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GESTATIONAL DIABETES

A pilot study on the usefulness of body mass index and waist hip ratio as a predictive tool for gestational diabetes in Asian Indians

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Abstract

Gestational diabetes mellitus (GDM) is a common public health issue of pregnancy and women who have had GDM are at high risk for developing of diabetes mellitus Type-2. The aim of this study was to find the association between various clinical and biochemical parameters and GDM. One hundred and six consecutive patients who attended the out patient unit of department of gynecology, Kottayam Medical College, were enrolled in the study and followed up through the whole antenatal, intra-partum and post-partum periods to identify the obstetric outcome. We found that the prevalence of GDM was seven times higher in those with higher waist–hip ratio (WHR > 0.85) compared with those having a lower WHR ($p < 0.001$).Those with higher WHR gained more weight than other group (10.6 kg *vs.* 8.1 kg; $p < 0.001$). Obesity (BMI ≥23) and higher WHR were associated with increased risk of gestational diabetes (BMI ≥23: OR = 7.5, CI 95% = (1.61–34.31), $p = 0.013$; WHR > 0.85: OR = 12.05, CI 95% = (1.82–77.43), $p = 0.007$). We found that a WHR of 0.849 has the optimal sensitivity and specificity for the prediction of GDM. A waist circumference of 85.5 cm (with sensitivity of 75%, specificity 81.4%) and a BMI of 24.3 kg/m^2 (sensitivity 75%, specificity 86.5%) had the best predictive value. In conclusion, we found that maternal obesity has a strong correlation with obstetric complications. We found WHR is more important risk determinant for GDM in overweight/obese women than women with normal weight/lean.

Keywords: *Gestational diabetes, waist hip ratio, risk determinant, obstetric complications, obesity*

Introduction

Gestational diabetes mellitus (GDM) is a common public health issues with a worldwide incidence of 2–7% of all pregnancies [1]. Recent data on the prevalence of GDM in our country was 16.55% based on the WHO criteria [2].

GDM is defined as carbohydrate intolerance of variable severity with onset or first recognition during pregnancy [1,3]. Gestational glucose intolerance has been linked to many adverse outcomes in both mother and the fetus. GDM can be considered as Type-2 diabetes which is unmasked or discovered during pregnancy. Perhaps, GDM is a combination of genetic predisposition, environmental, dietary, exercise and metabolic factors [1–3].

Type-2 diabetes accounts for over 50% of diabetes worldwide. It is a manifestation of a much broader underlying disorder, the metabolic syndrome. Obesity is one of the modifiable risk factors of metabolic syndrome. Maternal obesity is considered as an important factor in the diagnosis of gestational diabetes [1,4].

Waist–hip ratio (WHR) is a clinical criterion in diagnosing metabolic syndrome and it has been found to be a dominant, independent predictive variable of cardiovascular and coronary artery disease deaths in men and women than body mass index (BMI) [5].

There is a paucity of literature on gestational diabetes from India which would be the house of an estimated 79.4 million diabetic by 2030 [6].

Indians differ from the West genotypically, phenotypically as well as in dietary habits and lifestyle which make them more vulnerable to GDM. Moreover, in the under developed and developing countries due to lack of resources, it is impossible to screen for abnormal carbohydrate intolerance in

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every pregnant women. In the Indian context, screening is essential in all pregnant women as the Indian women have 11-fold increased risk of developing glucose intolerance during pregnancy compared with Caucasian women [7]. So it is necessary to have a risk predictor which is accurate and inexpensive. Our aim was to determine the usefulness of WHR waist circumference and BMI in screening for GDM. We also studied the correlation of maternal obesity as measured by WHR and BMI with GDM, peripartum complications, weight of the baby and congenital malformations.

Subjects and methods

One hundred and six pregnant women attending the out patient department of the department of gynecology and obstetrics, Government Medical College Hospital, Kottayam, Kerala, during the period from April 2005 to April 2006 were serially enrolled for the study during their first ante-natal visit after screening for the criteria described below.

Inclusion criteria: (1) Single live intrauterine pregnancies; gestational age 12 weeks or less at the first antenatal visit. (2) Maternal age: 18–35. We excluded subjects with (1) History of diabetes before pregnancy, (2) History of drugs known to cause insulin resistance (amiodarone, methotrexate, prednisone, anabolic steroids, phenytoin, barbiturates, valproic acid, nucleoside analogues, PPAR-gamma agonists, tamoxifen) within the prior 6 months, (3) History of thyroid or pituitary disorders, (4) Comorbid conditions and severe systemic illness like CCF/VHD, CHD and COPD and (5) Associated metabolic/inherited disorders.

The patients were explained about the study and a written informed consent was obtained. The protocol of the study was approved by the institutional ethics committee.

The subjects were grouped on the basis of WHR and BMI as follows:

- Group1: BMI less than 23 (lean/normal)
- Group 2: BMI greater than or equal to 23 (overweight/obese)
- Group-3: WHR less than or equal to 0.85 (narrow waist)
- Group-4: WHR greater than 0.85 (broad waist)

Detailed medical history, family history, diet and exercise habits were taken from the subjects. This was followed by a thorough clinical examination. All data vital to this study *viz.*; height (in metres approximated to the nearest centimetre in standing position), weight (in kilograms approximated to the nearest 100 g), systolic and diastolic BP (after 15 min of rest in supine position on right arm), routine blood and urine examination, ultra sonography, hematological and biochemical reports which are relevant to the study were collected and recorded.

Clinical identification of gestational diabetes

Gestational diabetes includes cases with abnormal carbohydrate intolerance with onset or first detected during the present pregnancy [3,8].

A 100 g glucose tolerance test is done in all pregnant women enrolled in the study between 24 and 28 weeks; subjects with blood glucose values equal to or greater than 95 mg% during fasting and 180, 155 and 145 mg% at 1, 2 and 3 h after 100 g glucose loading were considered as having impaired glucose tolerance [9].

Hypertension is diagnosed when the resting blood pressure is 140/90 mmHg or greater; korotkoff phase V is used to describe diastolic pressure. The diagnosis of gestational hypertension is made when the blood pressure is 140/90 mmHg or greater for the first time during pregnancy but in whom proteinuria is not identified and the BP returns to normal within 12-weeks post-partum. The minimum criteria for the diagnosis of pre-eclampsia include BP $\geq$140/90 mmHg and proteinuria more than or equal to 300 mg% in 24 h or more than 1+ dipstic in random urine samples [8].

BMI is promulgated by the World health organisation (WHO) as the most useful epidemiological measure of obesity. We followed the modified proposal for classification of weight by BMI in adult Asians by WHO according to which BMI between 18.5 and 22.9 was taken as normal, $\geq$23 as overweight (23–24.9 at risk, 25–29.9 Obese 1 and $\geq$30 Obese 2) [4].

WHR is the ratio between the waist and hip circumferences. It was measured on bare skin or with minimum clothing; the waist would be measured at the mid point between iliac crest and the lowest rib. The hip circumference would be measured at the widest area. A WHR of 0.85 was recommended by a WHO expert consultation on diabetes for women and hence we have used 0.85 as the cut-off for WHR in our study [10].

The term induction implies stimulation of contractions before the spontaneous onset of labour with or without rupture of membranes. Methods of induction include medical methods like prostaglandin E2, oxytocin and prostaglandin E1, mechanical methods like extra amniotic saline or amniolysis and surgical methods like artificial rupture of membranes [8].

The patients were followed up to the postnatal period. The complications immediately before the commencement of labour, during and immediately after the labour (peripartum period) were closely monitored, analysed and recorded.

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Statistical analysis

The data was analysed using standard statistical techniques using Microsoft Excel (MS Office 2003, Microsoft Corporation, USA) and 'Microstat' (Ecosoft Inc. 1984) and SPSS 11 for Windows (SPSS Inc.). Levene's test was done to assess the homogeneity-of-variance of variables in groups under study. Unpaired (2 tail) Student t test (StT) was performed to find any significant difference between two groups, assuming equal or unequal variance as determined by the Levene's test. Mann–Whitney test (M-W) was used when assumptions for Students T test were doubtful. Spearman's rho correlation was used to establish association between the variables. Chi-square test/Fishers' exact test was used to compare proportions, whichever appropriate. Odds ratio (OR) [11] was calculated by an online tool (http://statpages.org/ctab2x2.html).

Receiver operating characteristic (ROC) curve was constructed and analysed using SPSS 11 for Windows (SPSS inc.) to measure the effectiveness of BMI, waist circumference, WHR and FBS to discriminate between subjects having GDM from those who don't have GDM. The diagnostic accuracy of the quantitative measures was determined by calculating the area under curve (AUC). In the ROC graph, the X-axis is 1 minus the specifcity (the false positive rate) and the Y-axis is the sensitivity (the true positive rate). A diagonal line on the graph was from (0,0) in the lower left hand corner to (1,1) in the upper right hand corner. This line reflects the characteristics of a test with no discriminating power. The closer the graph gets to the upper left hand corner (0,1), the better the test is at discriminating between cases and non-cases. An index of the goodness of the test is AUC, a perfect test has area 1.0, whereas a non-discriminating test has area 0.5 [12].

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Results

At history level, the prevalence of diabetes, hypertension and obesity was 7.5%, 12.2% and 32%, respectively, in the study group.

In the study group, 20% of the patients and controls belonged to the poor socioeconomic class (manual labourers, farmers or partly employed or unemployed). The anthropometric, clinical and biochemical data of the total study population is summarised in Table I. We had 72 women in Group 1 (BMI $<$ 23), 34 in Group 2 (BMI $\geq$ 23), 63 women in Group 3 (WHR $\leq$ 0.85) and 43 women in Group 4 (WHR $>$ 0.85). An overview of the four sub-groups is given in Table II.

Subjects with narrow waist were younger than those with broad waist (mean age 26.2 $\pm$ 3.6 and 28.1 $\pm$ 3.9, $p < 0.05$).This means subjects gained weight as they aged. There was significant difference among the groups in weight gain during pregnancy. The third group on average gained 8.1 $\pm$ 2.5 kg during pregnancy whereas Group 4 gained 10.6 $\pm$ 3.3 kg ($p < 0.001$). The Group 4 gave birth to larger babies than Group 1 (3.1 $\pm$ 0.5 *vs.* 2.6 $\pm$ 0.3, $p < 0.001$) and similarly Group 1 patients gained 8.6 kg on average and Group 2 gained 10.24 kg. Obese patients gave birth to bigger babies (3.1 kg) than lean ones (2.7 kg). The narrow waist subjects had a lower plasma fasting glucose than the broad waist group (82.1 $\pm$ 6.4 Group 3 *vs.* 84.6 $\pm$ 8.1 Group 4, $p = 0.09$). The group with lesser WHR had a better glucose tolerance. FBS values for Group 1 were lower than those in Group 2 (82.3 $\pm$ 6.2 *vs.* 85.35 $\pm$ 8.7, $p = 0.03$). The prevalence of gestational diabetes was higher in women with broader waist compared to women with narrow waist ($n = 1$ for group 3, $n = 7$ for group 4; $z = -2.74$, $p < 0.001$). Obesity (BMI $\geq$ 23) and higher WHR were associated with increased risk of gestational diabetes (BMI $\geq$23: OR = 7.5, CI 95% = (1.61–34.31), $p = 0.013$; WHR $>$ 0.85: OR = 12.05, CI 95% = (1.82–77.43), $p = 0.007$). Similarly, the prevalence of GDM and PIH were higher in the Groups 2 and 4. The incidences of anomalies were more in the obese and also in high waist–hip group, but the incidence of IUGR was less in these two groups. The incidence of abnormal deliveries and need for induction were more in the obese/overweight and high WHR groups.

Table I. Anthropometric, clinical and laboratory measurements of the study population.

Total cases	106
Age (years)	26 ($\pm$4)
Height (cm)	155 ($\pm$5.4)
BMI (kg/m^2)	21.58 ($\pm$3.74)
Over weight (BMI $\geq$23)	32% (n = 34)
Weight gain during pregnancy (kg)	9.13 ($\pm$3)
Baby weight (kg)	2.83 ($\pm$0.47)
Waist circumference (cm)	81.5 ($\pm$7.8)
Waist–hip ratio	0.85 ($\pm$0.034)
PIH	12.2% (13)
FBS (mg/dL)	83.14 ($\pm$7.2)
Family h/o diabetes	20.75% (22)
GDM	7.5% (n = 8)
Abnormal deliveries	20.75% (22)
IUGR	15% (n = 16)

Results expressed as mean ($\pm$standard deviation) or percentage (actual number).

WHR is more important in overweight/obese mothers compared to lean

To verify whether WHR is relevant over BMI in discriminating women with gestational diabetes, we compared the incidence in overweight/obese women *versus* lean/normal using waist–hip as the criterion for discrimination.

Table II. Anthropometric, clinical and laboratory measurements of the study population.

	Group 1 (BMI < 23)	Group 2 (BMI ≥ 23)	Group 3 (W/H ≤ 0.85)	Group 4 (W/H > 0.85)
Total cases	72	34	63	43
Age (years)	26 ± 3.6	28.97 ± 3.5	26.2 ± 3.6	28.1 ± 3.9
Weight gain (kg)	8.6 ± 2.9	10.24 ± 3.1	8.1 ± 2.5	10.6 ± 3.3
Baby weight (kg)	2.7 ± 0.39	3.1 ± 0.54	2.6 ± 0.29	3.14 ± 0.53
PIH	2.8%	9%	3.2%	6.97%
GDM	2.8%	18%	1.6%	16.3%
FBS (mg/dL)	82.3 ± 6.2	85.35 ± 8.7	82.2 ± 6.4	84.6 ± 8.2
Abnormal deliveries	14%	38%	8%	41.8%
Induction	25.3%	44%	19.3%	49%

Results expressed as mean (± standard deviation) or percentage.

The incidence of GDM among overweight–obese women with a higher WHR was significantly high when compared to those having a lower WHR. However, the corresponding difference among normal weight–lean women was statistically insignificant (Figure 1).

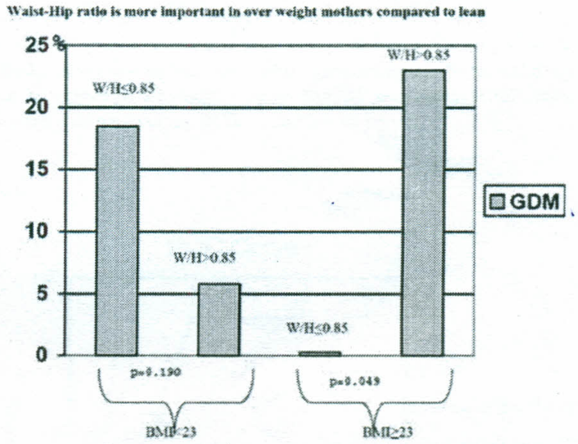

Figure 1. The incidence of GDM in obese women with a higher waist–hip ratio was significantly high when compared to those having a lower waist–hip ratio.

Gestational diabetes has a genetic basis

We observed a significant increase in the incidence of gestational diabetes in women having a family history of diabetes mellitus. Among women with a family history of diabetes, 18.2% had GDM whereas among women who had no family history of diabetes, only 4.8% had GDM ($z = 2.1$, $p = 0.017$).

Correlation of clinical, biochemical, obstetric and neonatal parameters

Complications associated with pregnancy, including GDM and PIH increases with advancing age. As expected BMI, waist circumference and WHR showed a significant positive correlation with age of the subjects (refer Table III).Weight gain was significantly correlated with the occurrence of GDM ($r = 0.34$, $p < 0.01$); those who gained more weight during pregnancy had to undergo abnormal delivery including instrumental deliveries and LSCS ($r = 0.306$, $p < 0.01$) they delivered babies of higher birth weight also ($r = 0.424$, $p < 0.01$). Obese patients and those with higher WHR gained more weight during pregnancy.

The occurrence of GDM is positively correlated with obesity (both with high BMI and high WHR). Higher baby weight and abnormal deliveries were more common in them. The incidence of PIH was also more in GDM ($r = 0.438$, $p < 0.01$). GDM patients were subjected to abnormal patterns of delivery($r = 0.28$, $p < 0.01$). Baby weight was also positively correlated with abnormal type of deliveries ($r = 0.361$, $p < 0.01$). The incidence of PIH was strongly correlated with the mother's weight, BMI and waist circumference and fasting blood sugar. But the correlation with WHR was less significant. The incidence of PIH was more in GDM patients ($r = 0.438$, $p < 0.01$). The incidence of PIH was more in older age patients ($r = 0.192$, $p < 0.01$).

The association of waist circumference and fasting blood sugar is more significant for women with gestational diabetes. We observed a very significant association between FBS and waist circumference ($r = 0.23$, $p < 0.01$). The fasting blood sugar increased with increase in waist circumference. Interestingly, this relation was stronger in women with gestational diabetes (Figure 2).

Receiver operated characteristic curve analysis for optimal cut-off values for WHR, waist circumference, BMI and fasting blood sugar. We found a WHR of 0.849 gives the optimum specificity and sensitivity when used to discriminate subjects having diabetes from those who don't. The WHR of 0.849 is associated with a sensitivity of 1 and a specificity of 0.515. WHR is more sensitive but less specific.

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Table III. Correlation of clinical, biochemical, obstetric and neonatal parameters in the study group.

	Wt	BMI	W/C	W/H	Wt.Gn.	GTT	GDM	Height	B.Wt	FBS
Age	0.195*	0.23*	0.219*	0.293**	0.241*	0.233**	0.256**			
SEC								−0.2*		
FH							0.206*			
Wt					0.352**	0.433**	0.381**		0.582**	0.279**
BMI				0.569**	0.329**	0.472**	0.42**		0.545**	0.3*
W/C					0.5**	0.44**	0.4**		0.6**	0.233*
W/H					0.35**	0.26**	0.38**		0.6**	0.23*
Wt. Gn.						0.374**	0.34**		0.424**	0.33**
GTT									0.4**	
Ab.Del.	0.31**	0.35**	0.25**	0.25**	0.31**	0.32**	0.28**		0.361**	0.298**
B.Wt.							0.354**			0.206*
ANOM					0.37**	0.374**	0.34**			
IUGR								−0.25**		
GDM										0.47**
PIH	0.424**	0.44**	0.395**	0.213*	0.321**	0.425**	0.438**		0.297**	0.256**
IND	0.237*	0.22*	0.221*	0.262**						

SEC, socio economic class; FH, family history of diabetes; Wt, weight; BMI, body mass index; W/C, waist circumference; W/H, waist hip ratio; Wt. Gn, weight gain; GTT, glucose tolerance test; Ab. Del, abnormal deliveries; B. Wt., birth weight; ANOM, anomalies; IUGR, intra uterine growth restriction; GDM, gestational diabetes; PIH, pregnancy induced hypertension; IND, induction of labour.
$^{*}p < 0.05$.
$^{**}p < 0.01$.

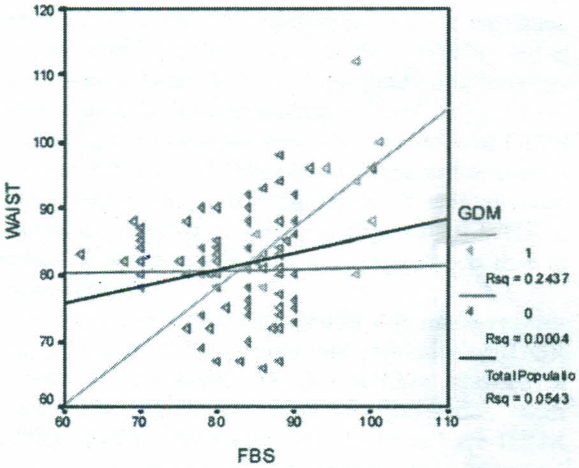

Figure 2. Waist circumference is an important determinant of GDM. The association between waist circumference and FBS becomes clearer when women with normal FBS are excluded. (Green line and triangles: GDM, Red line and triangles: Normal FBS, Black line: Total population).

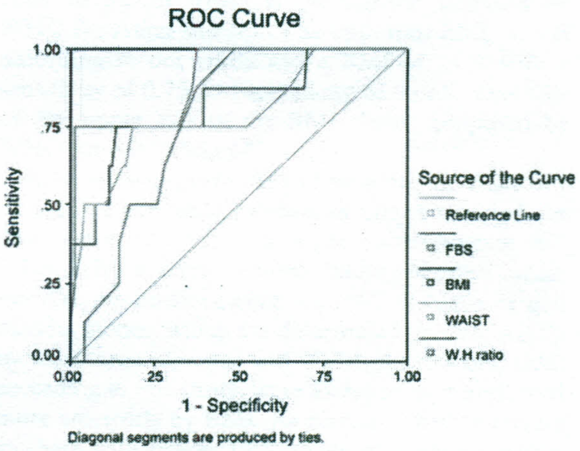

Figure 3. BMI to be a better determinant of gestational diabetes than waist circumference and waist–hip ratio on comparison of the area under the respective ROC curves.

We found BMI to be a better determinant of gestational diabetes than waist circumference and WHR on comparison of the area under the respective ROC curves (Figure 3).

Discussion

Women who have had GDM are at high risk for the development of diabetes [1]. This strong association between GDM and diabetes mellitus Type-2 (DM-2) could make it a useful tool in early identification of individuals at risk of developing DM later in their life. This is very important in the context of the evolving obesity pandemic as obese have a strong association with DM-2. However, we know very little how prevalent is GDM in India; and how it is associated with different markers of obesity.

Women with family history of diabetes suffered from gestational diabetes more frequently than those without [13–15]. In a study conducted in South Indian population by Tulika Bose [14] in 2005, the incidence of GDM in women with family history of diabetes was found to be 28.6%. The incidence of GDM in those with family history of diabetes was found to be 18.2% in our study whereas the corresponding figure was only 4.8% in mothers without a family history of diabetes.

Satter et al. [16] hypothesised that waist circumference would be as sensitive as BMI for predicting

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risk of pregnancy-induced hypertension or pre-eclampsia and could form the basis for health promotion involving raising awareness of the importance of or urging weight reduction for women planning pregnancies. In their study to assess whether waist circumference at the first antenatal visit predicts risk of developing hypertension later in pregnancy, greater waist circumference was noted in subjects who subsequently developed pregnancy-induced hypertension or pre-eclampsia. These observations support a pivotal role for central fat deposition as a reversible cause of hypertension, insulin resistance and increased plasma lipid levels.

Waist circumference was found to be an important determinant of GDM. Among the GDM patients those with higher WHR had higher FBS values. Wendland et al. (2007) [17] evaluated the diagnostic properties of waist circumference in the prediction of obesity-related pregnancy outcome. In their study, the incidence of adverse pregnancy outcomes (like gestational diabetes, pregnancy-induced hypertension and macrosomia) increased with increasing quintiles of anthropometric measurements. They found that a waist circumference of 82 cm maximised sensitivity (63%) and specificity (57%) and as such was potentially useful in predicting obesity-related outcomes in pregnancy.

Among the obese patients, the incidence of GDM was more in higher WHR patients than in the normal ones. But in the lean subjects, there was no such significant difference. Thus, in conclusion, WHR is found to be more important in obese subjects than in lean subjects.

Another important observation was made regarding the height of the mother and incidence of IUGR (Table III). Height of the mother showed a statistically significant negative correlation with IUGR. Tall mothers were less likely to have IUGR babies. This seems to be important as maternal height can be considered as an indicator of their childhood nourishment considering the racial homogeneity of the study population [18]. This underscores the lasting importance of childhood nourishment extending to the subsequent generations. Well-nourished mothers have lower chances of having IUGR babies. Multiple genetic and environmental factors contribute to IUGR. Nutrition is the major intrauterine environmental factor that alters expression of the fetal genome and may have lifelong consequences [19].

Overweight–obese and mothers with a higher WHRs gained more weight than others during the course of pregnancy. Incidences of abnormal deliveries were more in these subjects. Combining the study data with the literature, especially considering the large, mutually independent associations shown here for pre-pregnancy BMI and weight gain during pregnancy, suggests that both these nutritional aspects play an important role in this complication. Studies by Parker and Abrams [20] reported increased incidence of large-for-gestational-age births (>90th percentile of fetal growth standards) of 40% for obese women (BMI > 29 kg/m^2) and Cogswell et al. [21] found that high birthweight almost doubled among obese women who gained ≥13.7 kg compared with those who gained 6.8–8.6 kg during pregnancy, entailing an increased risk for cesarean. The weight gain could partly due to an increased fetal mass and possibly due to increased water retention because the incidence of PIH was also higher among them.

We found a WHR of 0.85 gives the optimum specificity and sensitivity when used to discriminate subjects having diabetes from those don't. This cut-off is essentially in agreement with the cut-off proposed by WHO expert committee [10].

Similarly, a waist circumference of 85.5 cm was found to be the optimum cut-off for discriminating mothers with GDM, with a sensitivity of 0.75 and specificity of 0.814. This value is higher than but close to 80 cm which is the cut-off proposed by WHO for Asian Indians. The optimum BMI cut-off according to our study was a BMI of 24.3, with a sensitivity of 0.75 and specificity of 0.865. This falls on the upper side of the BMI classes proposed by WHO for adult Asian Indians.

ROC analysis performed to evaluate the efficiency of possible surrogate markers of GDM revealed the dominance of BMI over waist circumference and WHR. This is a very relevant finding because unlike the risk for cardiovascular disease, diabetes or gall bladder stones, which are determined predominantly by waist circumference and WHR, the risk of GDM, according to our study, were found to be determined more efficiently by BMI. As discussed before among mothers with higher BMI those who have a higher WHR are more prone to develop GDM. Thus, BMI and WHI could be useful in screening for GDM in rural settings where resources are limited. This observation is a very significant outcome of our study. However, large population studies are needed to evaluate the validity of this pilot study whose results need to be taken with caution because of the small population size studied.

Declaration of interest: The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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