



Original article

Attempts at Weight Loss in U.S. Women with and without a History of Gestational Diabetes Mellitus

 Jodie Katon, PhD^{a,*}, Charles Maynard, PhD^{b,c}, Gayle Reiber, PhD^{a,b,c}
^a Department of Epidemiology, University of Washington School of Public Health, Seattle, Washington

^b VA Puget Sound Health Care System, Seattle, Washington

^c Department of Health Services, University of Washington School of Public Health, Seattle, Washington

Article history: Received 20 June 2011; Received in revised form 13 July 2012; Accepted 13 July 2012

A B S T R A C T

Background and Objective: Gestational diabetes mellitus (GDM) is a risk factor for type 2 diabetes. Relatively modest weight loss can delay or prevent the onset of type 2 diabetes. The objective of this study was to determine, using a nationally representative survey, whether among women without diabetes, those with a history of GDM (hGDM) were more likely than those without hGDM to be currently attempting weight loss.

Methods: This study used data from the 2003 Behavioral Risk Factor Surveillance System, a national, population-based, random-sample telephone survey. Women aged 18 to 44 years without diabetes who answered questions related to current weight loss activity were included in the analysis. The primary outcome was currently attempting weight loss. Logistic regression was used to analyze the association between hGDM and currently attempting weight loss.

Results: We included 53,608 women without diabetes: 1,260 (2%) with hGDM, and 52,348 (98%) without hGDM. Among women with hGDM, 53% were currently attempting weight loss compared with 47% of women without hGDM. Overall, after adjusting for age, race/ethnicity, education, marital status, and medical insurance, compared with women without hGDM, those with hGDM had 20% higher odds of currently attempting weight loss (95% confidence interval [CI], 0.97–1.49); however, among obese women (body mass index ≥ 30 kg/m²), compared with women without hGDM, those with hGDM had 46% lower odds of currently attempting weight loss (95% CI, 0.35–0.82).

Conclusions: Obese women with hGDM are less likely to be currently attempting weight loss compared with those without hGDM. Effective interventions for obese women with hGDM are needed.

Published by Elsevier Inc.

Introduction

Gestational diabetes mellitus (GDM), or glucose intolerance first recognized during pregnancy, affects 2% to 14% of pregnancies in the United States and is a recognized risk factor for type 2 diabetes (“ACOG Practice Bulletin. Clinical management guidelines for obstetrician-gynecologists. Number 30, September 2001 (replaces Technical Bulletin Number 200, December 1994). Gestational diabetes,” 2001). Up to 60% of women with a history of GDM (hGDM) develop type 2 diabetes within 5 to 10 years

postpartum (Kim, Newton, & Knopp, 2002). Although prepregnancy obesity is a risk factor for GDM, women with hGDM are also more likely to have excess gestational weight gain (Hedderson, Gunderson, & Ferrara, 2010), which is associated with increased risk of postpartum weight retention and obesity (Amorim, Rossner, Neovius, Lourenco, & Linne, 2007; Luke, Hediger, & Scholl, 1996). Evidence from the Diabetes Prevention Program Trial demonstrates that relatively modest weight loss, at a mean of 12 years since first occurrence of GDM, can prevent or delay the onset of type 2 diabetes among women with hGDM (Ratner et al., 2008).

Educating women with hGDM concerning their increased risk for type 2 diabetes and potential diabetes prevention behaviors may not produce long-term behavior change (Kim, McEwen, Kerr, et al., 2007; Swan, Kilmartin, & Liaw, 2007). One explanation for the discordance between understanding and behavior is that women with hGDM may systematically underestimate their

J.K. was supported by grant number T32 HD052462 from the National Institute of Child Health and Human Development (NICHD), NIH and by a grant from the Seattle chapter of Achievement Rewards for College Scientists (ARCS).

* Correspondence to: Jodie Katon, PhD, Department of Epidemiology, University of Washington School of Public Health, Box 357236, Seattle, WA 98195. Phone: (206) 543-1065; fax: (206) 543-8525.

E-mail address: jkaton@u.washington.edu (J. Katon).

individual risk for type 2 diabetes (Kim, McEwen, Piette, et al., 2007). Other potential barriers to diabetes prevention behaviors in the postpartum period by women with hGDM include lack of time and lack of childcare (Smith, Cheung, Bauman, Zehle, & McLean, 2005; Symons Downs & Ulbrecht, 2006).

Prior studies of health behaviors among women with hGDM focused on specific behaviors such as physical activity and consumption of fruits and vegetables (Kieffer, Sinco, & Kim, 2006) rather than intention to lose weight. However, findings from the Diabetes Prevention Program Trial indicate the importance of weight loss as a separate outcome. Therefore, our objective was to examine, in a nationally representative survey, whether among women without diabetes those with hGDM were more likely than women without hGDM to be attempting weight loss and to quantify differences in preferred weight loss methods.

Methods

Data Source

This study used data from the 2003 Behavioral Risk Factor Surveillance System (BRFSS) survey. The BRFSS is a cross-sectional telephone survey conducted by the U.S. Centers for Disease Control and Prevention (CDC) in conjunction with state health departments. The BRFSS uses a multistage cluster design based on random-digit dialing to select a representative sample of each state's noninstitutionalized civilian residents aged ≥ 18 years old. Data are then pooled across states to create national estimates. A detailed description of the survey methods has been previously published (CDC, 2004). The response rate for this study based on the median response rate to the 2003 national core questions was 42% (CDC, 2003). The University of Washington Human Subjects Division deemed the study exempt from Institutional Review Board review.

Study Population

The study population included women aged 18 to 44 years with recorded body mass index (BMI) who answered the survey questions: "Have you ever been told by a doctor that you have diabetes?" and "Are you now trying to lose weight?" Exclusions included women with established diabetes, who were pregnant at the time of the survey, and had unknown pregnancy, diabetes, or weight loss status (Figure 1).

Study Variables

Table 1 shows the BRFSS questions, potential responses, and how responses were categorized to define the exposure and primary and secondary outcomes. The primary exposure was self-reported hGDM. Women without established diabetes were categorized as having hGDM or no hGDM. The reliability of the BRFSS question regarding diagnosis of diabetes is high with reported kappa values ranging from 0.60 to 0.86 (CDC, 2004).

The primary outcome was currently attempting weight loss (yes, no). Secondary outcomes were attempting weight loss through reduced calorie or fat consumption, physical activity, or both. Respondents were asked, "Are you eating either fewer calories or less fat to lose weight?" and "Are you using physical activity or exercise to lose weight?" Respondents who answered, "don't know/not sure" or "refused" to either question were excluded ($n = 217$). Based on the responses four categories of weight loss methods were formed: None, low-fat or low-calorie diet alone, physical activity alone, and low-fat or low-calorie diet and physical activity. Women who did not report that they were currently attempting weight loss were excluded from analyses of the association of hGDM and these weight loss methods ($n = 27,667$).

Covariates included age (years), race/ethnicity (White, non-Hispanic; Black, non-Hispanic; Hispanic; other), BMI (< 25 kg/m²,

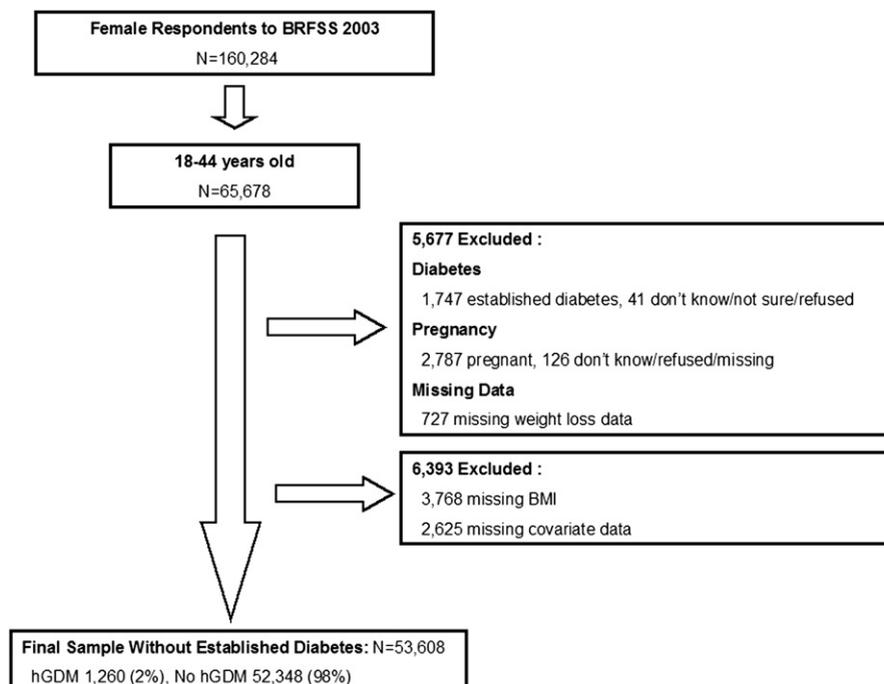


Figure 1. Inclusions, exclusions, and the final study sample.

Table 1
Behavioral Risk Factor Surveillance System Diabetes and Weight Loss Questions, Potential Responses, and Categorizations, 2003

Question	Potential Responses	Categorization
4.1 Have you ever been told by a doctor that you have diabetes?	Yes	Excluded
	Yes, but only during pregnancy	Yes, hGDM
	No	Reference category
	Don't know/not sure	Excluded
	Refused	Excluded
8.1 Are you now trying to lose weight?	Yes	Yes
	No	Reference category
	Don't know/not sure	Excluded
	Refused	Excluded
8.3 Are you eating either fewer calories or less fat to lose weight?	Yes, fewer calories	Yes
	Yes, less fat	Yes
	Yes, fewer calories and less fat	Yes
	No	Reference category
	Don't know/not sure	Excluded
	Refused	Excluded
8.4 Are you using physical activity or exercise to lose weight?	Yes	Yes
	No	Reference category
	Don't know/not sure	Excluded
	Refused	Excluded
8.3–8.4 Combined weight loss strategy	Low-fat or low-calorie diet and physical activity	Yes
	None	Reference category
	Low-fat or low-calorie diet alone	Reference category
	Physical activity alone	Reference category
8.5 In the past 12 months, has a doctor, nurse, or other health professional given you advice about your weight?	Yes, lose weight	Yes
	Yes, gain weight	Reference category
	Yes, maintain weight	Reference category
	No	Reference category
	Don't know/not sure	Excluded
	Refused	Excluded

Abbreviations: hGDM, history of gestational diabetes mellitus.

25–29.9 kg/m², ≥30 kg/m²), income (<\$15,000, \$15,000–\$25,000, \$25,000–\$35,000, \$35,000–\$50,000, and ≥\$50,000), education (less than high school, high school only, more than high school), currently married or partnered (yes/no), insurance (yes/no), at least one child younger than 18 years at home (yes/no), currently employed (yes/no), health status (excellent/very good/good, fair/poor), current smoking (yes/no), and meeting guidelines for moderate to vigorous physical activity (yes, ≥30 min/d moderate activity 5 d/wk or ≥20 min/d vigorous activity 3 d/wk; no, some activity but <30 min/d moderate activity 5 d/wk and <20 min/d vigorous activity 3 d/wk; sedentary, no moderate or vigorous activity).

BMI, receiving advice from a professional to lose weight, and self-reported health status were examined as potential modifiers of the association between hGDM and currently attempting weight loss among women without diabetes. Survey respondents were asked, “In the past 12 months, has a doctor, nurse, or other health professional given you advice about your weight?” Those answering “don't know/not sure” or “refused” were excluded from this analysis ($n = 184$). The remaining respondents were categorized as either receiving or not receiving advice to lose weight (Table 1). Self-reported health status was categorized as “excellent/very good/good” or “fair/poor.”

Statistical Analysis

Logistic regression was used to analyze the association between hGDM and currently attempting weight loss among women 18 to 44 years old without diabetes. For the analysis of the association of hGDM and weight loss strategies, the odds of attempting weight loss by low-fat or low-calorie diet alone, physical activity alone, and low-fat or low-calorie diet and physical activity were modeled separately using logistic regression. Table 1 illustrates the categorization of outcomes and referent groups. Appropriate sampling weights were used to account for survey design (CDC, 2003) and all analyses were done using STATA 9 (StataCorp, 2005). Because data were cross-sectional the final models only included covariates that were thought to be 1) a priori associated with hGDM and attempting weight loss, and 2) unlikely to be either a result of hGDM or attempting to lose weight. Unadjusted and adjusted odds ratios (OR) and 95% confidence intervals (CI) are reported and all tests had a two-sided alpha level of 0.05.

Modification of the association of hGDM and attempting weight loss by BMI, advice from a clinician to lose weight, and self-reported health status were examined through the separate introduction of interaction terms with hGDM. The significance of the interaction was assessed via the Wald test.

Sensitivity Analyses

Women's motivations for attempting to lose weight may change over time, and BRFSS does not contain data on time since GDM pregnancy. Therefore, we conducted an analysis restricted to women younger than 35 years, who might be assumed to be closer in time to their GDM pregnancy.

Results

Of the 160,284 female respondents to the 2003 BRFSS survey 65,678 were between 18 and 44 years old. A total of 5,677 (9%) respondents were excluded: 1,747 (3%) had established diabetes, 41 (0.1%) had unknown diabetes status, 2,787 (4%) were pregnant, 126 (1%) had unknown pregnancy status, and 727 (1%) were missing information regarding attempting weight loss (Figure 1). An additional 3,768 women were excluded owing to missing BMI data, and 2,625 women were excluded owing to other missing covariate data. Excluding women with missing BMI or covariates did not change the prevalence of hGDM in our sample. The final sample consisted of 53,608 women without diabetes: 1,260 with hGDM (2%) and 52,348 (98%) without hGDM.

Among women without diabetes, risk factors for type 2 diabetes were more common among those with hGDM compared with those without hGDM, specifically older age, belonging to a high-risk racial or ethnic group, a BMI of 30 kg/m² or higher, and less education (Table 2). Additionally women with hGDM were more likely to have at least one child younger than 18 years old living at home, were less likely to be employed, and were more likely to receive advice to lose weight compared with women without hGDM.

Table 3 shows that 53% of those with hGDM compared with 47% of those without hGDM were attempting weight loss. After adjustment for age, race/ethnicity, education, marital status, and medical insurance compared with women without hGDM, those with hGDM had 20% higher odds of attempting weight loss (OR, 1.20; 95% CI, 0.97–1.49).

Table 2
 Characteristics of Women Aged 18–44 Years, and No Diabetes, with and without a History of Gestational Diabetes (hGDM) in the United States, Behavioral Risk Factor Surveillance System 2003*

Characteristic	Total	hGDM	No hGDM
<i>n</i> [†]	53,608	1,260	52,348
Mean age (yrs)	32 (31.6–31.8)	34 (33.0–34.5)	32 (31.5–31.8)
Race/ethnicity (%)			
White, non-Hispanic	66 (64.8–66.3)	60 (54.3–65.0)	66 (64.9–66.5)
Black, non-Hispanic	12 (11.2–12.2)	10 (7.1–13.2)	12 (11.2–12.2)
Hispanic	15 (14.9–16.0)	22 (16.1–26.9)	15 (14.7–16.1)
Other	7 (6.7–7.6)	9 (5.9–11.5)	7 (6.7–7.6)
BMI, kg/m ² (%)			
<25	56 (55.1–56.6)	38 (33.0–42.7)	56 (55.5–57.0)
25–29.9	26 (24.9–26.3)	32 (26.5–36.6)	25 (24.8–26.1)
≥30	19 (18.0–19.2)	31 (25.9–35.3)	18 (17.7–18.9)
Fair or poor health status (%)	9 (8.5–9.4)	14 (10.2–18.0)	9 (8.3–9.2)
Income, US\$ (%)			
<15,000	12 (10.9–12.1)	14 (10.0–18.1)	11 (10.9–12.0)
15,000–25,000	17 (16.7–17.8)	17 (12.8–20.7)	17 (16.6–17.8)
25,000–35,000	14 (13.3–14.4)	12 (7.4–16.1)	14 (13.3–14.4)
35,000–50,000	18 (17.0–18.2)	20 (15.6–24.4)	18 (16.9–18.1)
≥50,000	40 (39.1–40.7)	37 (32.4–42.4)	40 (39.2–40.8)
Education level (%)			
Less than high school	9 (8.2–9.2)	12 (8.5–15.6)	9 (8.1–9.1)
High school graduate	28 (26.7–28.2)	27 (22.2–31.8)	28 (26.8–28.2)
More than high school	64 (63.1–64.6)	61 (55.8–66.2)	64 (63.2–64.7)
Currently married or partnered (%)	60 (59.1–60.6)	77 (73.2–81.2)	59 (58.6–60.2)
Medical insurance (%)	82 (81.3–82.5)	81 (76.5–85.0)	82 (81.3–82.5)
≥1 Child <18 living at home	68 (67.4–68.8)	94 (91.8–96.0)	68 (66.7–68.2)
Currently employed (%)	65 (64.4–65.9)	58 (53.2–63.4)	65 (64.5–66.1)
Current smoker (%)	24 (23.6–24.9)	23 (18.6–26.5)	24 (23.7–25.0)
Physical activity (%)			
Yes, meets guidelines	50 (49.2–50.7)	47 (42.3–52.6)	50 (49.2–50.8)
No, below guidelines	39 (38.5–40.0)	40 (34.6–44.6)	39 (38.5–40.0)
Sedentary, no activity	11 (10.3–11.3)	13 (9.5–16.4)	11 (10.3–11.3)
Advised to lose weight (%)	12 (11.2–12.2)	22 (16.6–26.5)	11 (10.9–11.9)

* Data are weighted mean or percent (95% confidence interval).

[†] Observed *n*, not weighted for survey sampling.

After adjustment, a significant interaction was detected between hGDM and current BMI (*p* for interaction = .01). Among those with a BMI of less than 25 kg/m², compared with women without hGDM, those with hGDM had 24% higher odds of attempting weight loss; among those with BMI 25 to 29.9 kg/m², no reliable association between hGDM and attempting weight loss was detected (OR, 1.01; 95% CI, 0.63, 1.62). However, among those with BMI of 30 kg/m² or higher, compared with women without hGDM, those with hGDM had 46% lower odds of attempting weight loss (OR, 0.54; 95% CI, 0.35–0.82).

A significant interaction was also detected between hGDM and receiving advice to lose weight (*p* for interaction = .02) after adjusting for age, race/ethnicity, education, marital status, and medical insurance. Overall, compared with those who did not receive advice to lose weight, a higher percentage of women who received such advice were attempting weight loss. Among those who received advice to lose weight, compared with women without hGDM, those with hGDM had 52% lower odds of attempting weight loss (OR, 0.48; 95% CI, 0.23–1.03). Conversely, among those who did not receive such advice, compared with women without hGDM, those with hGDM had 24% higher odds of attempting weight loss (OR, 1.24; 95% CI, 0.99–1.54). No interaction was detected between health status and hGDM (*p* for interaction = 0.98).

No reliable associations between hGDM and any specific methods for attempting weight loss were detected. After adjustment for age, race/ethnicity, education, marital status, and medical insurance, women with hGDM were no more or less

likely to attempt to lose weight through a low-fat or low-calorie diet alone (OR, 0.85; 95% CI, 0.59–1.29), physical activity alone (OR, 0.79; 95% CI, 0.55–1.13), or a combination of the two strategies (OR, 0.81; 95% CI, 0.61–1.10).

When the analysis was restricted to women younger than 35 years old, compared with women without hGDM, those with hGDM had 42% higher odds of currently attempting weight loss after adjusting for age, race/ethnicity, education, marital status, and medical insurance (OR, 1.42 95% CI, 1.09–1.85). Although no significant interaction was detected between hGDM and BMI (*p* for interaction = .22), a pattern of association between hGDM and currently attempting weight loss similar to that observed for the entire sample was evident. After adjusting for age, race/ethnicity, education, marital status, and medical insurance among those with BMI of less than 25 kg/m², compared with women without hGDM, those with hGDM had 26% higher odds of currently attempting weight loss (OR, 1.26 95% CI, 0.81–1.98); among those with BMI of 25 to 29.9 kg/m², compared with women without hGDM, those with hGDM had 14% higher odds of currently attempting weight loss (OR, 1.14 95% CI, 0.71–1.84); and among those with BMI of 30 kg/m² or greater, compared with women without hGDM, those with hGDM had 44% lower odds of currently attempting weight loss (OR, 0.56 95% CI, 0.36–1.22).

Discussion

This analysis examined the association of hGDM and currently attempting weight loss in a nationally representative

Table 3

Odds Ratios (OR) for Attempting to Lose Weight, Comparing Women with History of Gestational Diabetes (hGDM) with Those with no hGDM among Women Aged 18–44 Years and No Diabetes, Behavioral Risk Factor Surveillance System 2003

Total Sample	hGDM	n_{observed}^*	Trying to Lose Weight (%) [†]	Unadjusted OR (95% CI) [‡]	Adjusted OR (95% CI) ^{‡,§}
	No	52,348	47	Reference	Reference
	Yes	1,260	53	1.27 (1.03–1.57)	1.20 (0.97–1.49)
BMI (kg/m ²)	No	28,686	30	Reference	Reference
	Yes	499	35	1.26 (0.90–1.75)	1.24 (0.88–1.74)
<25	No	13,349	65	Reference	Reference
	Yes	386	66	1.03 (0.64–1.65)	1.01 (0.63–1.62)
25–29.9	No	10,313	75	Reference	Reference
	Yes	375	63	0.56 (0.37–0.85)	0.54 (0.35–0.82)
≥30	No	46,086	82	Reference	Reference
	Yes	6,087	69	0.50 (0.24–1.05)	0.48 (0.23–1.03)
Advice to lose weight [¶]	No	1,007	43	Reference	Reference
	Yes	244	49	1.29 (1.03–1.60)	1.24 (0.99–1.54)
Received	No	47,778	47	Reference	Reference
	Yes	1,113	52	1.26 (1.00–1.57)	1.19 (0.95–1.49)
Did not receive	No	4,525	54	Reference	Reference
	Yes	144	59	1.21 (0.64–2.30)	1.18 (0.62–2.25)
Health status [#]	No	47,778	47	Reference	Reference
	Yes	1,113	52	1.26 (1.00–1.57)	1.19 (0.95–1.49)
Excellent/very good/good	No	4,525	54	Reference	Reference
	Yes	144	59	1.21 (0.64–2.30)	1.18 (0.62–2.25)
Fair/poor	No	47,778	47	Reference	Reference
	Yes	1,113	52	1.26 (1.00–1.57)	1.19 (0.95–1.49)

* Observed data counts, not weighted for survey sampling.

† Weighted for the entire population.

‡ Odds ratios (95% confidence intervals) weighted to account for survey sampling.

§ Adjusted for age, race/ethnicity, education, marital status, and medical insurance.

|| p for interaction: Crude $p = .01$; adjusted $p = .01$.¶ p for interaction: Crude $p = .02$; adjusted $p = .02$.# p for interaction: Crude $p = .92$; adjusted $p = .98$.

sample of reproductive-age women without diabetes. Overall women with hGDM seemed more likely to be currently attempting weight loss compared with women without such a history, but this association varied by current BMI status. Approximately one third of women with hGDM achieved a healthy BMI (BMI < 25 kg/m²) and continued to attempt weight loss with greater frequency than their counterparts without such a history. However, among obese women hGDM was associated with lower odds of currently attempting weight loss.

The difference in our findings for normal weight women (BMI < 25 kg/m²) and obese women, regarding the association of hGDM and attempting weight loss, may explain the difference between our results and previous findings regarding hGDM and diabetes prevention behaviors (Kieffer, et al., 2006). Previously, Kieffer and associates (2006) reported that hGDM was not associated with increased odds of adoption of diabetes prevention behaviors, including physical activity and increased fruit and vegetable consumption. Unlike the present study, Kieffer and colleagues did not examine these associations by BMI. Combining obese and normal weight women may have neutralized any detectable association between hGDM and physical activity and fruit and vegetable intake.

Importantly, almost one third of women with hGDM were obese and in this subgroup, compared with women without hGDM, those with hGDM were less likely to be currently attempting weight loss. Potential explanations for the reluctance among women with hGDM to attempt weight loss, include low perceived individual risk (Feig, Chen, & Naylor, 1998; Kim, McEwen, Piette, et al., 2007; Swan, et al., 2007), low social support (Kim, McEwen, Kieffer, Herman, & Piette, 2008), lack of time (Smith, et al., 2005; Symons Downs & Ulbrecht, 2006), and lack of childcare (Smith, et al., 2005). Alternatively, at the time of the survey, many obese women might no longer be attempting

weight loss after prior failed attempts. Finally, BMI at the time of the survey may be a result of excess gestational weight gain or prepregnancy BMI, which are also risk factors for GDM and for which we were unable to adjust. Our findings regarding the impact of receiving advice to lose weight were unexpected. Overall, women who received advice to lose weight were more likely to attempt weight loss. However, among those receiving such advice, compared with women without hGDM, those with hGDM had lower odds of attempting to lose weight. Notably, 60% of women who received advice to lose weight were also obese. Therefore, these results may reflect our earlier finding that among obese women hGDM was associated with lower odds of attempting weight loss.

Strengths of this study include the use of a nationally representative sample to assess trends regarding weight loss behavior among women with hGDM who are at high risk for type 2 diabetes. A primary limitation to the use of BRFSS data is that measures are self-reported. Although studies have reported overall high reliability of the diabetes question in the BRFSS survey there may be substantial underreporting (Nelson, Holtzman, Bolen, Stanwyck, & Mack, 2001). Validity studies indicate that sensitivity of the diabetes question in BRFSS is estimated to be 67% to 100% and specificity is 98% to 99% (Bowlin et al., 1993; Martin, Leff, Calonge, Garrett, & Nelson, 2000). Additionally, despite the large national sample BRFSS is not generalizable to the entire U.S. population because it is limited to adults with land-based telephones. Individuals between ages of 18 and 34 are more likely to live in cell phone-only households (Link, Battaglia, Frankel, Osborn, & Mokdad, 2007) and a portion of younger women with and without hGDM may therefore have been excluded from the BRFSS survey. This may also result in the exclusion of very low-income individuals, who may have different risk profiles.

Additional limitations to the use of the BRFSS data were that the BRFSS did not include questions regarding parity or time since GDM. Therefore, nulliparous women were included in the group of women without hGDM. If nulliparous women were more likely to attempt weight loss including them in our analysis may have led to an overestimation of the association of hGDM and attempting weight loss among obese women, but an underestimation of the association of hGDM and attempting weight loss in the entire population.

Women with more distant hGDM might be less likely to be attempting weight loss. Assuming that in the total population hGDM was associated with an increased likelihood of attempting weight loss, the inability to adjust for or stratify by time since GDM may have resulted in underestimation of the association of hGDM and attempting weight loss in the total population. When we restricted our analysis to women younger than 35 years old, in an attempt to limit our sample to those with more recent GDM, the pattern of observed associations remained consistent. Importantly, the findings from a subanalysis of the Diabetes Prevention Program Trial indicate that the increased risk of diabetes associated with hGDM persists throughout a woman's life time and that weight loss many years after a GDM-affected pregnancy can reduce this risk (Ratner, et al., 2008).

A final methodologic limitation to this study, which must be considered when interpreting the results, is the exclusion of women with established diabetes. It is likely that a portion of these women had hGDM. Women with hGDM who already developed type 2 diabetes may have had the most severe GDM and the greatest number of risk factors for type 2 diabetes. By restricting our analysis to women with hGDM who had not yet developed type 2 diabetes, we focused on a group that could benefit from prevention strategies.

Implications for Practice and/or Policy

These limitations notwithstanding, this study provides important information regarding the weight loss behavior of women with hGDM. Our findings indicate that close to one third of women with hGDM remain obese, and that among obese women those with hGDM are less likely to attempt weight loss. This is of particular concern given current conservative estimates indicating that the prevalence of type 2 diabetes in the United States will increase from 1 in 10 in 2010 to between 1 in 5 and 1 in 3 by 2050 (Boyle, Thompson, Gregg, Barker, & Williamson, 2010). An important step toward reducing the incidence of type 2 diabetes may be developing interventions that encourage women who remain obese after a pregnancy affected by GDM to adopt diabetes prevention behaviors and to sustain these behaviors across their life course. Current theories of behavior change and health promotion emphasize a need to understand the patient's unique needs, barriers to change, and readiness to change (Rollnick, Mason, & Butler, 1999). For women with hGDM to successfully adopt diabetes prevention behaviors, health care providers need to assess women's readiness to change. Among interested women, provision of a sufficient number of education sessions and real-life applications will foster improved self-efficacy addressing the unique weight loss barriers faced by women with hGDM.

Additionally, our findings indicate that a portion of women with hGDM may be effectively engaging in diabetes prevention behaviors as evidenced by the increased likelihood of

attempting weight loss associated with hGDM among normal weight women. Understanding the motivations and behaviors of this subgroup might provide useful insight for developing effective lifestyle interventions among women with hGDM. New research that takes into account the impact of time since pregnancy on motivation to lose weight is also needed to inform development of lifestyle interventions for overweight and obese women with hGDM. These results add to a growing body of evidence that more attention needs to be paid to the care of women with hGDM in the postpartum period. Effective interventions and care for obese women with hGDM are needed that are consistent with current theories of behavior change and health promotion.

Acknowledgments

The authors thank Alan Cheadle for his input on this research and manuscript.

References

- ACOG Practice Bulletin. Clinical management guidelines for obstetrician-gynecologists. Number 30, September 2001 (replaces Technical Bulletin Number 200, December 1994). Gestational diabetes. (2001). *Obstetrics and Gynecology*, 98, 525–538.
- Amorim, A. R., Rossner, S., Neovius, M., Lourenco, P. M., & Linne, Y. (2007). Does excess pregnancy weight gain constitute a major risk for increasing long-term BMI? *Obesity (Silver Spring)*, 15, 1278–1286.
- Bowlin, S. J., Morrill, B. D., Nafziger, A. N., Jenkins, P. L., Lewis, C., & Pearson, T. A. (1993). Validity of cardiovascular disease risk factors assessed by telephone survey: The Behavioral Risk Factor Survey. *Journal of Clinical Epidemiology*, 46, 561–571.
- Boyle, J. P., Thompson, T. J., Gregg, E. W., Barker, L. E., & Williamson, D. F. (2010). Projection of the year 2050 burden of diabetes in the US adult population: Dynamic modeling of incidence, mortality, and prediabetes prevalence. *Population Health Metrics*, 8, 29.
- Feig, D. S., Chen, E., & Naylor, C. D. (1998). Self-perceived health status of women three to five years after the diagnosis of gestational diabetes: A survey of cases and matched controls. *American Journal of Obstetrics and Gynecology*, 178, 386–393.
- Hedderson, M. M., Gunderson, E. P., & Ferrara, A. (2010). Gestational weight gain and risk of gestational diabetes mellitus. *Obstetrics and Gynecology*, 115, 597–604.
- Kieffer, E. C., Sinco, B., & Kim, C. (2006). Health behaviors among women of reproductive age with and without a history of gestational diabetes mellitus. *Diabetes Care*, 29, 1788–1793.
- Kim, C., McEwen, L. N., Kerr, E. A., Piette, J. D., Chames, M. C., Ferrara, A., et al. (2007). Preventive counseling among women with histories of gestational diabetes mellitus. *Diabetes Care*, 30, 2489–2495.
- Kim, C., McEwen, L. N., Kieffer, E. C., Herman, W. H., & Piette, J. D. (2008). Self-efficacy, social support, and associations with physical activity and body mass index among women with histories of gestational diabetes mellitus. *Diabetes Education*, 34, 719–728.
- Kim, C., McEwen, L. N., Piette, J. D., Goewey, J., Ferrara, A., & Walker, E. A. (2007). Risk perception for diabetes among women with histories of gestational diabetes mellitus. *Diabetes Care*, 30, 2281–2286.
- Kim, C., Newton, K. M., & Knopp, R. H. (2002). Gestational diabetes and the incidence of type 2 diabetes: A systematic review. *Diabetes Care*, 25, 1862–1868.
- Link, M. W., Battaglia, M. P., Frankel, M. R., Osborn, L., & Mokdad, A. (2007). Reaching the US cell phone generation comparison of cell phone survey results with an ongoing landline telephone survey. *Public Opinion Quarterly*, 71, 814–839.
- Luke, B., Hediger, M. L., & Scholl, T. O. (1996). Point of diminishing returns: When does gestational weight gain cease benefiting birthweight and begin adding to maternal obesity? *Journal of Maternal and Fetal Medicine*, 5, 168–173.
- Martin, L. M., Leff, M., Calonge, N., Garrett, C., & Nelson, D. E. (2000). Validation of self-reported chronic conditions and health services in a managed care population. *American Journal of Preventive Medicine*, 18, 215–218.
- Nelson, D. E., Holtzman, D., Bolen, J., Stanwyck, C. A., & Mack, K. A. (2001). Reliability and validity of measures from the Behavioral Risk Factor Surveillance System (BRFSS). *Sozial- und Präventivmedizin*, 46(Suppl 1), S3–42.
- Ratner, R. E., Christophi, C. A., Metzger, B. E., Dabelea, D., Bennett, P. H., Pi-Sunyer, X., et al. (2008). Prevention of diabetes in women with a history of

- gestational diabetes: Effects of metformin and lifestyle interventions. *Journal of Clinical Endocrinology and Metabolism* 1–16.
- Rollnick, S., Mason, P., & Butler, C. (1999). *Health behavior change: A guide for practitioners*. Edinburgh: Harcourt Publishers Ltd.
- Smith, B. J., Cheung, N. W., Bauman, A. E., Zehle, K., & McLean, M. (2005). Postpartum physical activity and related psychosocial factors among women with recent gestational diabetes mellitus. *Diabetes Care*, 28, 2650–2654.
- StataCorp. (2005). *Stata statistical software: Release 9*. College Station, TX: StataCorp LP.
- Swan, W., Kilmartin, G., & Liaw, S. T. (2007). Assessment of readiness to prevent type 2 diabetes in a population of rural women with a history of gestational diabetes. *Rural Remote Health*, 7, 802.
- Symons Downs, D., & Ulbrecht, J. S. (2006). Understanding exercise beliefs and behaviors in women with gestational diabetes mellitus. *Diabetes Care*, 29, 236–240.
- U.S. Centers for Disease Control and Prevention (CDC). (2003). *Behavioral Risk Factor Surveillance System survey data*. Atlanta: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention.
- U.S. Centers for Disease Control and Prevention (CDC). (2004). *Behavioral Risk Factor Surveillance System, 2003 summary data quality report*. Atlanta: Author.

Author Descriptions

Jodie Katon, PhD, is a Postdoctoral Fellow at the Department of Veterans Affairs (VA) Puget Sound Health Care System, Health Services Research and Development (HSR&D). Her interests include gestational diabetes and women Veteran's health.

Charles Maynard, PhD, is an investigator at VA Puget Sound Health Care System, HSR&D. His primary research interests are cardiovascular health services research and administrative databases.

Gayle Reiber, PhD, is a Senior Career Scientist at the VA Puget Sound Health Care System, HSR&D. Her interests include prevention and treatment of diabetes and lower extremity complications and diabetes self-care and enhancement programs.