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Original article

Effects of initial body mass index on development of gestational diabetes in a rural Sri Lankan population: A case-control study

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ABSTRACT

Aim: High pre-pregnancy body mass index (BMI) and excessive pregnancy weight gain lead to higher incidence of gestational diabetes mellitus (GDM). Aim of the study was to assess the effects of initial BMI and pregnancy weight gain on development of GDM in a rural Sri Lankan population. It was also hypothesized that these effects could be more pronounced in shorter mothers.

Methods: A case-control study was conducted at two rural hospitals in Sri Lanka. A case was defined as a pregnant mother admitted for the completion of pregnancy and diagnosed to have GDM ($n = 99$). A similar group of mothers without GDM were recruited as controls ($n = 336$). Data were collected through health records and direct interviews.

Results: Mean age of GDM and non-GDM mothers were 32.8 years 28.1 years, respectively. High pre-pregnancy BMI was a significant risk for GDM, with a rising trend with increasing BMI. In contrast to underweight mothers, the risk increases from normal weight [odds ratio (OR) = 6.6, 95% confidence interval (CI) 2.2–19.4, $p < 0.01$], overweight (OR = 17.1, 95% CI 5.8–49.9, $p < 0.01$) and to obese (OR = 32.4, 95% CI 10.0–104.5, $p < 0.01$). There was no significant difference in weight gain across mother's height groups. Height or leg length did not show an association with GDM. Family history of diabetes and past GDM were associated with GDM. GDM mothers had higher likelihood for cesarian deliveries, and babies with higher birth weight.

Conclusion: The pre-pregnancy BMI was the most important modifiable risk factor for GDM, and it should be the main preventive measure.

1. Introduction

The prevalence of diabetes and pre-diabetes in adult females in Sri Lanka is 10.9% and 11.7%, respectively. According to a study in 2006, overall 21.8% of Sri Lankan adults had some form of dysglycemia [1].

Studies have shown that the incidence of pregnancy induced hypertension (PIH), gestational diabetes mellitus (GDM) and fetal macrosomia were associated with excessive maternal weight gain [2,3]. The effect of weight gain may be more significant in South Asian population due to their higher risk for insulin resistance and diabetes [4]. In a study on urban Sri Lankan population, 15% of mothers had weight gain more than recommended, and 67% gained less than recommended [5]. However studies done in Sri Lanka in relation gestational diabetes are limited, and an extensive literature search did not find any Sri Lankan data on effects of maternal weight gain or its effect on GDM.

Sri Lankan guidelines recommend universal screening at first visits with non-fasting 75 g oral glucose tolerance test (OGTT) or when it is not practical a post-prandial blood glucose test with a cutoff 2 h value of 140 mg/dl for OGTT or 130 mg for post-prandial cutoff. Those who are negative for GDM are screened again with an OGTT at 24–28 weeks of pregnancy [6,7].

The risk factors for GDM are body mass index (BMI) above 30 kg/m^2, previous macrosomic baby weighing 4.5 kg or above, previous GDM, first-degree relative with diabetes and high

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risk origin. Ethnicity has been proven to be an independent risk with higher incidence in Asians and Afro-Caribbean populations [8].

Increase weight gain and BMI is associated with increased risk for development of diabetes mellitus (DM). In the United States nurses prospective cohort study, a weight gain of 5–7.9 kg was associated with an odds ratio (OR) of 1.9 (95% CI, 1.5–2.3) [9]. A weight gain higher than this is expected in a normal pregnancy. Studies have shown that weight gains in first two trimesters are associated with a significant gain in fat mass and the patients with higher BMI gain a higher fat mass [10,11]. Increase in adiposity is associated with insulin resistance and diabetes [12]. In addition, the Asian women have higher insulin resistance even with a lower BMI compared with the Caucasian women [13].

Similar to DM, the incidence of GDM rises with higher BMI [14]. In the United States Nurses' Health Study II (NHS II), the OR for GDM were 2.13 (95% CI, 1.65–2.74) for pregravid over weight (BMI = 25–29.9 kg/m^2) and 2.90 (95% CI, 2.15–3.91) for obese (BMI $\geq$ 30 kg/m^2). Similar findings were observed in a Danish Study with OR of 2.5 and 5.9, respectively [15,16].

Height is associated inversely with the level of insulin resistance in adults without diabetes independent of the BMI and age [17]. Height is also shown to be an independent risk factor or development GDM and this association is strongest among Asians [18]. There is also evidence showing that shorter leg length is associated with higher incidence of GDM [19,20].

A unit gain in weight will have a different gain on BMI when the height is different. Therefore, a shorter mother gaining the same weight as a taller mother should have more weight related adverse effects.

Thus, the present study aimed to assess the effects of weight gain during pregnancy and initial BMI on development of GDM in a rural Sri Lankan population. In addition, we hypothesized that the effect of weight gain in causing GDM could be more pronounced in shorter mothers.

2. Materials and methods

A case-control study was conducted at two Base Hospital namely Elpitiya and Balapitiya in rural Southern Sri Lanka from June 2014 to May 2015.

This study population included pregnant mothers more than 16 years of age who are admitted to the obstetric units for the completion pregnancy such as delivery, or intrauterine deaths. Mothers admitted for other reasons, with multiple pregnancies or with pre-pregnancy diagnosis of diabetes were excluded. In addition, those who are unable to understand or to give information required according to data collector's judgment was excluded.

A case was defined as a pregnant mother who was admitted for the completion of pregnancy and diagnosed to have GDM. A similar group of mothers without GDM was recruited as controls.

The sample size was calculated to estimate an OR of 2.5 for the effect of pre-pregnant BMI on occurrence of GDM [16], with the following parameters: power 80%; alpha error = 0.05; rate of exposure (overweight) in community = 20%; case-to-control ratio = 1:3. Therefore, the study required sample of 100 cases and 300 controls [21].

Informed and written consent from native language was taken from all the mothers. Those who did not have at least one recorded weight before the period of amenorrhea (POA) of 15 weeks were excluded. Data was collected by the investigator through direct interviews and from pregnancy records on to a pre-designed data collection form. The study was conducted from 1st May 2014 to 15th September 2014. The final sample consisted of 99 cases and 336 controls.

Weight measurements were taken to the nearest 0.5 kg while subjects wore light clothing. Height without shoes was measured with a stadiometer to the nearest 1 cm with the subject standing and also while sitting on a stool. Trunk length was calculated by deducting the stool height from the measured sitting height. Leg length was calculated by deducting the trunk height from the measured standing height [22].

Each trimester weight was taken from maternity records. Pre-pregnancy weights were taken by recall method; there are several studies that support the accuracy of this method [23]. In the case of forgotten or unknown pre-pregnancy weight (20 GDM mothers and 75 non-GDM others), weights were calculated with a previously described formula which is derived from United States Institute of Medicine (IOM) criteria [24]. Pre-pregnancy weights were calculated by subtracting 0.5 kg, 1 kg and 2 kg for weeks of POA 8–10, 10–12 and 12–15, respectively. However, these calculations may not be correct for local population.

Weight gain rates were calculated by difference in weight dividing by the number of weeks taken to gain that weight. The weight gain rates were compared with initial BMI and height and leg length. These weight gains were also compared with IOM recommendations which are being adapted to Sri Lankan Ministry of Health recommendations [25,26]. The data analysis was done using Microsoft Excel and SPSS 16 software.

3. Results

All 435 mothers were from the same geographical area. Only 5 (5.0%) of mothers with GDM and 20 (5.9%) of non-GDM mothers had a formal employment. The economic status and physical activity levels were not calculated due to practical reasons and reliability.

The mean and the median age of the population were 29.2 years and 29 years {standard deviation (SD) of 5.9 years}. Mothers with diabetes were on average 4 years older with a mean age of 32.8 years compared with 28.1 years of non-GDM mothers (Table 1).

The mean pre-pregnancy BMI of the total sample, GDM and non-GDM mothers were 21.7 kg/m^2 (SD 4.05 kg/m^2), 25.15 (SD 3.6 kg/m^2) and 20.79 (SD 3.62 kg/m^2), respectively. This difference among GDM and non-GDM mothers was highly statistically significant, $p < 0.001$ (CI −5.17–3.53).

According to World Health Organization, guideline of Asian's BMI and risk stratification values were taken [27]

$>$16 kg/m^2—severe underweight
16–18.5 kg/m^2—underweight
18.5–23 kg/m^2—normal
23–27.5 kg/m^2—over weight
$>$27.5 kg/m^2—obese

Table 1
Comparison of characteristics of cases and controls.

Variable	GDM	Non-GDM
Mean age* [years (SD)]	32.7 (5.8)	28.1 (5.4)
Mean BMI* [kg/m^2 (SD)]	25.1 (3.6)	20.7 (3.6)
BMI category		
<16.0	1 (1%)	6 (1.8%)
16.0–18.4	2 (2%)	92 (27.4%)
18.5–22.9*	24 (24%)	150 (44.6)
23.0–26.9*	50 (50.5%)	66 (19.6)
≥27.0 kg/m^2	22 (22.2%)	22 (6.5%)
Mean height *m* (SD)	1.53 (5.5)	1.534 (5.9)
Total (*n*)	99 (22.7%)	336 (77.2%)

* Indicate statistically significant values.