%)	27 (73.0%)	
Practicing Cardio sports (Walking, running)			
• Yes	09 (50.0%)	17 (45.9%)	1.000
• No	09 (50.0%)	20 (54.1%)	
Family history of DM			
• Yes	13 (72.2%)	20 (54.1%)	0.249
• No	05 (27.8%)	17 (45.9%)	
Associated chronic disease			
• Yes	04 (22.2%)	06 (16.2%)	0.713
• No	14 (77.8%)	31 (83.8%)	
Taking medications/drugs			
• Yes	05 (27.8%)	02 (05.4%)	**0.032 ****
• No	13 (72.2%)	35 (94.6%)	
First pregnancy			
• Yes	07 (38.9%)	16 (43.2%)	1.000
• No	11 (61.1%)	21 (56.8%)	
Duration of current pregnancy			
• ≤22 weeks	09 (50.0%)	15 (40.5%)	0.570
• >22 weeks	09 (50.0%)	22 (59.5%)	
Complication during pregnancy			
• Yes	07 (38.9%)	17 (45.9%)	0.774
• No	11 (61.1%)	20 (54.1%)	
Last fasting blood sugar measurement			
• ≤95 mg/dl	12 (66.7%)	22 (59.5%)	0.769
• >95 mg/dl	06 (33.3%)	15 (40.5%)	
Last 1-hour postprandial blood sugar measurement			
• ≤140 mg/dl	13 (72.2%)	20 (54.1%)	0.249
• >140 mg/dl	05 (27.8%)	17 (45.9%)	
Last 2-hour postprandial blood sugar measurement			
• ≤120 mg/dl	10 (55.6%)	26 (70.3%)	0.368
• >120mg/dl	08 (44.4%)	11 (29.7%)	

§ P-value has been calculated using Fischer Exact test.
** Significant at p<0.05 level.

Table 3 examines the relationship between pre-pregnancy BMI and demographic and clinical variables. The prevalence of overweight/obese status before

Figure 1: Women's current and before BMI



pregnancy was significantly more common among housewives (p=0.020) and those who were taking medication/drugs (p=0.032).

DISCUSSION

This study explored the relationship between pre-pregnancy BMI and the development of gestational diabetes and pregnancy-related complications. Our results showed that 20% of the subjects were overweight before pregnancy, 12.7% were obese, 65.5% had a normal BMI, and 1.8% were underweight. These findings differed from the study by Pirjani et al. [26], where higher levels of obesity (52.5%) and overweight (27.8%) were reported. Similarly, studies conducted in Qassim [23] and Riyadh [24] also demonstrated similar results regarding overweight and obesity, with 63% and 68.1% being overweight or obese, respectively.

Our study identified being a housewife and taking medications/drugs as factors influencing overweight/obesity. It contrasts with a study conducted in the UAE [15], which found that mothers aged 35 years or older were more likely to be overweight, and obese mothers were more likely to have lower monthly income and deliver via cesarean section. This aligns with a study from Jeddah [3], which documented that women with GDM were more likely to be older and have higher BMI values. This observation was also supported by research from Madinah [4], where older maternal age, elevated BMI, increased blood pressure, previous history of GDM, history of delivering a deformed child, and family history of DM were identified as the main risk factors for GDM. However, in our study, age, family history of DM, and associated chronic diseases showed no significant association with pre-pregnancy BMI, contrary to previous reports.

Approximately 43.6% of our subjects experienced pregnancy complications, with GDM being the most common (75.0%).

Other complications included polyhydramnios (8.3%), spontaneous abortion (8.3%), and oligohydramnios (4.2%). However, our results did not show a direct association between pregnancy complications and pre-pregnancy BMI. In contrast, a study by Sun et al. [27] found several pregnancy complications linked to overweight and obesity, including GDM, gestational hypertension, macrosomia, large gestational age, and low birth weight. Kim et al. [20] also reported an increased risk of gestational hypertensive disorders with increasing BMI. Additionally, a study by Roman et al. [21] linked increasing BMI to adverse maternal and neonatal outcomes, such as stillbirth, shoulder dystocia, macrosomia, hypoglycemia, NICU admission, and neonatal jaundice. Similarly, a cohort study by Wahabi et al. [24] associated obesity with GDM, induction of labor (IOL), failed IOL, hypertensive events in pregnancy, and cesarean delivery.

Regarding blood sugar levels, approximately 61.8% of our subjects had a fasting blood sugar level of 95 mg/dL or less, 60% had a 1-hour postprandial blood sugar level of 140 mg/dL or less, and 65.5% had a 2-hour postprandial blood sugar level of 120 mg/dL or less. However, we found no significant association between fasting blood sugar levels and pre-pregnancy BMI. In contrast, Alfadhli et al. [4] reported that fasting blood glucose was diagnostic in approximately 48% of GDM cases, and 1-hour and 2-hour glucose tolerance tests (OGTT) were added for the remaining GDM cases. Agarwal et al. [28] emphasized the importance of 1-hour and 2-hour glucose concentrations during OGTT for GDM diagnosis, as they were detected in more than half of the GDM cases.

Limitation

The number of pregnant ladies visiting the GDM clinic was minimal during the data collection period.

CONCLUSION

Our study did not find a statistically significant relationship between pre-pregnancy BMI and GDM development. However, GDM seemed to affect more normal and underweight cases. Being a housewife and taking medications were identified as factors influencing pre-pregnancy BMI. Pregnancy complications observed included changes in amniotic fluid volume and spontaneous abortion. Further research is warranted to investigate the relationship between pre-pregnancy BMI and the development of GDM in the central region (AL-Qassim). Implementing strategic programs to prevent and manage complications associated with pre-pregnancy BMI among women in the Central Region is of paramount importance.

ACKNOWLEDGMENTS

The completion of this research could not have been possible without our principal investigator of this research. Additionally, we would like to thank Dr. Majed Wadi, Medical Education Department, College of Medicine, Qassim University for helping us with the process of reviewing and validating the manuscript.

REFERENCES

1. Care D. Classification and diagnosis of diabetes. Diabetes Care. 2017 Jan 1;40(Suppl 1):S11-24. doi:10.2337/dc17-S005

2. Zhu Y, Zhang C. Prevalence of gestational diabetes and risk of progression to type 2 diabetes: a global perspective. Current diabetes reports. 2016 Jan;16:1-1. doi:10.1007/s11892-015-0699-x

3. Alsaedi SA, Altalhi AA, Nabrawi MF, Aldainy AA, Wali RM. Prevalence and risk factors of gestational diabetes mellitus among pregnant patients visiting National Guard primary health care centers in Saudi Arabia. Saudi medical journal. 2020 Feb;41(2):144. doi:10.15537/smj.2020.2.24842

4. Alfadhli EM, Osman EN, Basri TH, Mansuri NS, Youssef MH, Assaaedi SA, et al. Gestational diabetes among Saudi women: prevalence, risk factors and pregnancy outcomes. Annals of Saudi medicine. 2015 May;35(3):222-30. doi:10.5144/0256-4947.2015.222

5. Wahabi H, Fayed A, Esmaeil S, Mamdouh H, Kotb R. Prevalence and complications of pregestational and gestational diabetes in Saudi women: analysis from Riyadh Mother and Baby cohort study (RAHMA). BioMed research international. 2017 Oct;2017. doi:10.1155/2017/6878263

6. Najafi F, Hasani J, Izadi N, Hashemi-Nazari SS, Namvar Z, Mohammadi S, et al. The effect of pre-pregnancy body mass index on the risk of gestational diabetes mellitus: a systematic review and dose-response meta-analysis. Obesity Reviews. 2019 Mar;20(3):472-86. doi:10.1111/obr.12803

7. Ye W, Luo C, Huang J, Li C, Liu Z, Liu F. Gestational diabetes mellitus and adverse pregnancy outcomes: systematic review and meta-analysis. Bmj. 2022 May 25;377. doi:10.1136/bmj-2021-067946

8. Bellamy L, Casas JP, Hingorani AD, Williams D. Type 2 diabetes mellitus after gestational diabetes: a systematic review and meta-analysis. The Lancet. 2009 May 23;373(9677):1773-9. doi:10.1016/S0140-6736(09)60731-5

9. Sullivan SD, Umans JG, Ratner R. Gestational diabetes: implications for cardiovascular health. Current diabetes reports. 2012 Feb;12:43-52. doi:10.1007/s11892-011-0238-3

10. Solomon CG, Willett WC, Carey VJ, Rich-Edwards J, Hunter DJ, Colditz GA, et al. A prospective study of pregravid determinants of gestational diabetes mellitus. Jama. 1997 Oct 1;278(13):1078-83. doi:10.1001/jama.1997.03550130052036

11. Anna V, Van Der Ploeg HP, Cheung NW, Huxley RR, Bauman AE. Sociodemographic correlates of the increasing trend in prevalence of gestational diabetes mellitus in a large population of women between 1995 and 2005. Diabetes care. 2008 Dec

1;31(12):2288-93. doi:10.2337/dc08-1038

12. Bao W, Michels KB, Tobias DK, Li S, Chavarro JE, Gaskins AJ, et al. Parental smoking during pregnancy and the risk of gestational diabetes in the daughter. International journal of epidemiology. 2016 Feb 1;45(1):160-9. doi:10.1093/ije/dyv334

13. Zhang C, Ning Y. Effect of dietary and lifestyle factors on the risk of gestational diabetes: review of epidemiologic evidence. The American journal of clinical nutrition. 2011 Dec 1;94(suppl_6):1975S-9S. doi:10.3945/ajcn.110.001032

14. Zhang C, Tobias DK, Chavarro JE, Bao W, Wang D, Ley SH, et al. Adherence to healthy lifestyle and risk of gestational diabetes mellitus: prospective cohort study. Bmj. 2014 September 30;349. doi:10.1136/bmj.g5450

15. Taha Z, Hassan AA, Papandreou D. Epidemiology of pre-pregnancy body mass index (BMI) among mothers in Abu Dhabi, the United Arab Emirates. Frontiers in Global Women's Health. 2022 Sep 13;3:893808. doi:10.3389/fgwh.2022.893808

16. Ahirwar R, Mondal PR. Prevalence of obesity in India: A systematic review. Diabetes & Metabolic Syndrome: Clinical Research & Reviews. 2019 Jan 1;13(1):318-21. doi:10.1016/j.dsx.2018.08.032

17. Salem V, AlHusseini N, Abdul Razack HI, Naoum A, Sims OT, Alqahtani SA. Prevalence, risk factors, and interventions for obesity in Saudi Arabia: a systematic review. Obesity Reviews. 2022 Jul;23(7):e13448. doi:10.1111/obr.13448

18. Jensen DM, Damm P, Sørensen B, Mølsted-Pedersen L, Westergaard JG, Ovesen P, et al. Pregnancy outcome and pre-pregnancy body mass index in 2459 glucose-tolerant Danish women. American journal of obstetrics and gynecology. 2003 Jul 1;189(1):239-44. doi:10.1067/mob.2003.441

19. Wei YM, Yang HX, Zhu WW, Liu XY, Meng WY, Wang YQ, et al. Risk of adverse pregnancy outcomes stratified for pre-pregnancy body mass index. The Journal of Maternal-Fetal & Neonatal Medicine. 2016 Jul 2;29(13):2205-9. doi:10.3109/14767058.2015.1081167

20. Kim SS, Zhu Y, Grantz KL, Hinkle SN, Chen Z, Wallace ME, et al. Obstetric and neonatal risks among obese women without chronic disease. Obstetrics and gynecology. 2016 Jul;128(1):104. doi:10.1097/AOG.0000000000001465

21. Roman AS, Rebarber A, Fox NS, Klauser CK, Istwan N, Rhea D, et al. The effect of maternal obesity on pregnancy outcomes in women with gestational diabetes. The Journal of Maternal-Fetal & Neonatal Medicine. 2011 May 1;24(5):723-7. doi:10.3109/14767058.2010.521871

22. Blumer I, Hadar E, Hadden DR, Jovanovič L, Mestman JH, Murad MH, et al. Diabetes and pregnancy: an endocrine society clinical practice guideline. The journal of clinical endocrinology &

Metabolism. 2013 Nov;98(11):4227-49.23. doi:10.1210/jc.2013-2465

23. Meher-Un-Nisa, Aslam M, Ahmed SR, Rajab M, Kattea L. Impact of obesity on fetomaternal outcome in pregnant saudi females. Int J Health Sci (Qassim). 2009 Jul;3(2):187-95.

24. Wahabi H, Esmaeil S, Fayed A. maternal pre-pregnancy weight and pregnancy outcomes in Saudi women: subgroup analysis from Riyadh Mother and Baby Cohort Study (RAHMA). BioMed Research International. 2021 Apr 1;2021. doi:10.1155/2021/6655942

25. El-Gilany AH, Hammad S. Body mass index and obstetric outcomes in pregnant in Saudi Arabia: a prospective cohort study. Ann Saudi Med. 2010 Sep-Oct;30(5):376-80. doi:10.4103/0256-4947.67075

26. Pirjani R, Shirzad N, Qorbani M, Phelpheli M, Nasli-Esfahani E, Bandarian F, et al. Gestational diabetes mellitus its association with obesity: a prospective cohort study. Eating and Weight Disorders-Studies on Anorexia, Bulimia and Obesity. 2017 Sep;22:445-50. doi:10.1007/s40519-016-0332-2

27. Sun Y, Shen Z, Zhan Y, Wang Y, Ma S, Zhang S, et al. Effects of pre-pregnancy body mass index and gestational weight gain on maternal and infant complications. BMC pregnancy and childbirth. 2020 Dec;20(1):1-3. doi:10.1186/s12884-020-03071-y

28. Agarwal MM, Dhatt GS, Shah SM. Gestational diabetes mellitus: simplifying the international association of diabetes and pregnancy diagnostic algorithm using fasting plasma glucose. Diabetes care. 2010 Sep 1;33(9):2018-20. doi:10.2337/dc10-0572