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Height and the risk of gestational diabetes: variations by race/ethnicity

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Abstract

Aims—Gestational diabetes is a common pregnancy complication affecting races/ethnicities disproportionally. Adult height, an indicator of both genetic and early-life factors, is inconsistently associated with gestational diabetes risk. We examined the association and whether it varies by races in a nationally representative US cohort.

Methods—Analyses were conducted among 135 861 pregnancies in the Consortium on Safe Labor study, 5567 of which were diagnosed with gestational diabetes based on medical records review. Generalized estimating equations were used to estimate odds ratios (95% confidence intervals) of gestational diabetes, controlling for other risk factors including body weight. Additionally, a meta-analysis of 15 761 pregnancies with gestational diabetes and 205 828 without gestational diabetes was conducted to estimate the pooled mean difference in height between those with gestational diabetes and control subjects.

Results—Height was inversely associated with gestational diabetes risk across races/ethnicities, with the strongest association among Asians (*P* for interaction < 0.01). Comparing extreme quartiles (> 168 vs. < 157 cm), adjusted odds ratios (95% confidence intervals) were 0.18 (0.09–0.36) for Asians/Pacific Islanders, 0.33 (0.29–0.38) for non-Hispanic white women, 0.39 (0.31–0.51) for Hispanics and 0.59 (0.47–0.75) for non-Hispanic black women. Meta-analysis found women with gestational diabetes to be significantly shorter than others.

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Competing interests

None declared.

Supporting Information

Additional Supporting Information may be found in the online version of this article:

Figure S1. Screening and inclusion of studies for quantitative meta-analysis.

Figure S2. Study-specific and pooled mean difference 95% confidence interval in height comparing women with gestational diabetes and women without gestational diabetes in 38 studies.

Figure S3. Funnel plot examining publication bias of included studies of height and analysis of gestational diabetes.

Table S1. Full list of 37 studies included in meta-analysis height of women with and without gestational diabetes.

Table S2. Summary of meta-analysis of 38 studies with information on height by gestational diabetes status.

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Conclusions—Taller women are at lower risk of developing gestational diabetes, with the magnitude of association varying significantly across races/ethnicities.

Introduction

Gestational diabetes mellitus, a common pregnancy complication defined as glucose intolerance with onset or first recognition during pregnancy, affects approximately 7% (ranging from 1 to 14%) of all pregnancies in the USA [1]. The incidence of gestational diabetes is higher among Asian, Hispanic, Native American and African-American women than non-Hispanic white women [2]. Gestational diabetes is related to increased risk of adverse pregnancy outcomes [3] and has substantial long-term adverse health impacts on both women and their offspring, including an elevated risk for Type 2 diabetes mellitus in later life among women and an increased risk for childhood obesity and impaired glucose tolerance among offspring [1,4,5]. Therefore, it is important to understand its aetiology and identify risk factors that may help identify women at high risk of gestational diabetes.

Adult height is an indicator of genetic, early-life and childhood factors and their interplay. Although the biological mechanism linking adult height and gestational diabetes is not known, several pathways have been suggested. For example, poor fetal nutrition may lead to low birthweight, which is associated with both shorter adult stature [6] and also risk of metabolic dysfunction in adulthood [7], possibly as a result of epigenetic changes attributable to maternal malnutrition [8]. Height varies across different populations, with Asians generally shorter than African-American or non-Hispanic white women. Height has been inversely associated with the risk of gestational diabetes in some but not all studies [9–14]. However, studies examining the association between height and gestational diabetes in racially/ethnically heterogeneous populations are sparse, and whether the inverse association of height with gestational diabetes varies across different races/ethnicities remains unclear. The current study aimed to investigate the association between height and gestational diabetes in a nationally representative cohort of 135 861 US pregnancies in nine American College of Obstetricians and Gynecologists districts and to further evaluate whether the association varies across women of different races. A meta-analysis was also conducted to systematically review available findings of the association of adult height and gestational diabetes risk across different race/ethnicity groups and confirm findings from the present study.

Subjects and methods

Study design and methods

The Consortium on Safe Labor study was conducted at 12 clinical centres (including 19 hospitals) in nine American College of Obstetricians and Gynecologists districts throughout the country in 11 states and the District of Columbia. Each institution extracted information on maternal demographic characteristics (including height, race/ethnicity, educational attainment, insurance status and age); medical, reproductive and antenatal history; labour and delivery summary; and post-partum and newborn outcomes via electronic medical records. Height data in the records was either measured by health professionals in clinics or self-reported. If height was self-reported, we are confident in participants' ability to report their heights as women of childbearing age (generally < 45 years of age) are not subject to age-related reductions in height and have been shown to be reliable reporters of height [15].

The study included 228 562 deliveries, which occurred between 2002 and 2008. Each clinical centre transferred data to coordinating centres, which mapped variables to predefined common codes. Validation studies of four key outcome diagnoses were conducted by selecting eligible charts and recollecting data by hand chart abstraction and comparing it with information downloaded from electronic medical records. This project was approved by the institutional review boards of all participating institutions.

Diagnosis of gestational diabetes was recorded in the medical record and universal gestational diabetes screening using American Diabetes Association criteria was recommended in the US clinics during the study period [16]. Women were excluded if they experienced multiple gestations, were missing data on the primary outcome or exposure—gestational diabetes or height (~16%), were positive for or missing data for Type 2 diabetes or delivered at less than 24 weeks. In addition, two sites were excluded that did not provide gestational diabetes data, as was one site that reported a gestational diabetes prevalence of less than 1%. The final analytic sample included 126 861 women and 135 861 pregnancies, of which 5567 were recorded as gestational diabetes pregnancies.

Statistical analysis

In the Consortium on Safe Labor study, means with standard deviations for continuous baseline characteristics and proportions for categorical characteristics were calculated and compared by gestational diabetes status using unpaired *t*- or χ^2-tests. Baseline characteristics were also compared across quartiles of height (cut points were calculated based on the entire study population) and assessed using analysis of variance (ANOVA) or χ^2-tests. Height was assessed both as a categorical (in quartiles) and continuous variable. Linear trend of the association was evaluated using the median height value analysed as a continuous variable in multivariate models for each racial category. Generalized estimating equations were used to estimate odds ratios and 95% confidence intervals of the prevalence of gestational diabetes for each height quartile and also for each centimetre increase in height. Repeated measures were added to the generalized estimating equation to avoid intra-person correlation, as a proportion of the women in the Consortium on Safe Labor study contributed information for more than one pregnancy. Multiplicative interaction terms were used to test for the significance of interactions. Stratified analyses were also conducted to estimate the effect size across strata. Covariates were selected a priori based on the literature and earlier studies. All models were adjusted for age.

In addition, as many more studies reported mean difference among women with gestational diabetes and women without gestational diabetes than those that reported odds ratios for gestational diabetes in association with height, we conducted a meta-analysis to calculate the pooled mean difference across studies, not the pooled odds ratios. Epidemiologic studies were identified that (1) were written in English, (2) included women aged 18 years or older, (3) reported height by gestational diabetes status or height was able to be calculated from BMI and weight, and (4) defined gestational diabetes. PubMed and Embase were searched using the Medical Subject Headings (MeSH) for gestational diabetes and the following freetext words: gestational diabetes, gestational diabetes, height, body mass index, BMI, weight, obesity, observational, cohort, and cross-sectional (see also Supporting Information, Fig. S1). Additional studies and data were hand searched using references from the retrieved articles and other relevant review articles. After titles and abstracts were reviewed, 596 full articles were deemed applicable and evaluated. Of these, 549 were excluded because they did not study adult mothers, did not report gestational diabetes prevalence, included no data on height, or were duplicate study populations. Along with the Consortium on Safe Labor, 37 studies were included in the meta-analysis. Very few of the eligible studies aimed to examine the association of height and gestational diabetes specifically and therefore did not provide the odds ratio for the association. To maximize the number of studies included, we used mean difference between gestational diabetes and non-gestational diabetes controls as the major estimate of effect size in the meta-analysis, as the majority of eligible studies provided means and standard deviations of mean. Two independent reviewers (EJS and EY) abstracted data from primary studies using predetermined criteria, with differences arbitrated by a third independent investigator (CZ) as necessary. Information abstracted included last name of first author, publication date, study location, study period, method for gestational diabetes screening, diagnostic criteria to define cases of gestational diabetes and the sample size (cases and controls), along with age, race, BMI (SD), weight (SD) and height (SD) for each gestational diabetes category. Fixed-effect and random-effects models of the mean difference in height were examined, weighted by the inverse variance of the height. Heterogeneity among studies was investigated using Cochran's Q-test with a significance level of an alpha of 0.1. If the studies appeared to be heterogeneous, a random-effects model was preferred. Publication bias and sensitivity analyses were performed.

Race-specific pooled estimates were also calculated. The studies were not weighted by quality. MIX software version 1.7 and SAS version 9.2 were used for all analyses [17,18].

Results

Consortium on Safe Labor study

The final analytical population included 135 861 pregnancies, 5567 of which were diagnosed with gestational diabetes mellitus. The overall prevalence of gestational diabetes was approximately 4%. Prevalence of gestational diabetes varied between 2.6 and 6.1% across sites. In general, women with gestational diabetes were older, heavier and less educated than women without gestational diabetes. On average, women with gestational diabetes were 1.5 cm shorter than women without gestational diabetes (Table 1). Females in the tallest quartile of height were better educated (33% had more than a high school diploma compared with 16% in the shortest quartile); predominately non-Hispanic white (66% compared with 40% in the shortest quartile); and more often privately insured (67% compared with 52% in the shortest quartile) (Table 2).

Height was significantly and inversely associated with gestational diabetes risk. Overall, women in the highest height quartile had over 60% lower risk of gestational diabetes when compared with women in the lowest quartile (adjusted odds ratio 0.34; 95% CI 0.29–0.40), even after accounting for maternal age, pre-pregnancy weight, race, insurance and education (Table 3). Similarly, every 5-cm increase in height was also associated with a 20%

significant decrease in risk of gestational diabetes (adjusted odds ratio 0.80; 95% CI 0.78–0.82). The association differed significantly by race/ethnicity, with the magnitude of the association strongest among Asians and smallest for non-Hispanic black women (Table 3). For instance, among Asians, women with height > 168 cm had an 82% reduced risk for gestational diabetes (adjusted odds ratio 0.18; 95% CI 0.09–0.36) as compared with women with height < 157 cm after adjustment for age and pre-pregnancy weight. Corresponding odds ratio 0.33 (95% CI 0.29–0.38) for non-Hispanic women, 0.39 (0.31–0.51) for Hispanics and 0.59 (0.47–0.75) for non-Hispanic black women (*P* for interaction for height and race < 0.001).

Meta-analysis

A total of 38 eligible studies (see also Supporting Information, Table S1), including the Consortium on Safe Labor, among 221 589 women (15 761 with gestational diabetes) were included in the quantitative synthesis to evaluate the mean difference of height between those with gestational diabetes and the control subjects without gestational diabetes (see also Supporting Information, Table, S1). Screening methods and diagnostic criteria for gestational diabetes varied among studies. However, most studies employed universal screening or universal diagnostic testing. A random-effects model was applied because of heterogeneity (Cochran's Q < 0.01). Pooling the mean difference in height by gestational diabetes status from the studies, women with gestational diabetes were on average 1.13 cm shorter than women without gestational diabetes (95% CI −1.5 to −0.78) (see also Supporting Information, Fig. S2). In general, a height difference was consistently observed across all racial/ethnic groups, except among non-Hispanic black women (Table 4). Funnel plots did not show evidence of publication bias (see also Supporting Information, Fig. S3). Sensitivity and trim and fill analyses showed that the removal of one study did not measurably alter the mean difference estimate or 95% confidence interval.

Discussion

In a large US cohort, we observed that taller adult stature was significantly associated with lower risk of gestational diabetes. The magnitude of the association varied significantly across different races/ethnicities and was strongest in Asians and weakest in non-Hispanic black women. In addition, in a meta-analysis of 38 studies, we found women with gestational diabetes were, in general, significantly shorter than women without gestational diabetes.

Our study has several unique strengths. The Consortium on Safe Labor represents a large study of a population of heterogeneous races/ethnicities with comprehensive information on maternal and pregnancy characteristics and reliable data collection. The meta-analysis systematically synthesized population-based cohorts from 21 countries, resulting in a large cohort of women with and without gestational diabetes. It has been argued that, because height is a basic anthropological measurement recorded in virtually every study, null results are unlikely to be present in the literature [19] and the height–gestational diabetes association exists because of publication bias. However, our meta-analysis, which pooled from all studies reporting height and extracting height information from BMI and weight (including several papers that reported the data, but were not primarily aimed to investigate the relationship between gestational diabetes and height), did not appear to confirm this hypothesis.

Because of the small number of cases of gestational diabetes in previous studies, race/ethnicity-specific associations of height with gestational diabetes have not been sufficiently evaluated in an ethnically or racially heterogeneous population. Our findings, however, were generally consistent with earlier studies [9–14,20] among ethnically homogeneous populations. For example, Ogonowski [10] found women with gestational diabetes were 2 cm shorter than control subjects [165.7 (5.6) vs. 163.8 (6.6) cm; $P < 0.01$], and a study in Seattle and Tacoma, Washington [9] found gestational diabetes risk in mothers taller than 170 cm was approximately 60% lower than in those 160 cm or shorter (relative risk 0.40, 95% CI 0.17–0.95).

Although the mechanisms whereby a shorter adult height is associated with a greater risk of gestational diabetes are not clear, several lines of evidence support this association. Adult height has been regarded as an indicator of the interplay of genetic and early-life environmental factors. Decreased growth hormones may result from inadequate intrauterine and childhood nutrition and subsequently to both impaired peripheral growth, as indicated by short stature, and the risk of impaired glucose tolerance in adulthood [21]. For example, leg length has been correlated with fetal and childhood nutrition and is thought to be more of a marker of early environmental influences than torso length, as children who are breastfed and are well fed in the first 4 years of life have longer legs and lower risk of Type 2 diabetes [22,23]. It is known that low birthweight is associated with shorter stature later in life [6], as well as increased risk for metabolic dysfunction in childhood and adulthood, including gestational diabetes [7]. The mechanism has been suggested to be fetal programming in response to maternal malnutrition [8]. One hypothesized pathway is through epigenetic changes, such as DNA methylation, that alter expression of growth or other metabolic factors *in utero* to compensate for nutritional insufficiencies. In later life, when nutrients are abundant, these adaptations contribute to gestational diabetes risk when facing metabolic challenges in pregnancy. Moreover, undernourished fetuses may be born with a reduced number and function of pancreatic β-cells [16,24], compromising insulin production and consequently resulting in a high risk for gestational diabetes. Another possible mechanism is shared genetic risk factors of short stature and related growth measures and defects in glucose metabolism. For instance, a polymorphism in the gene for insulin-like growth factor 1 (IGF-1) functional properties was significantly related to both shorter adult stature and an increased risk for Type 2 diabetes in the Rotterdam Study [25]. Moreover, risk alleles at the *CDKAL1* and *HHEX-IDE* loci were associated with both reduced birthweight and increased risk for Type 2 diabetes in studies of European populations [26,27]. Finally, an artifact may be at work. Height may affect oral glucose tolerance test results as shorter women have a lower mass of metabolically active tissues to respond to a standardized 75–100 g of oral glucose compared with taller women [10]. Asians are, on average, shorter than other groups, so this may explain why they are diagnosed with gestational diabetes more often.

Several potential limitations warrant discussion. First, ascertainment of gestational diabetes was dependent upon chart review without further validation. Universal gestational diabetes screening using American Diabetes Association criteria was recommended in the US clinics by both the American Diabetes Association and American College of Obstetrics and Gynecology during the study period [16]. We assumed that the majority of the selected clinical centres in the study followed the recommendation. Secondly, we did not have information on some variables that may be significantly associated with gestational diabetes risk, such as childhood socio-economic status and *in utero* and early-life nutrition deficiencies (or their indicators, such as maternal birthweight). Moreover, similar to other observational studies, bias attributable to unmeasured and unknown confounders cannot be ruled out. Another limitation of this study was the classification of race/ethnicity in the Consortium on Safe Labor study. Specifically, East Asians, South Asian Indians and Pacific Islanders were combined, despite the fact that gestational diabetes risk is not uniform in these populations [28]. Lastly, we were unable to determine nativity of participants.

In summary, our findings suggest adult height is significantly and inversely associated with gestational diabetes. The significant association persists across different races/ethnicities although the magnitude of the association varies. Findings from the present study indicate the potential role of these factors in the aetiology of gestational diabetes. Future studies investigating the underlying mechanisms are warranted.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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What's new?

- The present study, based on data from a large, representative cohort of pregnancies in the USA, aims to evaluate racial variations in the association of height with gestational diabetes.
- In addition, a meta-analysis of 38 studies, including the present study, was conducted to systematically review previous findings and to confirm findings from the present study.

Table 1

Baseline characteristics of the Consortium on Safe Labor study, USA, 2002–2008, by race and gestational diabetes status*

	All		White		Black		Hispanic		Asian		Multi-racial/unknown	
	Gestational diabetes	No gestational diabetes	Gestational diabetes	No gestational diabetes	Gestational diabetes	No gestational diabetes	Gestational diabetes	No gestational diabetes	Gestational diabetes	No gestational diabetes	Gestational diabetes	No gestational diabetes
n	5567	130 294	2571	70 924	813	24 365	1379	22 205	386	3804	418	8996
Height (cm)	161.7 (7)	163.2 (7)	163.3 (7)	164.6 (7)	163.9 (7)	163.7 (7)	158.8 (7)	159.4 (7)	157.7 (6)	159.7 (7)	161.1 (7)	161.7 (7)
P-value	< 0.001		< 0.001		0.59		0.0005		< 0.001		0.07	
	Height quartiles, *n* (%)†											
Q1: 101–157.48	1906 (34)	34 084 (26)	682 (27)	13 823 (19)	183 (23)	5777 (24)	678 (49)	10 113 (46)	199 (52)	1591 (42)	81 (38)	1115 (33)
Q2: 157.50–162.56	1521 (27)	34 189 (26)	704 (27)	18 673 (26)	213 (26)	5720 (23)	379 (27)	6166 (28)	120 (31)	1165 (31)	55 (26)	923 (27)
Q3: 162.60–167.64	1172 (21)	31 676 (24)	590 (23)	18 298 (26)	205 (25)	6473 (27)	236 (17)	4168 (19)	49 (13)	674 (18)	48 (22)	823 (24)
Q4: 167.89–210.0	968 (17)	30 345 (23)	595 (23)	20 130 (28)	212 (26)	6395 (26)	86 (6)	1758 (8)	18 (5)	374 (10)	30 (14)	530 (16)
P-value	< 0.001		< 0.001		0.32		0.02		< 0.001		0.51	
	Pre-pregnancy BMI (kg/m^2), *n*(%)											
< 18.5	91 (2.0)	5638 (5)	41 (2)	3195 (5)	6 (1)	758 (3)	17 (1)	912 (4)	19 (5)	344 (9)	3 (1)	161 (5)
18.6–24.9	1364 (30)	57 607 (54)	622 (24)	33 807 (48)	115 (14)	7845 (32)	386 (28)	10 383 (47)	138 (36)	1757 (46)	52 (24)	1390 (41)
25.0–29.9	1285 (28)	24 802 (23)	523 (20)	12 344 (17)	170 (21)	5055 (21)	411 (30)	5319 (24)	75 (19)	436 (11)	55 (26)	715 (21)
≥ 30	1851 (40)	19 570 (18)	848 (33)	9145 (13)	387 (48)	5573 (23)	446 (32)	3403 (15)	58 (15)	306 (8)	69 (32)	477 (14)
Missing	976 (18)	22 677 (17)	537 (21)	12 433 (18)	135 (17)	5134 (21)	119 (9)	2188 (10)	96 (25)	961 (25)	35 (16)	648 (19)
P-value	< 0.001		< 0.001		< 0.001		< 0.001		< 0.001		< 0.001	
Education, *n* (%)												
Less than high school	655 (12)	12 263 (9)	61 (2)	1962 (3)	73 (9)	2857 (12)	470 (34)	6425 (29)	12 (3)	142 (4)	26 (12)	616 (18)
High school diploma	877 (16)	19 687 (15)	322 (13)	9370 (13)	160 (20)	3667 (15)	310 (22)	5020 (23)	29 (8)	361 (9)	37 (17)	625 (18)
More than high school	1179 (21)	32 058 (25)	690 (27)	23 222 (33)	110 (14)	2412 (10)	228 (20)	3530 (16)	56 (15)	699 (18)	47 (22)	563 (17)
Unknown	2856 (51)	66 286 (51)	1498 (58)	36 370 (51)	470 (58)	15 429 (63)	371 (27)	7230 (33)	289 (75)	2602 (68)	104 (49)	1587 (47)
P-value	< 0.001		< 0.001		< 0.001		< 0.001		< 0.001		0.04	
Insurance, *n* (%)												
Private	3290(59)	77 566 (60)	2094 (81)	55 966 (79)	292 (36)	8152 (33)	357 (26)	5711 (26)	314 (81)	2863 (75)	85 (40)	1026 (30)
Public	1777 (32)	40 992 (31)	443 (17)	13 970 (20)	406 (50)	12 556 (52)	753 (55)	10 958 (49)	53 (14)	711 (19)	74 (35)	1279 (38)
Self-pay	67 (1)	1495 (1)	13 (1)	426 (1)	14 (2)	435 (2)	24 (2)	380 (2)	8 (2)	97 (3)	4 (2)	102 (3)
Other/unknown	433 (8)	10 241 (8)	21 (1)	562 (1)	101 (12)	3222 (13)	245 (18)	5156 (23)	11 (3)	133 (4)	51 (24)	984 (29)
P-value	0.95		0.03		0.63		< 0.001		0.07		0.06	
Pre-pregnancy weight (kg)	77.4 (21)	67.8 (17)	78.9 (21)	67.4 (16)	88.5 (24)	73.8 (21)	72.7 (18)	64.6 (15)	63.7 (16)	60.3 (16)	76.4 (22)	66.5 (16)
P-value	< 0.001		< 0.001		< 0.001		< 0.001		0.0006			
Maternal age (years)	30.7 (6)	27.1 (6)	30.7 (6)	27.8 (5)	29.9 (6)	25.4 (6)	30.9 (6)	26.6 (6)	31.5 (5)	29.1 (5)	31.1 (6)	27.4 (7)
P-value	< 0.001		< 0.001		< 0.001		< 0.001		< 0.001		< 0.001	

	All		White		Black		Hispanic		Asian		Multi-racial/unknown	
	Gestational diabetes	No gestational diabetes	Gestational diabetes	No gestational diabetes	Gestational diabetes	No gestational diabetes	Gestational diabetes	No gestational diabetes	Gestational diabetes	No gestational diabetes	Gestational diabetes	No gestational diabetes
Parity, *n* (%)												
0	1823 (33)	50 721 (39)	877 (34)	27 095 (38)	239 (29)	9436 (39)	390 (29)	8297 (37)	159 (41)	1738 (46)	72 (34)	1463 (43)
1	1670 (30)	39 422 (3)	791 (31)	21 633 (31)	241 (30)	6866 (28)	384 (28)	7047 (32)	131 (34)	1286 (34)	75 (35)	1005 (30)
2	1072 (19)	22 189 (17)	465 (18)	12 084 (17)	159 (20)	4257 (17)	331 (24)	4083 (18)	50 (13)	461 (12)	34 (16)	516 (15)
3	521 (9)	10 282 (8)	229 (9)	5771 (8)	83 (10)	2003 (8)	142 (10)	1751 (8)	27 (7)	183 (5)	20 (9)	228 (7)
4 or more	481 (9)	7680 (6)	209 (8)	4341 (6)	91 (11)	1803 (7)	132 (10)	1027 (5)	19 (5)	136 (4)	13 (6)	179 (5)
P-value	< 0.001		< 0.001		< 0.001		< 0.001		0.15		0.07	

* Data presented are mean (standard deviation) unless otherwise specified.

† Xxxxxxxxxxxxxxx.

Table 2

Baseline characteristics of the Consortium on Safe Labor study, USA, 2002–2008, by quartiles of adult height (cm) in the overall Consortium population*

	Height (quartile) (range cm)†				
	Q1 101–157.5 *n* = 35 990	**Q2 157.6–162.6 *n* = 35 710**	**Q3 162.67–167.6 *n* = 32 848**	**Q4 167.98–210.0 *n* = 31 313**	***P*-value**
Gestational diabetes (%)	5.3%	4.3%	3.6%	3.1%	< 0.001
Pre-pregnancy BMI (kg/m^2), n (%)					
< 18.5	1176 (3.3)	1432 (4.0)	1471 (4.5)	1650 (5.27)	< 0.001
18.6–24.9	14 591 (40.5)	16 000 (44.8)	14 698 (44.8)	13 682 (43.7)	
25.0–29.9	7405 (20.6)	6506 (18.2)	6164 (18.8)	6012 (19.2)	
≥ 30	5881 (16.3)	5402 (15.1)	4999 (15.2)	5139 (16.4)	
Missing	6937 (19.3)	6370 (17.8)	5516 (16.8)	4830 (15.4)	
Education, *n* (%)					< 0.001
Less than high school	4945 (13.7)	3574 (10.0)	2786 (8.5)	1613 (5.2)	
High school diploma	5230 (14.5)	5437 (15.2)	5151 (15.7)	4746 (15.2)	
More than high school	5718 (15.9)	8294 (23.2)	8842 (26.9)	10 383 (33.2)	
Unknown	16 542 (46.0)	15 007 (42.0)	13 134 (40.0)	11 908 (38.0)	
Insurance, *n* (%)					< 0.001
Private	18 564 (51.6)	21 455 (60.1)	19 966 (60.8)	20 871 (66.7)	
Public	13 733 (38.2)	10 531 (29.5)	9897 (30.0)	8648 (27.6)	
Self-pay	534 (1.5)	4401 (1.1)	333 (1.0)	294 (0.9)	
Other/unknown	3159 (8.8)	3323 (9.3)	2692 (8.2)	1500 (4.8)	
Pre-pregnancy weight (kg)	61.5 (14.3)	66.0 (15.6)	70.0 (17.0)	76.0 (19.5)	< 0.001
Race, *n* (%)					< 0.001
Non-Hispanic white	14 505 (40.3)	19 377 (54.3)	18 888 (57.5)	20 725 (66.2)	
Non-Hispanic black	5960 (16.6)	5933 (16.6)	6678 (20.3)	6607 (21.1)	
Hispanic	10 791 (30.0)	6545 (18.3)	4404 (13.4)	1844 (5.9)	
Asian/Pacific Islander	1790 (5.0)	1285 (3.6)	723 (2.2)	392 (1.3)	
Multi-racial/other/unknown	26.7 (6.1)	2570 (7.2)	2155 (6.6)	1745 (5.6)	
Maternal age (years)	26.7 (6.1)	27.3 (6.0)	27.5 (5.9)	27.7 (5.7)	< 0.001
Parity, *n* (%)					< 0.001

	Height (quartile) (range cm)[†]				
	Q1 101–157.5 *n* = 35 990	**Q2 157.6–162.6 *n* = 35 710**	**Q3 162.67–167.6 *n* = 32 848**	**Q4 167.98–210.0 *n* = 31 313**	***P*-value**
0	14 050 (39.0)	13 800 (38.6)	12 624 (38.4)	12 070 (38.6)	
1	10 984 (30.5)	10 835 (30.3)	9837 (30.0)	9436 (30.1)	
2	6065 (16.9)	6006 (16.8)	5789 (17.6)	5401 (17.3)	
3	2732 (7.6)	2840 (8.0)	2609 (7.9)	2622 (8.4)	
4 or more	2159 (6.0)	2229 (6.2)	1689 (6.1)	1784 (5.7)	

[*] Data presented are mean and standard deviation unless otherwise specified.

[†] Height cut points calculated based on entire study population.

Table 3

Adjusted odds ratios and 95% confidence intervals for the association between height and gestational diabetes by races/ethnicities in the Consortium on Safe Labor study, USA, 2002–2008

	All			White		Non-Hispanic black		Hispanic		Asian/Pacific Islander	
Height (cm): range (median)[‡c]	**Gestational diabetes (*n*)**	**Odds ratio[*] (95% CI)**	**Odds ratio[†] (95% CI)**	**Gestational diabetes (*n*)**	**Odds ratio[*] (95% CI)**	**Gestational diabetes (*n*)**	**Odds ratio[*] (95% CI)**	**Gestational diabetes (*n*)**	**Odds ratio[*] (95% CI)**	**Gestational diabetes (*n*)**	**Odds ratio[*] (95% CI)**
Q1: 101–157.5 (154.9)	1906	1.00 (Ref)	1.00 (Ref)	682	1.00 (Ref)	183	1.00 (Ref)	678	1.00 (Ref)	199	1.00 (Ref)
Q2:157.5–162.6 (162)	1521	0.66 (0.61–0.72)	0.73 (0.66–0.81)	704	0.64 (0.56–0.72)	213	0.99 (0.79–1.24)	379	0.72 (0.63–0.84)	120	0.72 (0.54–0.96)
Q3: 162.7–167.6 (165.1)	1172	0.46 (0.43–0.51)	0.53 (0.47–0.59)	590	0.46 (0.40–0.52)	205	0.68 (0.54–0.87)	236	0.58 (0.49–0.68)	49	0.43 (0.28–0.65)
Q4: 167.7–210 (172)	968	0.32 (0.30–0.36)	0.34 (0.29–0.40)	595	0.33 (0.29–0.38)	212	0.59 (0.47–0.75)	86	0.39 (0.31–0.52)	18	0.18 (0.09–0.36)
P-value for trend		< 0.001	< 0.001		< 0.001		< 0.001		< 0.001		< 0.001
Each 5-cm increment	5567	0.77 (0.73–0.78)	0.80 (0.78–0.82)	2571	0.78 (0.76–0.80)	813	0.86 (0.81–0.91)	1379	0.83 (0.80–0.86)	386	0.76 (0.70–0.83)

[*] Models adjusted for age and pre-pregnancy weight.

[†] Adjusted for age, pre-pregnancy weight, race, insurance, education and height and race interaction term; height and race interaction term statistically significant (*P* for interaction < 0.05).

[‡] Height cut points calculated based on quartiles of the entire study population.

Table 4

Race-stratified mean differences in height (cm) by gestational diabetes status among women in the Consortium on Safe Labor Cohort study, USA, 2002–2008, and by meta-analysis

Race/ethnicity	No. of studies	No. with gestational diabetes	No. with normal glucose tolerance	Mean difference (95% CI)	*P*-value
Consortium on Safe Labor					
All	N/A	5567	130 294	−1.54 (−1.34 to 1.74)	< 0.001
Non-Hispanic white	N/A	2571	70 924	−1.31 (−1.03 to 1.59)	< 0.01
Non-Hispanic black	N/A	813	24 365	0.14 (−0.37 to 0.64)	0.60
Hispanic	N/A	1379	22 205	−0.67 (−0.29 to 1.05)	< 0.01
Asian/Pacific Islander	N/A	386	3804	−1.64 (−0.91 to 2.36)	< 0.001
Meta-analysis					
All	38	15 761	205 828	−1.13 (−1.49 to 0.78)	< 0.001
European Caucasian	9	5276	83 278	−1.00 (−1.57 to 0.43)	< 0.01
African/African-American	5	1466	26 170	−0.29 (−1.15 to 0.57)	0.50
Hispanic	7	4304	34 271	−1.22 (−1.72 to 0.71)	< 0.001
Asian	10	2083	42 791	−0.94 (−1.43 to 0.45)	< 0.01