Gestational Diabetes Mellitus in Korean Women: Similarities and Differences from Other Racial/Ethnic Groups

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Gestational diabetes mellitus (GDM) reflects defects in insulin secretion in response to the metabolic demands of pregnancy. While GDM is increasingly common worldwide due in large part to the obesity epidemic, its frequency is relatively low in Korean women. In this report, the prevalence and risk factors for GDM, perinatal outcomes, and postpartum course are compared in non-Korean and Korean women. While Koreans and non-Koreans with GDM share pathophysiology and complications, there may be differences in the role of obesity and thus the effectiveness of interventions targeting obesity in GDM women. Further investigations of the effectiveness of weight loss interventions and pharmacotherapy specifically among Korean women are needed. Dietary and other lifestyle data from Korean populations could inform prevention and treatment strategies in other countries which suffer from significantly higher prevalences of GDM.

Keywords: Diabetes, gestational; Epidemiology; Postpartum period; Pregnancy

INTRODUCTION

Gestational diabetes mellitus (GDM) is a disease state characterized by underlying defects in maternal insulin sensitivity and secretion, which are unmasked in response to the metabolic stressors of pregnancy [1]. In this review, I summarize what is known about the epidemiology of GDM among Korean women and discuss similarities and differences with reports from other countries. First, I review prevalence of GDM and risk factors, particularly body mass index (BMI) and the genetics of GDM. Second, I discuss perinatal outcomes, specifically macrosomia. I conclude with a discussion of postpartum maternal outcomes and behavior modification.

PREVALENCE AND RISK FACTORS FOR GDM

Due to increases in prepregnancy maternal body weight and increasing gestational weight gain [2], the United States and other countries have observed increases in the prevalence of GDM over the past few decades [3,4]. These increases have occurred independent of changes in diagnostic criteria. As population-based trend data are not available, it is not known if Korean women have experienced similar increases in GDM prevalence, prepregnancy weight, or gestational weight gain over the past 20 years. However, hospital-based reports suggest that the prepregnancy BMI of Korean mothers has not changed substantially in the past two decades [5,6]. In 1995, the prevalence of GDM in Korea was only 2% in Korea [5]. This estimate is similar to a report including ethnic Korean women living in the United States in 2003 [7]. In this report, using a national birth-certificate based dataset maintained by the Center for Disease Control and Prevention, Korean women (n=10,710) had the lowest prevalence of GDM (2.9%) compared to other United States Asian subgroups including Japanese (5.7%) and Chinese (5.4%) [7]. There is probably some re-
gional variation, as ethnic Korean women in the United States have been noted to have a slightly higher GDM prevalence (4.7%) in medical center-based reports [8].

**BMI and gestational weight gain**

In several meta-analyses of primarily non-Asian populations, prepregnancy BMI has been the most significant risk factor for GDM [9,10]. In one report of 70 studies [10], women with BMIs <20 kg/m² had decreased odds of GDM compared to women with BMIs 20 to 24.9 kg/m²; women who had BMIs 25 to 29.9 kg/m² had roughly a 2-fold increased odds of diabetes; women who were moderately obese (BMI 30 to 34.9 kg/m²) had a 3-fold increased odds; and women who were morbidly obese (BMIs ≥35 kg/m²) had a 5-fold increased odds [10]. In the United States, the population-attributable fraction of GDM for prepregnancy obesity, or the proportion of cases of GDM that would be averted if obesity were corrected, has been estimated at 46% [11].

Among Korean women, prepregnancy BMI is a risk factor for GDM [6]. However, fewer Korean women with GDM are overweight or obese, even using lower Asian-specific cutpoints for obesity. In one hospital-based report, a prepregnancy BMI >25 kg/m² was associated with increased odds of GDM compared to a BMI 18 to 22.9 kg/m² (odds ratio [OR], 4.46; 95% confidence interval [CI], 2.63 to 7.59), while greater gestational weight gain was not associated with increased risk of GDM. This report also suggested that the obesity epidemic has not reached the proportion of the United States and other European countries. In this cohort, which consisted of deliveries between 2007 and 2009, only 9.8% of the 2,413 gravidas were overweight (BMI 23 to 24.9 kg/m² for guidelines specific to Asians) and only 8.5% of gravidas had BMIs >25 kg/m² [6]. Therefore, the population attributable fraction of GDM due to obesity is low among Koreans.

Among non-Koreans, gestational weight gain may increase risk of GDM beyond prepregnancy BMI. In one study, women who gained 0.41 kg/week or more had increased risk of GDM (OR, 1.74; 95% CI, 1.16 to 2.60) compared to women in the lowest tertile of weight gain (<0.27 kg/wk) after adjustment for other GDM risk factors including age and prepregnancy BMI [12]. Increased gestational weight gain through 24 weeks combined with elevated prepregnancy BMI appears to confer particular risk; in one series, women with GDM had higher prepregnancy BMI and greater gestational weight gain compared to controls [13]. However, the risk of GDM was similar in women who had low or normal prepregnancy BMIs and high levels of gestational weight gain, compared to women who had low or normal prepregnancy BMIs and lower levels of gestational weight gain [13].

In contrast, among Koreans, one study found no linear association between gestational weight gain and GDM risk apart from prepregnancy BMI [6]. It is possible that this is because Korean women who were underweight or normal weight prior to pregnancy had the greatest gestational weight gain, 13.4 kg (SD 4.2 kg), and the majority of women were within Institute of Medicine guidelines for gestational weight gain [6]. Park et al. [14] also noted that overweight women had increased odds of GDM, but tended to have lesser gestational weight gain throughout the pregnancy, possibly because of intentional lifestyle changes; of note, it is unclear whether gestational weight gain before the GDM diagnosis, typically at 24 weeks gestation, was associated with GDM risk.

**Heritability**

Family history of diabetes increases risk for GDM in both non-Korean and Korean populations. In non-Korean populations, women with a maternal history of diabetes (OR, 3.0; 95% CI, 1.2 to 7.3), paternal history (OR, 3.3; 95% CI, 1.1 to 10.2), or sibling history (OR, 7.1; 95% CI, 1.6 to 30.9) had greater risk of GDM than women without a family history [15]. Similarly, among Korean women, the risk of developing GDM doubled with a parental history and increased 5-fold in cases with a sibling history [16]. In both Korean and non-Korean populations, a sibling with a family history of diabetes conferred greater risk than a parent with such a history, and having any family history of diabetes increased risk of GDM compared to no history. These studies suggest the importance of shared environmental exposures and genetic susceptibility.

Since GDM and type 2 diabetes both involve defects in insulin secretion in response to insulin resistance, investigators have examined whether genetic variants conferring increased risk for type 2 diabetes also increase risk for GDM. Among non-Korean populations, and specifically Danish women, type 2 diabetes risk variants also conferred increased risk for GDM [17]. The presence of a greater number of high-risk alleles conferred greater risk, and the magnitude of GDM risk conferred by these alleles was similar to that observed for diabetes risk [17]. Variants were associated with impaired β-cell function, insulin resistance, and obesity. Variants for transcription factor 7-like 2 and glucokinase increase risk for elevated fasting
glucose during pregnancy, probably through insulin secretion, and consequently, the latter has also been associated with macrosomia in Europeans [18].

Among Korean women, variants for cyclin-dependent kinase 5 (CDK5) regulatory subunit-associated protein 1-like 1 and melatonin receptor 1B (MTNR1B) were associated with increased risk for GDM [19]. CDKAL1 has been postulated to affect β-cell compensation [20]. MTNR1B, a G-protein-coupled receptor, is also present in β-cells and therefore may affect insulin secretion [21]. Unlike the studies in non-Koreans, loci associated with insulin resistance and obesity were not associated with GDM, underlining the role of impaired insulin secretion in GDM pathophysiology. The Korean cohort was smaller, and the power to detect associations with particular variants may have been limited, or it is possible that these variants have a lesser impact in Koreans compared to non-Koreans.

While at least 41 genetic loci increase risk for type 2 diabetes or abnormalities of carbohydrate metabolism, these known loci explain a small proportion of the heritability of type 2 diabetes [22]. Similarly, maternal genetic risk did not improve discriminatory ability for predicting fetal anthropometrics, and known genotypes reflect less than 1% of variance in maternal glucose levels [18]. However, presence of specific polymorphisms can be used in conjunction with clinical characteristics to predict when women with histories of GDM convert to type 2 diabetes. Kwak et al. [23] found that women with histories of GDM who had specific variants for CDK inhibitors (CDKNA2B) and hematopoietically expressed homeobox, associated with impaired β-cell replication and secretion, respectively, had a greater risk for type 2 diabetes within 2 months after delivery than women who had variants in CDKAL1.

**Intrauterine deprivation**

The Barker hypothesis, formulated by David Barker, posits that intrauterine deprivation is a risk factor for adult chronic disease including diabetes [24]. Several reports in non-Korean populations suggest that markers of intrauterine deprivation, including low birthweight, may increase risk for gestational diabetes [25,26]. Mechanisms may include fewer β-cells among small for gestational age infants [27] or fetal insulin resistance leading to lesser growth in utero [28]. Therefore, impaired fetal growth combined with rapid weight gain in childhood may particularly stress the β-cell. Exposure to excess glucocorticoids may also play a role, as babies small for gestational age have higher glucocorticoid levels than babies who are larger [29]. To our knowledge, there have not been reports examining the association between birth weight and risk of GDM in Koreans. However, there are several reports examining other markers of intrauterine and early childhood development. Height is another marker for intrauterine deprivation, in that babies who are small for gestational age tend to be significantly shorter than babies who are larger for gestational age [30]. Among Polish mothers, women with GDM have been slightly but significantly shorter than women without GDM (165.7 cm vs. 163.8 cm; P < 0.001), an association that persisted even after adjustment for other measures such as age and prepregnancy BMI [31]. Similarly, among Koreans, women with GDM are slightly but significantly shorter than women with normal glucose tolerance (158 cm vs. 160 cm; P < 0.001) [32].

**PERINATAL OUTCOMES**

Among non-Korean populations, women with GDM are at greater risk for perinatal complications than women without GDM [33]. Maternal complications include preeclampsia and primary cesarean section, and neonatal complications include greater infant birth weight, large for gestational age infants, and necessity of phototherapy for hyperbilirubinemia. Complications have the strongest associations with the 1-hour glucose value on the index oral glucose tolerance test (OGTT) [33]. Similarly, prevalence of these complications was highest among Korean women with GDM compared to women with no elevated glucose levels on the index OGTT (39.2% vs. 22.3%) [34,35]. Risk of a large for gestational age infant is related to degree of elevation of all of the glucose values, in that the odds of a large for gestational age infant doubled with each 100 unit increase in area under the curve on the index OGTT [36]. However, in both non-Korean [37] and Korean women [38], even the elevation of only the 1-hour value on the OGTT, in the absence of a diagnosis of GDM, increases risk of complications.

Alterations in other metabolic parameters besides glucose are associated with macrosomia, underlining the fact that protein and lipid abnormalities accompany glucose intolerance. Among non-Korean women with GDM, maternal free fatty acid levels and triglyceride levels at delivery correlate with neonatal weight and fat mass, suggesting that maternal lipid profiles influence neonatal weight [39]. The investigators speculated that women with GDM had enhanced placental transport or enhanced lipolysis because of fetal insulin resistance.
Among Korean women with GDM, maternal fasting triglyceride levels at 24 to 32 weeks gestation was also associated with increased risk of large for gestational age infants, even after adjustment for other risk factors such as elevated prepregnancy BMI and gestational weight gain [41].

Maternal prepregnancy BMI is a risk factor for macrosomia among non-Korean populations with GDM. In the Hyperglycaemia and Adverse Pregnancy Outcome Study, maternal BMI at the time of the index OGTT and hyperglycemia confers independent risks for macrosomia [42]. Others have reported that the effects of GDM and maternal prepregnancy BMI may vary by race/ethnicity, in that GDM conferred greater risk for macrosomia among non-Hispanic blacks than whites [43]. Among Korean women with GDM, the relationship between maternal prepregnancy BMI and macrosomia is not as strong as in non-Korean women. In one series, Korean women with GDM had a BMI of 22.9 kg/m² (SD 3.5 kg) compared to controls who had a BMI of 22.0 kg/m² (SD 2.8 kg) [35]. The infants of women with GDM still had excessive fetal growth and hyperinsulinemia as indicated by cord C-peptide and insulin concentrations [35].

Limiting gestational weight gain among Korean women with GDM may lower the risk of macrosomia; however, the parameters of gestational weight gain may need to be quite low [44]. In one Korean report, low gestational weight gain in was defined according to Institute of Medicine standards as less than 11.5, 6.8, and 5.0 kg for women who were normal weight, overweight, or obese before pregnancy [44] and averaged only 2.4 kg for overweight and obese women. Women with GDM who had low levels of gestational weight gain had macrosomia less often than women with excessive gestational weight gain, despite similar fasting glucose levels [44]. While gestational weight gain was not associated with any adverse outcomes, including small for gestational age infants, these results suggest that limits on gestational weight gain for minimization of macrosomia may differ between Korean and non-Asian women, and may need to be lower than is recommended by current guidelines.

POSTPARTUM MATERNAL OUTCOMES

It is well-established that women with GDM are at risk for glucose intolerance after delivery. Theoretically, several variables could influence postpartum maternal glucose tolerance: maternal insulin sensitivity and secretion prior to pregnancy, intrapartum stresses upon β-cell function, intrapartum accretion of energy stores that persist after delivery, and postpartum behaviors. As it is unknown whether pregnancy accelerates declines in β-cell reserve, the relative importance of intrapartum and postpartum factors is not clear: parity, apart from weight gain, has inconsistent associations with postpartum diabetes [45-48]. In addition, there are no studies that include precise measures of β-cell function, such as hyperinsulinemic euglycemic glucose clamp studies, that compare insulin disposition before and after high-risk pregnancies. However, cross-sectional data suggest that gestational weight gain is less important than prepregnancy factors among Korean women, because both women with GDM (n=269) and without GDM (n=306) gained approximately 7.5 kg during pregnancy (P=0.94) [49] but differed significantly in prepregnancy BMI.

Among non-Korean populations, the risk of GDM recurrence in one report (n=65,132) [50] was 41%, compared to 4% among women without GDM in their first pregnancy. Korean women with histories of GDM are also at increased risk for recurrence of GDM [51]. Kwak et al. [51] found that among women who had another pregnancy, 45% had recurrent GDM, a strikingly similar estimate to non-Koreans. Non-Koreans with GDM are at increased risk of postpartum diabetes as well: a 2007 meta-analysis reported that women with histories of GDM had a higher risk for diabetes than women without such histories (relative risk [RR], 7.43; 95% CI, 4.79 to 11.51) [52].

Korean women with histories of GDM are also at increased risk for postpartum diabetes [53-55]. Compared to Korean women without histories of GDM, Korean women with GDM had a 3.7 increased odds (OR, 3.7; 95% CI, 2.2 to 6.3) for developing diabetes over approximately 2 years [54], after adjustment for potential confounders such as age, family history of diabetes, education, income, smoking alcohol use, waist circumference, blood pressure, and lipid levels. Over 5 years, approximately 41% of Korean women with GDM developed type 2 diabetes [53].

BMI and weight as risk factors for postpartum glucose tolerance

Postpartum weight is strongly associated with increased risk of recurrent GDM as well as diabetes. In a systematic review conducted in 2009, body fat measures had the most consistent associations with diabetes risk compared to other types of factors including age, parity, and family history of diabetes [56]. Specifically, prepregnancy BMI was associated with significantly
increased risk of future diabetes after a GDM delivery; for every 1 kg increase in prepregnancy weight, there was a 40% increase in odds of developing type 2 diabetes (OR, 1.40; 95% CI, 1.20 to 1.60). Intrapartum weight measures and postpartum weight measures were also associated with increased diabetes risk [56]. Peters et al. [45] reported that for every 4.5 kg increase in weight postpartum, there was a 2-fold increase in the risk of type 2 diabetes, even after adjustment for other factors including postpartum BMI, OGTT results, and breastfeeding. While this finding was not consistent across all older reports [57], more recent reports suggest that maternal weight gain in the United States between pregnancies might play a larger role in postpartum glucose intolerance, perhaps due to the aforementioned steady increase in BMI over the past decade among women of reproductive age [2]. In one recent examination of 22,351 women in a multiethnic population in northern California, women had a significant increase in their odds of GDM in their subsequent pregnancy with each unit of BMI gained between pregnancies [58]. A higher absolute level of BMI before the subsequent pregnancy also increased risk of GDM in that subsequent pregnancy [58].

Among Korean women, absolute levels of BMI between pregnancies and weight between pregnancies predict GDM in the subsequent pregnancies [51]. In particular, visceral fat levels are associated with future risk of glucose intolerance; Cho et al. [53] compared the strength of association between postpartum BMI, weight, skin thickness, waist-hip ratio and waist circumference, and diabetes risk. Waist circumference as characterized by quartiles and body fat measures had the strongest associations, suggesting that adipose tissue as opposed to other tissue compartments and visceral fat deposition as opposed other types of fat deposition conferred the highest risk for diabetes. Korean women with GDM at one year postpartum have greater proportion of visceral fat than Korean women without histories of GDM, and as in previous studies of Korean women with GDM, women were not obese; average BMI was 21.8 kg/m² (SD 2.4 kg) in controls versus 22.5 kg/m² (SD 2.8 kg) in women with GDM with postpartum normal glucose tolerance [59]. Insulin sensitivity, as measured by intravenous glucose tolerance tests, was associated with visceral fat even after adjustment for body weight and BMI [59].

However, among Koreans, weight gained between pregnancies has not been associated with GDM risk [51]. It is unclear why intrapartum weight gain was not associated with risk of recurrent GDM in Korean women but has been in the United States. One possible explanation is that Korean gain relatively smaller amounts of weight between pregnancies; intrapartum weight gain was fairly small among Korean women, 1.2 kg (3.7) [51], whereas the majority of United States women gained over 2.25 kg [58]. Therefore, weight gain between pregnancies was larger and more likely to increase demand on the β-cell in the next pregnancy among United States women. Another, possibly concurrent explanation is suggested by the fact that in the United States report, women who were not overweight at their index GDM pregnancy but who lost weight after their index pregnancy did not significantly reduce their odds of future GDM [58]. While it is not known whether these women were more likely to be Asian, it is possible that weight is not as strong a risk factor for impaired insulin secretion or insulin sensitivity in a subset of women with GDM.

One explanation for the increased risk of GDM observed at lower cutpoints for BMI among Koreans could be a higher proportion of visceral fat compared to overall BMI among Koreans [60]. While Korean and other East Asian women have not been compared directly to other racial/ethnic groups, Korean women may have relatively greater proportions of visceral fat for specific levels of BMI compared to non-Hispanic whites; such racial/ethnic differences in proportions of visceral fat to body weight have been observed between other ethnicities [61]. Korean premenopausal women specifically have lower correlations between visceral fat and anthropometric measurements such as waist circumference compared to Korean postmenopausal women or men [62].

**Metabolic markers**

Adipose tissue is now recognized as an endocrine organ as well as a lipid storage compartment. The adipokines, or adipose-derived hormones, have been linked with risk of postpartum glucose intolerance particularly in women with histories of GDM. Among non-Koreans, women with histories of GDM have lower adiponectin independent of obesity and insulin sensitivity than women without such histories [63]. Low adiponectin levels during pregnancy are associated with degree of glycemia postpartum [64]. Among non-Koreans, lower adiponectin levels prepregnancy have been linked to increased risk for GDM, suggesting that to some extent these abnormalities precede the GDM pregnancy. Hedderson et al. [65] have reported that women in the lowest quartile of adiponectin have a 5-fold increased risk of GDM (OR, 5.2; 95% CI, 2.6 to 10.1) compared to women in the lowest quartile. The association
between lower adiponectin and higher glucose levels is also present in the first and early second trimester of pregnancy [66,67] and later in pregnancy [68], independent of BMI.

Similarly, Korean women with histories of GDM and postpartum diabetes had higher retinol binding protein 4 (RBP4) and lower adiponectin than women with histories of GDM and normal glucose tolerance, while women with impaired glucose tolerance had intermediate levels [69]. Leptin and resistin did not differ by GDM status [69]. Although RBP4 and adiponectin are synthesized by adipose tissue, there was no correlation between RBP4 or adiponectin concentrations with visceral fat.

**Insulin use during the index pregnancy**

The degree of β-cell impairment during the index pregnancy is reflected by decreased insulin levels as well as insulin use, as opposed to dietary or other pharmacotherapies. Thus, insulin use and endogenous levels during the index pregnancy reflect postpartum risk of glucose intolerance. Particularly in populations at high-risk for type 1 diabetes such as northern Europeans, insulin use may reflect autoantibody mediated β-cell impairment rather than from demand imposed by insulin resistance. In a cohort of 437 German women with GDM, 148 required insulin and of these women, 30.4% were autoantibody positive for islet cell antibodies, insulin autoantibodies, or glutamic acid decarboxylase (GAD) antibodies [48]. Among these women, 30% developed type 1 diabetes by 2 years postpartum, compared with 2% of antibody negative patients [48].

Among Korean women, lower insulin levels (both fasting and postchallenge) during the index pregnancy were associated with increased risk of recurrent GDM [51]. In a 2009 systematic review of 14 articles which included one report in Koreans, insulin use and anthropometric measures were most strongly associated with increased risk of GDM recurrence [56]. As in northern Europeans, need for insulin may reflect impending type 1 diabetes, rather than insulin resistance due to visceral fat or adiposity. Among 887 Korean with GDM, only 1.7% (n = 15) had antibodies to GAD, but of these women, approximately half (n = 7) required insulin therapy during the index pregnancy as opposed to 23% of Korean women with GDM who were GAD antibody negative [70]. While only 12 of the GAD antibody positive women were examined postpartum, 33% developed diabetes postpartum compared to a 7% incidence of diabetes among GAD antibody negative women [70].

Along with insulin levels and insulin use, glucose levels during and after the index pregnancy will reflect maternal insulin sensitivity and secretion and thus risk for postpartum glucose intolerance. In a 2009 review of 11 articles in primarily non-Korean populations [71], elevations in prenatal OGTT values fasting were all associated with increased diabetes risk, with the strongest associations observed with fasting glucose and 1-hour glucose [37,72-81]. Women with a greater number of abnormal values elevated fasting or postchallenge values had greater risk [82]. Among Korean women, impaired glucose tolerance after the index pregnancy was associated with increased risk of GDM recurrence compared to normal glucose levels after the index pregnancy (RR, 2.31; 95% CI, 1.24 to 4.30) [51].

**Cardiovascular dysfunction**

Among other racial/ethnic groups, GDM is associated with increased risk of cardiovascular dysfunction, although it is unclear whether this occurs apart from a diagnosis of postpartum glucose-intolerance and diabetes. Specifically, among non-Koreans, women with histories of GDM had greater vascular resistance, lower stroke volume, lower cardiac output [83]. Small cross-sectional studies conflict as to whether flow mediated dilation is impaired among women with histories of GDM [84]. Among Italian women, women with GDM had higher carotid intimal medial thickness at approximately 6.5 years postpartum compared to women without histories of GDM [85], even after adjustment for other cardiovascular disease (CVD) risk factors. Other have noted that GDM is associated with increased risk of cardiovascular events and hospitalizations for CVD, although the association between GDM and cardiovascular event risk was attenuated by adjusting for diabetes [86,87].

Among Koreans, carotid intimal medial thickness has not been reported to differ at 1 year postpartum between women with and without GDM [88], unlike the Italian study mentioned in the preceding paragraph. While explanations for the differences between non-Korean and Korean populations are speculative, the lack of relationship at 1 year postpartum in the Korean women could be attributed to the earlier examination and younger ages of the Korean women compared to the Italian women, or possibly less aggressive CVD among Korean women with histories of GDM. To my knowledge, CVD events and other subclinical markers of atherosclerosis have not been examined in Korean women by GDM status.
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BEHAVIORS AND BEHAVIORAL INTERVENTION

Among non-Korean populations with GDM, which tend to have a high prevalence of obesity, decreasing postpartum obesity can decrease diabetes risk. This was demonstrated in the Diabetes Prevention Program (DPP), a randomized controlled trial of lifestyle change versus metformin versus placebo, which had inclusion criteria of overweight and glucose intolerance [88]. Among the 350 women with histories of GDM, randomization to intensive lifestyle change targeting weight reduction led to significant reductions in diabetes incidence compared to placebo; metformin had similar benefit [89]. It is worth noting that DPP women may differ from the typical postpartum GDM population, in that women with GDM in the DPP were approximately 43±8 years of age, and about 12 years from their last delivery; it was not known whether this was their GDM delivery. Thus, infants or young children presumably had matured and presented less of a barrier to lifestyle modification, and GDM women who were at extremely high risk for diabetes may have converted soon after delivery. Moreover, the mean weight loss at 3 years was only 1.6 kg among with GDM after 3 years, compared to 4.0 kg among women without GDM.

Among non-Korean populations, lifestyle interventions closer to delivery have not yet proven to be effective. In another randomized controlled trial of 450 Chinese women with histories of GDM, there were no differences in glucose levels between the lifestyle intervention and control group at 3 years [90]. In another randomized trial in the United States [91], randomization of postpartum GDM women to lifestyle change (n=100) versus control (n=100) did not result in increased weight loss, although between arm differences in these outcomes were close to meeting statistical significance (P<0.10 but P>0.05); a larger trial is currently underway.

It is not clear whether weight loss interventions similar to the DPP would improve glucose tolerance among Korean women with histories of GDM, for several reasons. Although BMI is a risk factor for diabetes, the relatively low prevalence of overweight and obesity compared to non-Korean populations, even using lower cutpoints for Asians, raises the possibility that interventions targeting body mass might have a relatively reduced impact. Similarly, randomized trials in the United States are underway to limit gestational weight gain, but the relatively small amounts of gestational weight gain among Koreans combined with the lack of association between gestational weight gain and postpartum risk suggest that such interventions might have less of an impact in Koreans.

It is possible that other types of lifestyle changes other than those strictly targeting weight loss might decrease diabetes risk in Koreans. Among non-Koreans [92] and Koreans [87,93] with histories of GDM, unhealthy diets, indicated by greater fat intake as a proportion of caloric intake, are associated with diabetes. Among non-Koreans, the risk reduction was partially mediated by body mass changes [92]. Among Korean women with histories of GDM, women with postpartum diabetes had greater animal fat intake compared to women who did not [87]. While breastfeeding has been found to beneficial in non-Korean populations with histories of GDM for reduction of diabetes risk [94], apart from changes in weight gain, the impact of breastfeeding upon glucose tolerance has been less striking among Koreans [93].

Insulin sensitizers such as thiazolidinediones have been shown to reduce diabetes risk among United States Mexican women [95]. However, their current use is limited by concerns of increased risk to the heart, liver, bones, and bladder, as well as questions about safety in future pregnancies and general reluctance to prescribe lifetime medications for prevention in a reproductive-aged population. Theoretically, based upon the DPP results, metformin would reduce diabetes risk among overweight women with GDM and glucose intolerance, but it is not known whether this benefit would be observed in non-obese women with glucose intolerance, or among populations with normal postpartum glucose levels.

CONCLUSIONS

An increasing proportion of pregnancies worldwide are affected by glucose intolerance, in contrast to the relative infrequency of GDM among Korean women. These differences may be attributed to both genetic and environmental factors, particularly the lower proportion of obesity in Korean women. Population-based measures aimed at obesity and interventions targeting postpartum weight gain have proven difficult to translate in the immediate postpartum years among non-Korean populations. It is unknown whether such interventions would address the prenatal or postpartum risk in Korean women with GDM. However, GDM risk and postpartum risk among Korean GDM women may have different relationships with obesity than in non-Koreans, suggesting that additional strategies for addressing β-cell impairment need to be explored. Population-
based data on anthropometrics, dietary habits, and physical activity as well as glucose tolerance in Korean women could yield suggestions for GDM prevention and treatment in non-Koreans.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

ACKNOWLEDGMENTS

Dr. Kim was supported by R01 064557 from the National Institutes of Health.

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