Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Hypertriglyceridemic Waist Phenotype as Determinant and Early Marker for Gestational Diabetes Mellitus in Saudi Women

Nasser M. Al-Daghri

ndaghri@ksu.edu.sa

King Saud University

Nasiruddin Khan

A'Sharqiyah University

Malak Nawaz K. Khattak

King Saud University

Rahaf Alsufyani

King Saud University

Rinad Alanazi

King Saud University

Manar Ibrahim S Alhassan

King Saud University

Bushra S. Alshuayfani

King Saud University

Hanan A. Alfawaz

King Saud University

Article

Keywords: Waist circumference, triglycerides, Early pregnancy, Early detection, HOMA-IR

Posted Date: November 13th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-10799993/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

Abstract

Purpose

Abdominal obesity in the early stages of pregnancy is regarded as a potential risk factor for glucose intolerance in the later stages of pregnancy. Our study aims to assess the association between hypertriglyceridemic waist circumference (HTGW) phenotype and gestational diabetes (GDM).

Methods

The study included 562 Saudi pregnant women (8 weeks of gestation) aged 27–35 years undergoing a regular antenatal examination. The subjects were divided into four groups namely (a) Normal Waist/Normal Triglycerides (NWNT); (b) Normal Waist/High Triglycerides (NWHT); (c) Elevated Waist/Normal Triglycerides (EWNT); (d) Hypertriglyceridemic Waist (HTGW). Baseline examinations were performed and serum biochemical indicators were measured and recorded. ANOVA and multinomial logistic regression analysis was performed to determine the association of GDM with waist triglycerides phenotype. P value < 0.05 was considered statistically significant.

Results

The prevalence of GDM (42.9%) was significantly higher among HTGW phenotype than other groups. Moreover, the odds of having GDM were 3.68-fold higher (95% CI: 1.97–6.87) among HTGW compared with the reference group (NWNT).

Conclusion

We conclude that there is a significant correlation between HTGW phenotype and GDM. Hence, measurement of waist and triglyceride levels (hypertriglyceridemic-waist phenotype) during early pregnancy may be useful as a simple marker for the risk of GDM.

What does this study add to the clinical work?

This study highlights the potential advantages of including TG levels and WC measurements in the screening for GDM, promoting early detection and management that can mitigate health risks for both the mother and the child.

Introduction

Gestational diabetes mellitus (GDM) is the most common type of diabetes during pregnancy, indicating potential dysfunction of the beta cells [1]. GDM impacts approximately 1 in 11 pregnancies in the United

States [2]. The occurrence of GDM nearly doubled from 2006 to 2017 along with increased prevalence of physical inactivity, overweight/obesity, and advanced maternal age [3]. GDM increases the risk for adverse outcomes during pregnancy. It has been previously observed that GDM can lead to numerous negative impacts on the pregnancy outcomes for expectant mothers and their newborns, significantly influencing both maternal and neonatal health [4, 5]. Studies reported the association of GDM with increased risk of preterm delivery, cesarean section, infants born large for gestational age and required neonatal intensive care unit (NICU) admission, neonatal hypoglycaemia, and respiratory distress [6, 7].

Hence, its early diagnosis accompanied by reliable and accessible screening tools may improve these outcomes for women and children [8,]. The diagnostic tool currently in use for GDM such as fasting oral glucose tolerance test are costly, time-consuming and generally uncomfortable for pregnant women and they do not facilitate diagnosis until after the conclusion of the second trimester of pregnancy [9]. A comparatively more comfortable screening tool, 50-g glucose load followed by a one-hour plasma glucose analysis, still poses problems being unpleasant and time consuming for women, limiting its use mainly to women at risk for GDM. Several attempts have been made but no findings have so far revealed a simple method for conducting early and widely available screening. Reports suggest that pre-conception identification of increased waist circumference or high levels of serum triglycerides is a useful determinant of GDM [10]. Hypertriglyceridemic-waist phenotype (HTGW) was shown to be associated with increased risk of abnormal glucose metabolism [11]. HTGW phenotype has been identified as an easily available early screening tool for the risk of GDM during early pregnancy [12], cardiovascular disease, and a good indicator for metabolic syndrome [13]. A similar finding in a Chinese study suggests HTGW as an effective indicator of T2DM [14]. In addition, a meta-analysis demonstrated a high probability of diabetes associated with HTGW phenotype [11]. The present study aims to explore the association between HTGW phenotype and GDM in early pregnancy, in order to manage the occurrence and development of GDM.

Materials and methods

2.1 Subjects

The analysis is based on the outcomes of the standard 75 g oral glucose tolerance test (OGTT) conducted at 27.1 ± 4.1 weeks of gestation. In accordance with the criteria set by the International Association for Diabetes in Pregnancy Study Group (IADPSG), women exhibiting a fasting glucose level of ≥ 5.1 mmol/L and/or a 2-hour OGTT value of ≥ 8.5 mmol/L were identified as having gestational diabetes mellitus (GDM) [15, 16]. While a history of GDM is typically considered a significant risk factor, it was intentionally excluded from this study to assess the predictive ability of metabolic indices in a population without previous GDM, thus minimizing potential confounding factors related to recurrent GDM. As previously described (17), participants were recruited from various hospitals in Riyadh, Saudi Arabia. The inclusion criteria specified pregnant Saudi women with a singleton pregnancy. To ensure a highly homogeneous group, women with known multiple pregnancies, a history of GDM, or those suffering from chronic conditions such as type 2 diabetes mellitus (T2DM) and renal or hepatic

disorders were excluded. Additional inclusion and exclusion criteria were outlined previously [18]. All participants provided informed consent prior to their inclusion. The study was approved by the Institutional Review Board (IRB) of the College of Medicine, King Saud University (KSU) (IRB no: E-13-1013).

2.2 Anthropometry and blood collection

Baseline assessments, which included fasting blood collection and anthropometric measurements, were conducted at the time of recruitment (during the first trimester, between 8 and 14 weeks of gestation) as previously documented [18]. The anthropometric measurements included height (cm), weight (kg), waist and hip circumferences (cm) (WHC), as well as systolic and diastolic blood pressure (mmHg), all taken following standard protocols. The fasting blood samples obtained during this visit were promptly sent to the Chair for Biomarkers in Chronic Diseases (CBCD) at KSU, where they were processed, aliquoted, and stored at the appropriate temperature for future analysis. Subsequently, later in the pregnancy (at a gestational age of 27.1 ± 4.1 weeks), participants were contacted for a follow-up hospital visit to undergo standard GDM screening as previously outlined [16, 17].

2.3 Laboratory measurements and follow-up visit for GDM screening:

The biochemical parameters analyzed for fasting blood samples collected during the initial visit included glucose, HbA1c%, total cholesterol, HDL cholesterol, triglycerides (TG), and insulin (μU/mL). These parameters were measured using routine biochemical testing conducted on an automated biochemistry analyzer (Konelab 20, Thermo-Fischer Scientific, Espoo, Finland). The total coefficient of variation (CV) for glucose was ≤ 5%; for HbA1c, it was ≤ 3.5%; for total cholesterol, ≤ 4%; for HDL cholesterol, ≤ 4%; for TG, ≤ 4%; and for insulin, ≤ 4%. The Quality Assurance Department at KSU continuously monitored the standards and controls employed for these biochemical tests to ensure highly reproducible study outcomes.

Later in the course of pregnancy (gestational age 27.1 ± 4.1 weeks), participants were invited for a follow-up hospital visit to undergo standard screening for gestational diabetes mellitus (GDM). Blood samples were collected two hours post prandial and also during fasting. The “Insulin resistance index” utilized was the “Homeostasis Model Assessment for Insulin Resistance” (HOMA-IR) calculated as [19]:

HOMA-IR = Fasting Insulin(μU/mL) × Fasting glucose(mmol/L)/22.5

The subjects were divided into four groups based on TG and WC in the first trimester [20]: (a) Normal Waist/Normal Triglycerides (NWNT): WC ≤ 85 and fasting triglycerides ≤ 1.7 mmol/L (130 mg/dL); (b) Normal Waist/High Triglycerides (NWHT): WC ≤ 85 and fasting TG > 1.7 mmol/L; (c) Elevated Waist/Normal Triglycerides (EWNT): WC > 85 and fasting TG < 1.7 mmol/L; (d) Hypertriglyceridemic Waist (HTGW): Waist circumference > 85 and fasting triglycerides > 1.7 mmol/L.

Statistical analysis

Data were analyzed using SPSS (version 22 Chicago, IL, USA). Continuous data were presented as mean ± standard deviation (SD) for normal variables and non-Gaussian variables were presented as median (1st and 3rd) percentiles. Categorical data were presented as frequencies and percentages (%) and analyzed using a Chi-square test for association. All continuous variables were checked for normality using Kolmogorov-Smirnov test. Non-Gaussian variables were log-transformed prior to parametric analysis. ANOVA and Kruskal-Wallis H test were performed to compare mean and median differences in Gaussian and Non-Gaussian variables for Waist-triglycerides phonotype and post hoc analysis was performed by Bonferroni test. Multinomial logistic regression analysis was performed for risk factors associated with GDM with waist triglycerides phenotype, unadjusted and adjusted for age, menarche age, and parity. P-value < 0.05 was considered statistically significant.

Results

Baseline clinical characteristics of the participants

The baseline clinical characteristics of the participants having GDM with different groups of phenotypes of serum TG concentrations and WC are presented in Table 1. The majority of the variables were significantly different (P < 0.001) among four groups.

Table 1. Baseline Clinical Characteristics of Participants

Baseline metabolic parameters across different groups

At visit 1, the total cholesterol, total cholesterol-HDL ratio, LDL-c, glucose, and HOMA-IR, (all P < 0.001), in the HTGW group were significantly higher than other groups (Table 2).

Table 2. Baseline Metabolic Characteristics of Participants

Follow-up visit outcomes

Table 3 represents the visit 2 (follow-up) outcomes showing significantly high weight, BMI (both P < 0.001), 1-hr blood glucose (P = 0.002), 2-hr blood glucose (P = 0.005), and fasting insulin levels (P = 0.007) in the HTGW group than other groups (Table 3).

Table 3. Weight, BMI, Glycemic and Insulin Response Outcomes (Follow-up Visit)

Odds of GDM associated with Hypertriglyceridemic-waist phenotype

Table 4 represents the odds ratio (ORs) demonstrating the independent predictors of GDM among participants. The prevalence of GDM was 42.9%, and was significantly higher than those in EWNT

(32.9%) and NWHT (26.8%) groups. The odds of having GDM was 3.68-fold (95% CI: 1.97–6.87) higher among HTGW as compared to reference group (NWNT). After adjusting for age and menarche age, by multinomial logistic regression analysis, the odds for GDM were still 3.36 times (95% CI: 1.65–6.87) higher than in the normal group.

Table 4. Odds of GDM across phenotypes

Discussion

In this study, we found that HTGW phenotypes were significantly associated with increased risk of GDM. The GDM that develops during pregnancy affects nearly 1 in 7 pregnant women [21]. The prevalence shows an increasing pattern with each passing year in parallel with T2DM. GDM contributes threats including short- and long-term morbidity and mortality for both women and child. On one hand, women with GDM are at higher risk of developing T2DM and CVD events [22, 23]. On the other hand, children born to mothers with GDM are predisposed to a higher risk of large for gestational age (LGA), and future issues such as obesity and glucose intolerance [24–26]. The recommended screening for GDM in pregnant women without existing diabetes is performed at 24 to 28 weeks of gestation [2, 27, 28]. However, various studies demonstrate that early screening and treatment of GDM in pregnant women helps in managing strategies and taking active measures to reduce its occurrence and associated complications, ensuring better outcomes for both mother and child [29–31]. The HTGW (the combination of an increased WC and hypertriglyceridemia) has been identified as a simple, easily available, and inexpensive clinical marker of visceral obesity and metabolic irregularities [32, 33]. Previous studies suggested a higher risk of GDM with HTGW phenotype, and the information may be utilized to predict the probability of developing DM [34–37]. Therefore, in our present study, we aimed to demonstrate the relationship between HTGW and GDM and compared other risk factors for GDM, to support the basis for its early screening and management.

In the present study, pregnant women with HTGW phenotypes show various indices of metabolic abnormalities. Abnormal glucose measurement parameters such as (FPG, OGTT at 0, 1 and 2 hour), lipid levels such as (TG, total cholesterol, cholesterol-HDL ratio, LDL-c), and insulin index such as HOMA-IR were significantly higher than other groups. Our results suggest a predisposition towards higher risk of GDM among pregnant women in HTGW phenotype group. The odds of having GDM were significantly higher (3.68 times) among HTGW as compared to the normal group and remained high (3.36 times) even after adjustment for age and menarche age. Our present finding is supported by another study performed by Brisson D and colleagues demonstrating the association of HTGW phenotype with abnormal metabolic indices capable to aid in the improvement of early screening for gestational diabetes. Moreover, the study showed that odds ratio of HTGW with glucose intolerance remained high even after adjusting for confounding factors [38]. Another study supported our present findings by showing that measurement of waist girth in combination with triglyceride level in the first trimester of pregnancy could improve early screening for gestational glucose intolerance [12].

Over the last few decades, the risk factors associated with GDM had been studied extensively that lead to evolved diagnostic criteria and management approaches due to evidences related to maternal hyperglycemia and adverse perinatal outcomes. GDM is the most common complication in pregnancy and 1 in 6 live births had been diagnosed with GDM [39]. The GDM is associated with increased risk of pregnancy complications such as preeclampsia, stillbirth, birth injury, preterm birth, large size for gestational age, and newborn hypoglycemia. As mentioned earlier, mothers with GDM may be at increased risk of type 2 diabetes, and their offspring may be at increased risk of obesity, type 2 diabetes (T2DM), and other metabolic disorders.

The prevalence of GDM globally varies between 1% and 30% [40, 41]. In a recent systematic review of the Middle East, the most prevalent countries for diabetes mellitus are Iran (32.3%) and Saudi Arabia (24.2%) followed by Qatar (9.7%) [42]. In Saudi Arabia, the prevalence of GDM is reportedly high as compared to other countries [43]. Riyadh mother and baby cohort study (RAHMA) showed a prevalence of 24.2% of GDM among pregnant women [44].

Although the pathogenesis of GDM is not well understood, scientific reports show that dysfunction of β-cells and pregnancy-induced insulin resistance are the most important factors leading to GDM [45]. The inability of pancreatic β-cells to respond adequately to the increased insulin demand during pregnancy is a defining feature of gestational diabetes mellitus (GDM), resulting in hyperglycemia. In addition, placental hormones interfere with the normal action of insulin during pregnancy, leading to disturbed regulation of blood glucose levels [46]. Other reports suggest that, due to the development of insulin resistance during pregnancy, the cell's response to insulin is reduced, which leads to GDM [47].

GDM is a combination of genetic susceptibility, metabolic factors, environmental factors, and dietary and lifestyle behavior. WC is among one of the important predictive markers of GDM, including maternal weight, gestational weight gains and gestational BMI [48, 49]. Increased WC, is shown as a simple and valid index of abdominal obesity, and a determinant for diabetes [50]. More importantly, studies suggest that higher serum triglyceride levels may cause lipotoxic β-cell injury, impairing insulin secretion even more [39]. Therefore, HTGW may lead to insulin resistance (IR) and an increased risk of GDM. Moreover, the use of different biomarkers of IR and metabolic syndrome in clinical settings is limited due to cost and standardization process. In this regard, the use of the combined effect of high waist circumference and TG concentration has been proposed to be a valuable method of screening for pregnant women with possible high risk of GDM [51]. Our present study demonstrated a uniform pattern of increasing prevalence of GDM from normal waist and triglyceride level to the combined effect of high waist and TG level. Consequently, the integration of waist circumference and triglycerides enhanced the capacity to identify early GDM.

Increased HOMA-IR in early pregnancy is considered as a risk factor of GDM [52, 53]. Our present study demonstrated higher HOMA-IR values in the HTGW than any other group. Other parameters such as glucose level, cholesterol-HDL ratio, and fasting insulin levels were significantly higher in hypertriglyceridemic waist phenotype than other groups with a combination of normal waist and

triglyceride, NWET and EWNT. Moreover, the occurrence of GDM among HTGW phenotype was higher than the other three groups, suggesting a higher risk of GDM among this group. Hence, our present study suggests that obesity, IR, and other effects may lead to the occurrence and development of GDM.

The current research examined the influence of HTGW in the screening process for GDM and concluded that the HTGW phenotype notably increased the risk of GDM. Therefore, including TG levels and WC measurements in the screening for GDM could be beneficial for its early identification and control. Nevertheless, these results require additional clarification, therefore, future research would benefit from a larger sample size.

The current study has certain limitations. Firstly, the small sample size may restrict the generalizability of the findings. Secondly, the cross-sectional design of the research hinders the ability to establish causal relationships or definitively validate the results. Third, although the results were adjusted for many variables, the study failed to adequately evaluate lifestyle factors, such as nutrition and physical activity, which are recognized to influence metabolic health and can impact the prognostic accuracy of the indices. Finally, reliance on biochemical measurements, which can be affected by various factors including stress, illness, or laboratory inconsistencies, may compromise the results. Addressing these limitations in future research could enhance the effectiveness of this screening tools and provide a more comprehensive understanding of the application of these indices in predicting GDM.

Declarations

Funding

The authors are thankful to the Ongoing Research Funding Program-Research Chairs (ORF-RC-2026-14-00), King Saud University, Riyadh, Saudi Arabia, for funding this research.

Competing Interests

The authors have no competing interests to declare that are relevant to the content of this article.

Author Contributions

Nasser M. Al-Daghri, Nasiruddin Khan contributed to the study conception and design. Methodology and sample analysis was carried out by Rahaf Alsufyani, Rinad Alanazi, Manar Ibrahim S. Alhassan, Bushra S. Alshuayfani. Data curation was done by Malak Nawaz K. Khattak. Writing and original draft preparation was performed by Nasiruddin Khan. Writing, review and editing was done by Nasser M. Al-Daghri, Malak Nawaz K. Khattak, Rahaf Alsufyani, Rinad Alanazi, Manar Ibrahim S. Alhassan, Bushra S. Alshuayfani, Hanan A. Alfawaz . In addition, Hanan A. Alfawaz supervised the project administration while Nasser M. Al-Daghri was responsible for funding acquisition. All authors have read and agreed to the final version of the manuscript.

Ethics approval

This study was conducted in accordance with the Declaration of Helsinki and ethical approval was obtained from the College of Medicine, King Saud University, (KSU), Riyadh, Saudi Arabia.

Consent to Participate

Written informed consent was obtained from all individuals before they participated in the study

Consent to Publish

This manuscript does not include any identifiable individual data (such as images, videos, or personal details). Accordingly, consent to publish was not required.

References

1. ElSayed, N. A. et al. 2. Classification and Diagnosis of Diabetes: Standards of Care in Diabetes-2023. *Diabetes Care*. **46**, S19–S40. 10.2337/dc23-S002 (2023).
2. Pillay, J. et al. Screening for Gestational Diabetes: Updated Evidence Report and Systematic Review for the US Preventive Services Task Force. *JAMA* **326**, 539–562. 10.1001/jama.2021.10404 (2021).
3. Zhou, T. et al. Prevalence and Trends in Gestational Diabetes Mellitus Among Women in the United States, 2006–2017: A Population-Based Study. *Front. Endocrinol. (Lausanne*. https://doi.org/10.3389/fendo.2022.868094 (2022).)13:868094.
4. Yamamoto, J. M. et al. Gestational Diabetes Mellitus and Diet: A Systematic Review and Meta-analysis of Randomized Controlled Trials Examining the Impact of Modified Dietary Interventions on Maternal Glucose Control and Neonatal Birth Weight. *Diabetes Care*. **4**, 1346–1361. 10.2337/dc18-0102 (2018).
5. Farrar, D., Duley, L., Dowswell, T. & Lawlor, D. A. Different strategies for diagnosing gestational diabetes to improve maternal and infant health. *Cochrane Database Syst. Rev.* https://doi.org/10.1002/14651858.CD007122.pub4 (2017). 8,CD007122.
6. HAPO Study Cooperative Research Group et al. Hyperglycemia and adverse pregnancy outcomes. *N Engl. J. Med.* **358**, 1991–2002. 10.1056/NEJMoa0707943 (2008).
7. Prakash, G. T., Das, A. K., Habeebullah, S., Bhat, V. & Shamanna, S. B. Maternal and Neonatal Outcome in Mothers with Gestational Diabetes Mellitus. *Indian J. Endocrinol. Metab.* **21** (6), 854–858. 10.4103/ijem.IJEM_66_17 (2017).
8. Iqbal, R. A. & Nazir, S. Potential novel biomarkers for gestational diabetes mellitus in first and early second trimesters: A comprehensive review. *Reprod. Biol.* **25**, 101059. 10.1016/j.repbio.2025.101059 (2025).
9. American Diabetes Association. Standards of medical care in diabetes (2009) Diabetes Care 32 Suppl:S13-S61. 10.2337/dc09-S013
10. Gunderson, E. P. et al. Longitudinal study of prepregnancy cardiometabolic risk factors and subsequent risk of gestational diabetes mellitus: The CARDIA study. *Am. J. Epidemiol.* **172**, 1131–

1143. 10.1093/aje/kwq267 (2010).

11. Ma, C. M. et al. Hypertriglyceridemic waist phenotype and abnormal glucose metabolism: a system review and meta-analysis. *Endocrine* **64**, 469–485. 10.1007/s12020-019-01945-6 (2019).
12. Faris, A., Rasheed, Raghad, H., Mshattat, U. M., Alnakkash, Saad, A. & Hussain Hypertriglyceridemia and waist phenotype as markers in the prediction of gestational diabetes in Iraqi women. *Res. J. Obstet. Gynecol.* **11** (1), 25–30. https://doi.org/10.3923/rjog.2018.25.30 (2018).
13. de Cuevillas, B., Alvarez-Alvarez, I., Riezu-Boj, J. I., Navas-Carretero, S. & Martinez, J. A. The hypertriglyceridemic-waist phenotype as a valuable and integrative mirror of metabolic syndrome traits. *Sci. Rep.* **11**, 21859. 10.1038/s41598-021-01343-x (2021).
14. Xu, M. et al. Hypertriglyceridemic Waist Phenotype and Lipid Accumulation Product: Two Comprehensive Obese Indicators of Waist Circumference and Triglyceride to Predict Type 2 Diabetes Mellitus in Chinese Population. J Diabetes Res 2020:9157430. (2020). 10.1155/2020/9157430
15. International Association of Diabetes and Pregnancy Study Groups Consensus Panel et al. International association of diabetes and pregnancy study groups recommendations on the diagnosis and classification of hyperglycemia in pregnancy. *Diabetes Care*. **33**, 676–682. 10.2337/dc09-1848 (2010).
16. Gupta, Y., Kalra, B., Baruah, M. P., Singla, R. & Kalra, S. Updated guidelines on screening for gestational diabetes. *Int. J. Womens Health*. **7**, 539–550. 10.2147/IJWH.S82046 (2015).
17. Yakout, S. M., Khattak, M. N. K., Alnaami, A. M., Alenada, A. & Al-Daghri, N. M. Assessing the diagnostic value of the metabolic score for insulin resistance in gestational diabetes mellitus. *J. King Saud Univ.* **37**, 4452024. 10.25259/JKSUS_445_2024 (2025).
18. Al-Ajlan, A. et al. Vitamin D deficiency and dyslipidemia in early pregnancy. *BMC Pregnancy Childbirth*. **15**, 314. https://doi.org/10.1186/s12884-015-0751-5 (2015).
19. Tang, Q., Li, X., Song, P. & Xu, L. Optimal cut-off values for the homeostasis model assessment of insulin resistance (HOMA-IR) and pre-diabetes screening: Developments in research and prospects for the future. *Drug Discov Ther.* **9**, 380–385. 10.5582/ddt.2015.01207 (2015).
20. Amini, M. et al. The association of hypertriglyceridemic waist phenotype with type 2 diabetes mellitus among individuals with first relative history of diabetes. *J. Res. Med. Sci.* **16**, 156–164 (2011).
21. Saeedi, P. et al. Global and regional diabetes prevalence estimates for 2019 and projections for 2030 and 2045: Results from the International Diabetes Federation Diabetes Atlas, 9(th) edition. *Diabetes Res. Clin. Pract.* **157**, 107843. 10.1016/j.diabres.2019.107843 (2019).
22. Vounzoulaki, E. et al. Progression to type 2 diabetes in women with a known history of gestational diabetes: systematic review and meta-analysis. *BMJ* **369**, m1361. 10.1136/bmj.m1361 (2020).
23. Murray, S. R. & Reynolds, R. M. Short- and long-term outcomes of gestational diabetes and its treatment on fetal development. *Prenat Diagn.* **40**, 1085–1091. 10.1002/pd.5768 (2020).

24. Moon, J. H. & Jang, H. C. Gestational Diabetes Mellitus: Diagnostic Approaches and Maternal-Offspring Complications. *Diabetes Metab. J.* **46**, 3–14. 10.4093/dmj.2021.0335 (2022).
25. Tan, P. C., Ling, L. P. & Omar, S. Z. The 50-g glucose challenge test and pregnancy outcome in a multiethnic Asian population at high risk for gestational diabetes. *Int. J. Gynaecol. Obstet.* **105**, 50–55. 10.1016/j.ijgo.2008.11.038 (2009).
26. Boyd, E., Metzger, D. R., Coustan, Elisabeth, R. & Trimble Hyperglycemia and Adverse Pregnancy Outcomes. *Clin. Chem.* **65**, 937–938. https://doi.org/10.1373/clinchem.2019.303990 (2019).
27. ElSayed, N. A. et al. on behalf of the American Diabetes Association. 2. Classification and Diagnosis of Diabetes: Standards of Care in Diabetes-2023. *Diabetes care*. **46**, S19–S40. https://doi.org/10.2337/dc23-S002 (2023).
28. ACOG Practice Bulletin No. 190: Gestational Diabetes Mellitus *Obstet. Gynecol.* **131**:e49–e64. https://doi.org/10.1097/AOG.0000000000002501 (2018).
29. Hillier, T. A. et al. Impact of earlier gestational diabetes screening for pregnant people with obesity on maternal and perinatal outcomes. *J. Perinat. Med.* **50**, 1036–1044. 10.1515/jpm-2021-0581 (2022).
30. McLaren, R. A. Jr et al. Early screening for gestational diabetes mellitus: a meta-analysis of randomized controlled trials. *Am. J. Obstet. Gynecol. MFM*. **4**, 100737. 10.1016/j.ajogmf.2022.100737 (2022).
31. Bastian, B. et al. Early screening and diagnosis of gestational diabetes mellitus (GDM) and its impact on perinatal outcomes. *Diabetes Res. Clin. Pract.* **217**, 111890. 10.1016/j.diabres.2024.111890 (2024).
32. Lemieux, I. et al. Hypertriglyceridemic waist: a useful screening phenotype in preventive cardiology? Can J Cardiol 23 Suppl B:23B-31B. (2007). 10.1016/s0828-282x(07)71007-3
33. Sam, S. et al. Hypertriglyceridemic waist phenotype predicts increased visceral fat in subjects with type 2 diabetes. *Diabetes Care*. **32**, 1916–1920. 10.2337/dc09-0412 (2009).
34. Martin, A. M. et al. Abdominal visceral adiposity in the first trimester predicts glucose intolerance in later pregnancy. *Diabetes Care*. **32**, 1308–1310. 10.2337/dc09-0290 (2009).
35. Zhang, M. et al. Hypertriglyceridemic-waist phenotype predicts diabetes: a cohort study in Chinese urban adults. *BMC Public. Health*. **12**, 1081. 10.1186/1471-2458-12-1081 (2012).
36. Díaz-Santana, M. V., Suárez Pérez, E. L., Ortiz Martínez, A. P., Guzmán Serrano, M. & Pérez Cardona, C. M. Association Between the Hypertriglyceridemic Waist Phenotype, Prediabetes, and Diabetes Mellitus Among Adults in Puerto Rico. *J. Immigr. Minor. Health*. **18**, 102–109. 10.1007/s10903-014-9985-y (2016).
37. Lee, B. J. & Kim, J. Y. Identification of Type 2 Diabetes Risk Factors Using Phenotypes Consisting of Anthropometry and Triglycerides based on Machine Learning. *IEEE J. Biomed. Health Inf.* **20**, 39–46. 10.1109/JBHI.2015.2396520 (2016).
38. Brisson, D., Perron, P., Guay, S. P., Gaudet, D. & Bouchard, L. The hypertriglyceridemic waist phenotype and glucose intolerance in pregnancy. *CMAJ* **182**, E722–E725. 10.1503/cmaj.100378

(2010).

39. Sweeting, A., Wong, J., Murphy, H. R. & Ross, G. P. A Clinical Update on Gestational Diabetes Mellitus. *Endocr. Rev.* **43**, 763–793. 10.1210/endrev/bnac003 (2022).
40. Eades, C. E., Cameron, D. M. & Evans, J. M. M. Prevalence of gestational diabetes mellitus in Europe: A meta-analysis. *Diabetes Res. Clin. Pract.* **129**, 173–181. 10.1016/j.diabres.2017.03.030 (2017).
41. Li, L. J., Huang, L., Tobias, D. K. & Zhang, C. Gestational Diabetes Mellitus Among Asians - A Systematic Review From a Population Health Perspective. *Front. Endocrinol. (Lausanne)*. **13**, 840331. 10.3389/fendo.2022.840331 (2022).
42. Al-Rifai, R. H., Abdo, N. M., Paulo, M. S., Saha, S. & Ahmed, L. A. Prevalence of Gestational Diabetes Mellitus in the Middle East and North Africa, 2000–2019: A Systematic Review, Meta-Analysis, and Meta-Regression. *Front. Endocrinol. (Lausanne)*. **12**, 668447. 10.3389/fendo.2021.668447 (2021).
43. Alsaedi, S. A., Altalhi, A. A., Nabrawi, M. F., Aldainy, A. A. & Wali, R. M. Prevalence and risk factors of gestational diabetes mellitus among pregnant patients visiting National Guard primary health care centers in Saudi Arabia. *Saudi Med. J.* **41**, 144–150. 10.15537/smj.2020.2.24842 (2020).
44. 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. Res. Int.* **2017**, 1–9 (2017).
45. Martín-Estal, I. & Castorena-Torres, F. Gestational Diabetes Mellitus and Energy-Dense Diet: What Is the Role of the Insulin/IGF Axis? *Front. Endocrinol. (Lausanne)*. **13**, 916042. 10.3389/fendo.2022.916042 (2022).
46. Hod, M., Kapur, A. & McIntyre, H. D. Evidence in support of the International Association of Diabetes in Pregnancy Study Groups' criteria for diagnosing gestational diabetes mellitus worldwide in 2019. *Am. J. Obstet. Gynecol.* **221**, 109–116 (2019).
47. Kampmann, U., Knorr, S., Fuglsang, J. & Ovesen, P. Determinants of maternal insulin resistance during pregnancy: an updated overview. J Diabetes Res 2019:5320156. (2019).
48. Torloni, M. R. et al. Prepregnancy BMI and the risk of gestational diabetes: a systematic review of the literature with meta-analysis. *Obes. Rev.* **10**, 194–203. 10.1111/j.1467-789X.2008.00541.x (2009).
49. Qiao, Q. & Nyamdorj, R. Is the association of type II diabetes with waist circumference or waist-to-hip ratio stronger than that with body mass index? *Eur. J. Clin. Nutr.* **64**, 30–34. 10.1038/ejcn.2009.93 (2010).
50. Schmidt, M. I. et al. Gestational diabetes mellitus diagnosed with a 2-h 75-g oral glucose tolerance test and adverse pregnancy outcomes. *Diabetes Care*. **24**, 1151–1155. 10.2337/diacare.24.7.1151 (2001).
51. Yang, S. H., Kim, C., An, H. S., An, H. & Lee, J. S. Prediction of Gestational Diabetes Mellitus in Pregnant Korean Women Based on Abdominal Subcutaneous Fat Thickness as Measured by Ultrasonography. *Diabetes Metab. J.* **41**, 486–491. 10.4093/dmj.2017.41.6.486 (2017).

52. Song, S. et al. HOMA-IR as a risk factor of gestational diabetes mellitus and a novel simple surrogate index in early pregnancy. *Int. J. Gynaecol. Obstet.* **157**, 694–701. 10.1002/ijgo.13905 (2022).
53. Duo, Y. et al. Predictability of HOMA-IR for Gestational Diabetes Mellitus in Early Pregnancy Based on Different First Trimester BMI Values. *J. Pers. Med.* **13**, 60. 10.3390/jpm13010060 (2022).

Tables

Tables 1 to 4 are available in the Supplementary Files section.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- TablesAG.docx