

# Body Mass Index (BMI) and Glucose Intolerance during Pregnancy in White European Women

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## Abstract

**Background:** The risk of gestational diabetes mellitus (GDM) in accordance to Body Mass Index (BMI) is often based on studies where the calculation of BMI is frequently self-reported and is usually unreliable. We evaluated the risk of an abnormal oral glucose tolerance test (OGTT) in a population where BMI was measured and selective screening for GDM was practiced.

**Methods:** We carried out a prospective observational study where 1935 white European women with a singleton pregnancy were recruited. In the first trimester maternal height and weight were measured digitally. Statistical analysis was performed using SPSS version 15.0. BMI centiles were calculated from the study population. A Chi-square test was used to test the differences in categorical variables between the groups. A p-value <0.05 was considered significant.

**Results:** In 1935 women, 547 OGTTs were performed and 70 of these were abnormal. The prevalence of an abnormal OGTT was higher in women with Class 2 and 3 obesity compared to women with Class 1 obesity (23.3% vs. 10.1%, respectively;  $p=0.008$ ). The frequency of an abnormal OGTT was higher in women with a BMI  $\geq 90$ th centile ( $\geq 33.1 \text{ kg/m}^2$ ) compared to women with a BMI between the 80th and 90th centiles ( $\geq 29.3$  and  $< 33.1 \text{ kg/m}^2$ ), (21.5% vs 8.1% respectively;  $p=0.005$ ).

**Conclusion:** When BMI is measured, we recommend to increase the cut-off point for selective screening of GDM to  $\geq 33.0 \text{ kg/m}^2$ . This may decrease unnecessary obstetric interventions and healthcare costs.

**Keywords:** Body Mass Index, Gestational Diabetes Mellitus, Glucose intolerance, Maternal obesity.

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## Introduction

The reported prevalence of gestational diabetes mellitus (GDM) varies widely between 1 and 14% of all pregnancies (1). A prevalence of 2.7% has been reported for the Irish population (2). This wide variation may be explained in part by ethnic differences, and also by a lack of consensus in screening for GDM (3, 4).

Universal screening for GDM, for example, is practiced by 84% of obstetricians in Canada and by 94%–97% in the United States of America, but only in 17% of obstetric units in Britain (5, 6).

There are also wide variations nationally and internationally about the criteria for selective

screening, the type of glucose load testing, the criteria for the diagnosis of GDM and the timing of the glucose load testing.

Maternal obesity increases the risk of GDM (2, 7, 8). A systematic review found that the odds ratio for GDM in obese women with a Body Mass Index (BMI)  $\geq 30.0 \text{ kg/m}^2$  was 3.8 (95% CI, 3.3–4.3) compared with normal weight women (1). In another meta-analysis including studies involving selective screening, the risk of developing GDM was estimated to be about two, four and eight times higher among overweight, obese and severely obese women, respectively compared with

normal-weight pregnant women (9). The recent NICE guidelines on diabetes in pregnancy lists a BMI  $\geq 30.0 \text{ kg/m}^2$  as one of five independent risk factors for the development of GDM (10).

In previous studies estimating the risk of GDM according to BMI, the calculation of BMI was often self-reported or the methodology unstated (1). Self-reporting, however, is unreliable and the degree of unreliability differs according to ethnicity, gender and obesity category (11, 12). In a Canadian study, women underreported their weight by an average of 2.5 kg and discrepancies increased in obese BMI categories (13). We have reported that 22% of women were categorised in the wrong category if BMI calculations were based on selfreporting (14).

The aim of this study was to determine the risk of glucose intolerance and GDM by both BMI categories and BMI centiles in a population where BMI was measured accurately and selective screening for GDM was practiced.

### Methods

This prospective observational study was conducted in a large university teaching hospital between July 2008 and March 2010. Women were recruited at their convenience after an ultrasound confirmed an ongoing singleton pregnancy in early pregnancy. The study was confined to white European women to avoid ethnicity as a confounding variable. Women with a diagnosis of diabetes mellitus in the prepregnancy period, women under the age of 18 years and women who could not give consent were excluded.

At recruitment, maternal height and weight were measured digitally by a single trained observer. Height was measured in centimetres to one decimal point using a wall-mounted meter stick (Seca 242). The women were asked to remove their footwear and to stand barefoot with their back against the measuring rod. Their heels were against the plate, and their back and head were straight. The head stop was pushed down until it touched the head.

Maternal weight was measured in kilograms to the nearest decimal point in a standardized way using a Tanita MC 180 MA (Tokyo, Japan). The women were asked to empty their bladder before the measurement. They were also asked to remove any heavy clothing items. To account for the weight of the clothes during the measurement 0.5 kg was deducted from the measured weight.

Screening for GDM was based on risk factors. Women with either a historical risk factor (previous macrosomic infant, first degree relative with diabetes mellitus, previous unexplained stillbirth, maternal age  $>40$  years or maternal weight  $>90 \text{ kg}$ ) or a risk unique to the current pregnancy (confirmed glycosuria, polyhydramnios or suspected macrosomia) were screened. A normal glucose response in pregnancy was defined as a fasting value of  $<5.3 \text{ mmol/L}$ , a 1-hour postprandial value of  $<10.0 \text{ mmol/L}$ , a 2-hour postprandial value of  $<8.6 \text{ mmol/L}$  and a 3-hour postprandial value of  $<7.8 \text{ mmol/L}$  after a 3-hour 100 g OGTT at around 28th gestational week (15). One abnormal level was classified as glucose intolerance, while two or more abnormal levels were classified as GDM. Clinical and sociodemographic details were collected prospectively and computerised.

Statistical analysis was carried out using SPSS version 15.0. BMI centiles were calculated from the study population. A Chi-square test was used to evaluate differences in categorical variables between the groups. A p value  $<0.05$  was considered significant. The study was approved by the Hospital's Research Ethics Committee in June 2008 and an informed consent was obtained.

### Results

Of the 2000 women enrolled into the study, 41 (2.0%) subsequently miscarried and 24 (1.2%) transferred elsewhere for antenatal care. The characteristics of the remaining 1935 women are shown in table 1. An OGTT was performed on 547 women. Screening was more likely to occur in the obese categories because maternal weight  $>90 \text{ kg}$  was used as an indication for screening. The overall incidence of an abnormal OGTT in our study population was 3.6%.

**Table 1.** Characteristics of study population (n=1935)

Mean age (years) (M $\pm$ SD)	28.9 $\pm$ 5.3
Mean parity (M $\pm$ SD)	0.8 $\pm$ 1.1
Mean gestational age at recruitment (weeks) (M $\pm$ SD)	10.8 $\pm$ 2.3
Primigravidas (%)	923 (47.7)
Smokers (n)	445 (23.0)
BMI ( $\text{kg/m}^2$ ) (n)	
<18.5	46 (2.4)
$\geq 18.5$ and $<25.0$	1010 (52.2)
$\geq 25.0$ and $<30.0$	521 (26.9)
$\geq 30.0$ and $<35.0$	193 (10.0)
$\geq 35.0$	65 (7.4)

**Table 2.** Oral glucose tolerance test (OGTT) results analysed by Body Mass Index (BMI) category (n=547)

BMI category ( $kg/m^2$ )	OGTTs performed (n)	One abnormal level (%)	Two abnormal levels (%)	Abnormal OGTT (%)
<18.5	4	0	0	0
$\geq 18.5$ and <25.0	196	7 (3.6)	7 (3.6)	14 (7.1)
$\geq 25.0$ and <30.0	128	12 (9.4)	6 (4.7)	18 (14.1)
$\geq 30.0$ and <35.0	99	7 (7.1)	3 (3.0)	10 (10.1) *
$\geq 35.0$	120	15 (12.5)	13 (10.8)	28 (23.3) *

\* p=0.008

**Table 3.** Oral glucose tolerance test (OGTT) results analysed by Body Mass Index (BMI) centiles (n=547)

BMI Centile ( $kg/m^2$ )	OGTTs Performed (n)	One abnormal level (%)	Two abnormal levels (%)	Abnormal OGTT (%)
<10 <sup>th</sup> (<20.0)	23	0	0	0
$\geq 10^{\text{th}}$ and <20 <sup>th</sup> ( $\geq 20.0$ & <21.2)	24	0	1 (4.2)	1 (4.2)
$\geq 20^{\text{th}}$ and <80 <sup>th</sup> ( $\geq 21.2$ & <29.3)	265	19 (7.2)	11 (4.2)	30 (11.3)
$\geq 80^{\text{th}}$ and <90 <sup>th</sup> ( $\geq 29.3$ & <33.1)	86	4 (4.7)	3 (3.5)	7 (8.1) *
$\geq 90^{\text{th}}$ ( $\geq 33.1$ )	149	18 (12.1)	14 (9.4)	32 (21.5) *

\*p=0.005

Table 2 shows the abnormal OGTTs analysed by BMI category as a percentage of OGTTs done. This shows that the prevalence of an abnormal OGTT was higher in women with Class 2 and 3 obesity (BMI  $\geq 35.0$   $kg/m^2$ ) compared to women with Class 1 obesity (BMI  $\geq 30.0$  and <35.0  $kg/m^2$ ) (23.3% vs. 10.1%, respectively; p=0.008). The frequency of an abnormal OGTT was not higher in women with Class 1 obesity compared to women who were overweight (10.1% vs. 14.1%, respectively).

Table 3 shows the abnormal OGTTs analysed by BMI centiles for the study population. The frequency of an abnormal OGTT was higher in women with a BMI  $\geq 90^{\text{th}}$  centile ( $\geq 33.1$   $kg/m^2$ ) compared to women with a BMI between the 80<sup>th</sup> and 90<sup>th</sup> centiles ( $\geq 29.3$  and <33.1  $kg/m^2$ ) (21.5% vs. 8.1%; p=0.005).

### Discussion

We found that pregnant women with Class 1 obesity at their first antenatal visit did not have an increased risk for abnormal OGTT compared to women in the normal weight or overweight BMI categories. However, about one in five pregnant women with a BMI  $\geq 35.0$   $kg/m^2$  had an abnormal OGTT. We also found that when analysis was done by BMI centiles rather than by WHO BMI categories the incidence of abnormal OGTT was 21.5% in  $\geq 90^{\text{th}}$  centile compared with 8.1% in women with a BMI between the 80<sup>th</sup> and 90<sup>th</sup> centiles (p=0.005). Our findings indicate that the

recommended cut-off point for selective screening for GDM of a BMI  $\geq 30.0$   $kg/m^2$  may need to be revisited when BMI is measured, and not self-reported.

A weakness in our study is that the screening was selective rather than universal; therefore, some cases of abnormal glucose tolerance were inevitably missed. However, screening of low risk women for GDM is likely to have only missed 0.5–0.6% of cases, particularly in a white European population (16). Also, all women in our study were screened with a diagnostic OGTT, rather than as a two step process starting with 50 g glucose loads, which improves diagnostic specificity (17). Another weakness in our study was that we were not able to control for other risk factors for GDM in our analysis.

Outside pregnancy, it has been reported that the association between obesity and health conditions generally may be overestimated if self-reported BMI is used (18). In particular, misclassification due to underreporting BMI levels results in an exaggerated association between obesity and type 2 diabetes mellitus (19). A Canadian analysis based on a sample of 2667 respondents revealed that for diabetes, hypertension and cardiac disease, the odds ratio for the overweight and obese categories were substantially higher for models based on self-reported values rather than those based on measured ones (13). For example, based on self-reported BMI the adjusted odds ratio for diabetes was 3.2 in Class 1 obesity and 11.8 in Class 2 and

3 obesity. However, when based on measured BMI, the adjusted odds ratio for diabetes was lower at 2.2 in Class 1 obesity and 7.0 in Class 2 and 3 obesity (13). If subjects are 1–3  $kg/m^2$  above the BMI cut-off for the obese category on measurement are categorised as overweight due to under-reporting of BMI, this may potentially lead to an exaggeration of risk in the Class 1 obesity BMI groups because subjects with a BMI  $\geq 33.0 kg/m^2$  are over presented.

Previous studies on GDM and the risk of obesity often used prepregnancy BMI (1). However, half of pregnancies are unintended and this is a potential source of bias. We used digital measurements of maternal BMI in the first trimester of pregnancy. Contrary to previous studies, we have recently reported that maternal weight or adiposity on average does not change in the first trimester (20). Moreover, the early ultrasound dating of pregnancy in our study means that the timing of measurements, including the OGTT, was standardized by gestational age. Analysis of the risk of GDM by BMI centiles suggests that the risk starts to escalate above the 90th centile (a measured BMI  $\geq 33.1 kg/m^2$ ). The recent meta-analysis used the midpoint for each BMI category which may also have led to imprecision about the true mean BMI within any category and thus, an over-estimation of the true relationship between GDM and, for ex-ample, Class 1 maternal obesity (1).

### Conclusion

Our findings show that the current practices on selective screening for GDM based on BMI need to be re-evaluated. The accurate calculation of BMI means that women who should be screened for GDM should not be missed, and thus, potential adverse lifelong consequences of GDM for the woman and her offspring can be avoided. Increasing the cut-off point for screening from  $\geq 30.0$  to  $\geq 33.0 kg/m^2$  can substantially reduce the number of screening tests, may avoid unnecessary obstetric interventions and may reduce maternal anxiety. To our knowledge, this is the first study that examined the risk of GDM based on BMI centiles as well as BMI category and further studies are required to confirm our results in a population where other confounding variables for GDM are controlled.

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