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Original Article

Medical nutrition therapy for pregnant women with gestational diabetes mellitus—A retrospective cohort study

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A B S T R A C T

Objective: Women diagnosed with gestational diabetes mellitus (GDM) remain at high risk of developing type 2 diabetes mellitus in the future. The effectiveness of medical nutrition therapy (MNT) acting on GDM is increasingly becoming noteworthy.

Materials and Methods: A retrospective cohort study involving 488 GDM cases was conducted. The prepregnancy weight, weight changes during pregnancy, glucose levels, GDM management, follow-up, and birth outcomes were recorded from 2008 to 2012.

Results: Overall, 62.91% of the women received MNT, with an increasing trend from 2008 to 2012 ($p < 0.01$). The fasting plasma glucose, 2-hour blood glucose, and weight gain at 28 weeks, 32 weeks, and 36 weeks as well as intrapartum were lower in the MNT group than in the non-MNT group. Total weight gain during pregnancy and the rates of adverse events during pregnancy were lower in the MNT group compared to the non-MNT group (all $p < 0.05$). Moreover, 92.2% of the participants in the MNT group had a normal oral glucose tolerance test result, and the rate of exclusive breastfeeding within 4 months after delivery was 54.4% in the MNT group; both were higher than those of the non-MNT group (66.3%, $p < 0.001$; 29.3%, $p < 0.05$).

Conclusion: MNT can reduce the incidence of pregnancy complications, increase the exclusive breastfeeding rate, and improve pregnancy outcomes.

Introduction

Gestational diabetes mellitus (GDM) is defined as glucose intolerance that is first detected during pregnancy. Shortly after delivery, glucose homeostasis is restored to nonpregnancy levels, but women diagnosed with GDM remain at high risk of developing type 2 diabetes mellitus (T2DM) in the future [1]. The association between GDM and T2DM is important for the elucidation of the causes of these disorders, and for the prediction and possible prevention or delay of T2DM in women. GDM has a negative impact on pregnant women as well as fetal and neonatal development. GDM causes maternal polyhydramnios, pregnancy-induced hypertension syndrome, fetal macrosomia, deformities, and stillbirths. GDM is also linked to apnea syndrome, hypoglycemia, hypocalcemia, and polycythemia in newborns. Long-term exposure to intrauterine hyperglycemia increases the risks of obesity, diabetes, and other metabolic syndromes in children [2]. Studies show that by managing blood sugar during pregnancy, short- and long-term outcomes for the mother and children can be significantly improved [3]. A number of known risk factors for GDM have become increasingly prevalent among pregnant Chinese women: the average age of pregnant women is increasing,

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and according to the Nutrition and Health Status Survey of Residents in China, carried out in 2002, the prevalence of overweight and obesity rose 39% and 97%, respectively, compared to the results of the previous survey conducted in 1992 [2]. Excessive body weight gain during pregnancy is an independent risk factor for GDM.

Medical nutrition therapy (MNT) is a key tool to manage GDM and can positively influence pregnancy outcomes of mother and child health [4,5]. The clinical manifestations of GDM are most apparent during the mid and third trimesters of pregnancy and include abnormally high blood glucose, and even diabetic ketoacidosis [6,7]. In this stage, maternal nutritional needs reach their peak, and the contradiction between glucose control and nutritional needs is most pronounced [8]. MNT to manage GDM is designed to guarantee nutritional needs during pregnancy while achieving acceptable glucose control [9,10].

The *China Medical Nutrition Therapy Guidelines for Diabetes (2010)* [11], edited by the Chinese Diabetes Society and the China Medicine Doctor Association Nutrition Doctor Specialized Committee, is the first diabetes MNT guideline published in China. It focuses on evidence-based MNT, dietary recommendations, MNT of diabetic complications, MNT workflow, and personalized MNT programs for special situations, such as GDM, children with diabetes, and diabetes among the elderly.

A few studies about the status and effectiveness of MNT to manage GDM in China had been published. We reviewed the experience with regard to diagnosis of GDM and its management through MNT among high-risk pregnant women in a hospital in Beijing, China, in the period 2008–2012. We focused on pregnant women's weight changes, blood glucose monitoring results, adverse events during pregnancy, pregnancy outcomes, infant feeding, and postpartum prognosis. The findings were then discussed with a view to establish a more rational and effective prenatal care model.

Methods

Study site, participants, and definitions

The retrospective cohort study focused on the register of high-risk pregnancies, which was managed by the associated Department of Clinical Nutrition and Obstetrics of the China–Japan Friendship Hospital (Beijing, China) during 2008–2012. The study participants were high-risk pregnant women with GDM (a singleton fetus), who had undergone regular pregnancy examination and have delivered a live-born baby. Women who had a history of adverse pregnancy outcomes or multiple pregnancies were excluded. The diagnostic criteria for GDM in the hospital were as follows: positive 75-g oral glucose tolerance test (OGTT) result in gestational Weeks 24–28 as described by the American Diabetes Association 2004 [12] and the Guidelines for Clinical Diagnosis and Treatment Recommendations for GDM (2007, Draft) promulgated in China during 2008–2011 [13–16]. The following cutoffs were observed: fasting plasma glucose (FPG), 5.3 mmol/L; 1-hour blood glucose (1hBG), 10 mmol/L; and 2-hour blood glucose (2hBG), 8.6 mmol/L. Patients with one item reaching or exceeding the above threshold values were diagnosed to have GDM. In 2012, the International Association of Diabetic Pregnancy Study Group 2010 and the professional standards for diagnosis of GDM issued by the Ministry of Health based on the American Diabetes Association 2011 were introduced in the hospital, and the following cutoffs were observed: FPG, 5.1 mmol/L; 1hBG, 10 mmol/L; and 2hBG, 8.5 mmol/L. Patients with at least one of these diagnostic factors reaching or exceeding the above threshold values were diagnosed with GDM.

Aside from the maternal monitoring records archived in the Medical Records room and the high-risk pregnancy documentation archived at the Department of Prevention and Healthcare, nutritional treatment records archived at the Department of Clinical Nutrition were also reviewed. Written informed consent for the use of health data for research purposes was obtained from all participants when they accepted the pregnancy monitoring. The study protocol has been revised by the Ethical Committee of China–Japan Friendship Hospital, and verbal consent was obtained from the patients (IRB 2015-110).

Management of high-risk pregnant women

The Department of Prevention and Healthcare keeps the files detailing the status and management of pregnant women with GDM and their fetuses. The documentation also tracks the incidence of common complications during pregnancy and their management (gestational hypertension, pregnancy vulvovaginal candidiasis, etc.), use of insulin during pregnancy, adverse pregnancy outcomes (preterm birth, premature rupture of membranes and amniotic fluid abnormalities, neonatal hypoglycemia, etc.), mode of delivery (cesarean section or vaginal delivery), birth weight, neonatal blood glucose levels, postpartum infant feeding, and OGTT reexamination results. A complete set of data was acquired, with missing data completed by consulting complementary medical records. Home visits or telephone follow-up interviews were conducted to identify data not available in the hospital.

Medical nutrition therapy

Pregnant women with GDM were routinely advised to receive MNT counseling in the associated Department of Clinical Nutrition and Obstetrics, where trained nutritionists provide individualized MNT programs for pregnant women with confirmed GDM. Nutritionists filled in the general prepregnancy record form upon the initial diagnosis of GDM and referral to them; these data included height, prepregnancy body weight, medical history and family history, and the prepregnancy body type {calculated as the prepregnancy body mass index (BMI) based on the 2002 standards issued by the Working Group on Obesity in China, International Life Science Institute [17]}. They also established daily energy requirements and calorie supply proportions of the three major nutrients in accordance with the *China Medical Nutrition Therapy Guideline for Diabetes (2010)* based on the prepregnancy body type, gestational age at the time of GDM diagnosis, increase in body weight during pregnancy, blood pressure, and lipid outcomes [11]. They then provided suggestions with regard to the type of food, specifically quantifying the recommended intake for each type of food. They also assisted in the selection of foods among similar food types via the “method of food exchange serving” to diversify the patients' diets while ensuring a balanced intake of all necessary nutrients. Finally, they suggested reasonably arranged meal times and foods in each meal based on blood glucose monitoring data, recommended staple foods with low glycemic index values, and emphasized eating many small meals to reduce each meal's glycemic load. Regular postprandial exercise was also recommended. Pregnant women were encouraged to obtain private fast blood glucose meters, kitchen scales, and body weight scales for self-monitoring of finger-prick blood glucose, food intake, and body weight at home. The monitoring forms (3 d/wk) focused on food contents in each meal, intake, fasting glucose, 2-hour postprandial blood glucose, and fasting body weight measured in the morning for timely adjustment of the therapy on follow-up appointments.

The first follow-up visit was scheduled within 2 weeks since the initial diagnosis of GDM and the start of MNT. Compliance was assessed based on the food diary. Further follow-up visits every 2–4 weeks were suggested depending on the patient's compliance. The monitoring form was to be filled in prior to each follow-up visit, and nutritionists assessed whether nutrient intake was appropriate and whether the body weight increase was reasonable based on the reported data.

Statistical analysis

All data were analyzed using the SPSS 17.0 software (SPSS Inc., Chicago, IL, USA). Rates were expressed as percentages and compared using the chi-square test. Cardinal data were expressed as mean ± standard deviation; comparisons among groups were performed with the t test or a nonparametric test depending on whether variances were equal. A p value < 0.05 was considered statistically significant. The chi-square test for trend was used to analyze the application situation of MNT, linear correlation analysis was used to analyze the relationship between body weight and OGTT results, and the chi-square test was used to analyze the impact of MNT on the course of pregnancy and pregnancy outcomes.

Results

Diagnosis of GDM and acceptance of MNT during 2008–2012

Data on 6350 pregnant women aged 21–44 years (mean age, 27.1 ± 4.7 years) were collected over the period 2008–2012. Their prepregnant BMI ranged from 18.3 kg/m^2 to 30.2 kg/m^2 (mean, 23.5 ± 1.5 kg/m^2). GDM was diagnosed among 488 of these women. This group had a mean age of 30.1 ± 4.1 years (range, 21–44 years), and their mean prepregnant BMI was 24.7 ± 3.0 kg/m^2 (range, 18.4–30.2 kg/m^2). The prepregnant BMI of the 5862 pregnant women with normal OGTT was 23.3 ± 1.2 kg/m^2 (range, 18.7–28.4 kg/m^2) and their mean age was 26.8 ± 4.6 years (range, 21–44 years). Both differences between the two groups were statistically significant ($t = 21.7$ and 9.7, respectively; both $p < 0.001$).

In 2008, 2009, 2010, 2011, and 2012, the prevalence of GDM among screened pregnant women was 5.7%, 5.5%, 7.9%, 9.0%, and 10.2%, respectively. MNT was respectively provided to 30.3%, 43.1%, 66.7%, 69.9%, and 80.7% of the women, indicating a statistically significant increasing trend (χ^2 trend = 8.19, $p < 0.01$; see Table 1).

Correlation between BMI and OGTT test results

Among the standard outcomes of the OGTT test, FBG and 1hBG were significantly correlated to body weight gain since the time of diagnosis (both correlation coefficients = 0.996; $p < 0.01$). The 2hBG level was correlated to prepregnant body weight, prepregnant BMI, and body weight at the time of diagnosis (correlation coefficients = 0.788, 0.854, and 0.785, respectively; all $p < 0.01$). A negative correlation was observed between 2hBG and body weight gain in the early stage of pregnancy (correlation coefficient −0.119; $p < 0.01$; Table 2).

Baseline characteristics of women diagnosed with GDM

Among the 488 pregnant women with GDM, 307 (62.9%) women received MNT. Table 3 shows the characteristics of the participants. There were no statistical differences observed between the MNT group and the non-MNT group in age, education level, occupation, monthly household income, pregnancy BMI, OGTT results, and gestational weeks and body weight of GDM diagnosis.

Impact of MNT on body weight change and blood glucose during pregnancy

The body weights of women from the two groups in the six time points were shown in Figure 1. The average body weight gain from the date of GDM diagnosis until 32 weeks gestational age was 1.2 ± 0.2 kg (range, 0.9–1.7 kg) among women accepting MNT, higher than that in the group of pregnant women not receiving MNT (−0.1 ± 1.5 kg; range, −2.0 to 2.0 kg), $t = -14.720$ ($p < 0.001$). The mean body weight gain of the group of pregnant women receiving MNT from the 32nd week to 36th week of pregnancy and from the 37th week of pregnancy to delivery were both 1.2 ± 0.2 kg (range, 0.9–1.7 kg), lower than that of the group not receiving MNT, where values of 2.9 ± 0.4 kg (range, 2.5–4.3 kg) and 2.3 ± 0.4 kg (range, 1.8–3.4 kg) were recorded. Both differences were statistically significant ($t = 64.634$ and 42.392, respectively; both $p < 0.001$.

The FBG, 1hBG, and 2hBG of the two groups of pregnant women at the time of diagnosis were not statistically significantly different. The FBG and 2hBG of the group of pregnant women receiving MNT in the 28th, 32nd, and 36th weeks of pregnancy and at delivery were lower compared with the group not receiving MNT (all $p < 0.001$; Figure 2).

Impact of MNT on pregnancy complications and pregnancy outcomes

The insulin usage, incidence of amniotic fluid abnormalities, rate of delivery by cesarean section, and frequency of fetal macrosomia were all lower in the group of pregnant women receiving MNT compared with the group not receiving MNT (all $p < 0.05$). No difference was found between the two groups with regard to gestational hypertension, vulvovaginal candidiasis, preterm birth,

Table 1
Proportion of GDM diagnoses among pregnant women and uptake of MNT for GDM from 2008 to 2012.

Year	GDM diagnosis			MNT attendance		
	N	Positive (%)	Negative (%)	N	Uptake (%)	No uptake (%)
2008	1157	66 (5.70)	1091 (94.30)	66	20 (30.30)	46 (69.70)
2009	1312	72 (5.49)	1240 (94.51)	72	31 (43.06)	41 (56.94)
2010	1295	102 (7.88)	1193 (92.12)	102	68 (66.67)	34 (33.33)
2011	1259	113 (8.98)	1033 (91.02)	113	79 (69.91)	34 (30.09)
2012	1327	135 (10.17)	1192 (89.83)	135	109 (80.74)	26 (19.26)
total	6350	488 (7.69)	5862 (92.31)	488	307 (62.91)	181 (37.09)
χ^2_{trend}	1.48			8.19		
p	0.139			<0.01		

Chi-square test for trend.
GDM = gestational diabetes mellitus; MNT = medical nutrition therapy.

Table 2
Linear correlation analysis between body weight and OGTT results ($N = 488$).

Body weight index	FPG (mmol/L)	1hBG (mmol/L)	2hBG (mmol/L)
Prepregnancy body weight (kg)	0.086	0.085	0.788**
Prepregnancy BMI (kg/m^2)	0.087	0.090*	0.854**
Body weight when diagnosed (kg)	0.083	0.084	0.785**
Gain in body weight when diagnosed with GDM (kg)	0.996**	0.996**	0.022
Gain in body weight at 12 wk gestation (kg)	−0.034	−0.039	−0.119**

Linear correlation analysis: *$p < 0.05$; **$p < 0.01$.
1hBG = 1-hour blood glucose; 2hBG = 2-hour blood glucose; BMI = body mass index; FPG = fasting plasma glucose; GDM = gestational diabetes mellitus; OGTT = oral glucose tolerance test.

Table 3
Baseline characteristics of participants ($N = 488$).

Variables	Statistics	MNT group ($n = 307$)	Non-MNT group ($n = 181$)	p
Age (y)	Mean ± SD	32.0 ± 4.3	31.6 ± 4.3	0.267[a]
	Range	21–44	21–41	
Education level, n (%)	High	233 (75.90)	149 (82.32)	0.230[b]
	Middle	45 (14.66)	18 (9.94)	
	low	29 (9.45)	14 (7.73)	
Occupation, n (%)	Mental	169 (55.05)	103 (56.91)	0.909[b]
	Manual	53 (17.26)	29 (16.02)	
	Home	85 (27.69)	49 (27.07)	
Household monthly income, n (%)	<2500 RMB	32 (10.42)	13 (7.18)	0.232[b]
	≥2500 RMB	275 (89.58)	168 (92.82)	
Pregnancy status				
BMI (kg/m^2)	Mean ± SD	25.9 ± 4.4	25.5 ± 4.3	0.361[a]
	Range	18.4–33.7	18.4–33.3	
Body weight (kg)	Mean ± SD	66.2 ± 12.7	65.2 ± 12.4	0.402[a]
	Range	41.1–96.6	43.1–96.6	
Gestational weeks of GDM diagnosis	Mean ± SD	25.0 ± 1.3	25.2 ± 1.4	0.454[c]
	Range	24–28	24–28	
OGTT results				
FPG (mmol/L)	Mean ± SD	7.54 ± 1.42	7.62 ± 1.48	0.549[a]
	Range	4.80–10.37	4.66–10.13	
1hBG (mmol/L)	Mean ± SD	13.05 ± 1.92	13.15 ± 2.03	0.555[a]
	Range	10.00–17.13	10.10–16.67	
2hBG (mmol/L)	Mean ± SD	10.16 ± 1.30	10.03 ± 1.12	0.265[a]
	Range	8.50–14.42	8.20–13.93	
Body weight of GDM diagnosis	Mean ± SD	75.7 ± 12.7	74.8 ± 12.3	0.460[a]
	Range	48.9–107.7	53.0–107.3	
Weight gain of GDM diagnosis	Mean ± SD	9.5 ± 2.1	9.6 ± 2.2	0. 562[a]
	Range	6.0–13.7	6.2–13.5	

1hBG = 1-hour blood glucose; 2hBG = 2-hour blood glucose; BMI = body mass index; FPG = fasting plasma glucose; GDM = gestational diabetes mellitus; MNT = medical nutrition therapy; OGTT = oral glucose tolerance test; SD = standard deviation.
[a] Student t test.
[b] Chi-square test.
[c] Mann–Whitney test.

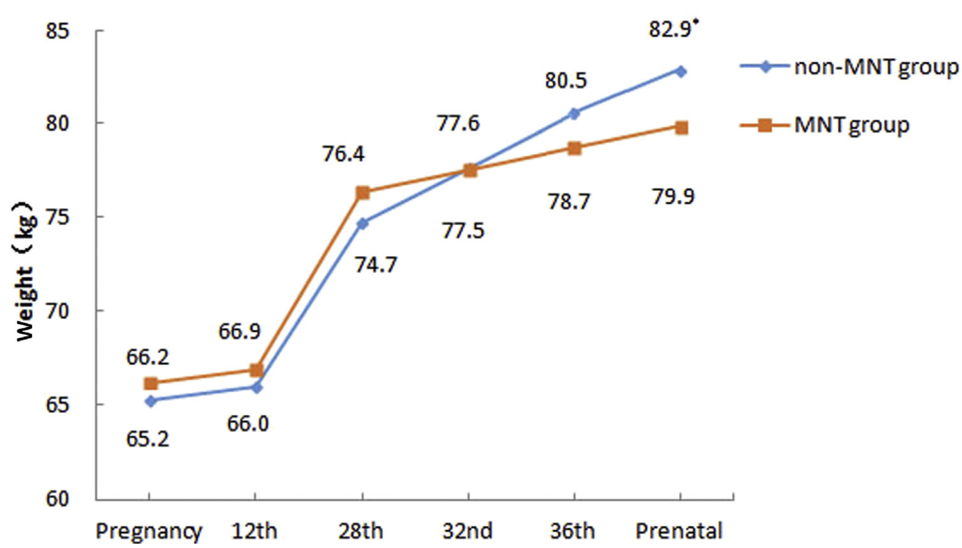

Figure 1. Weight change of pregnant women with GDM. * $p < 0.05$, weight between the two groups. GDM = gestational diabetes mellitus; MNT = medical nutrition therapy.

premature rupture of membranes, and neonatal hypoglycemia (all $p > 0.05$; Table 4).

Impact of MNT on postpartum infant feeding

The rate of exclusive breastfeeding within 4 months after delivery was 54.4% among women receiving MNT, higher than that in the group not receiving MNT (29.3%, $p < 0.05$).

Impact of MNT on postpartum prognosis

Among the 488 pregnant women with GDM, only 125 women underwent a 75-g OGTT reexamination within 6–12 weeks after delivery. Overall, 98 women underwent a 75-g OGTT reexamination test within 6 months since delivery, and 265 women underwent the 75-g OGTT reexamination within 12 months since delivery. Overall, 92.2% of the group of pregnant women receiving MNT had

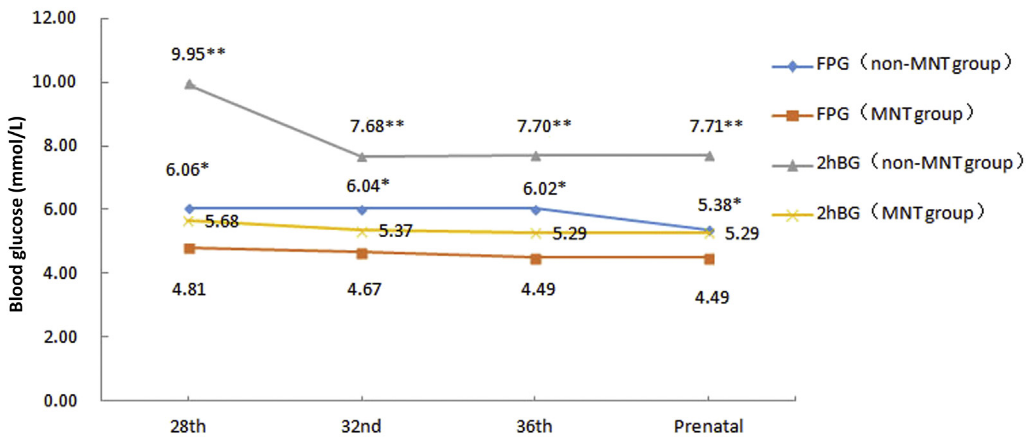

Figure 2. Changes in blood glucose of pregnant women with GDM. * $p < 0.001$, FPG between the two groups. ** $p < 0.001$, 2hBG between the two groups. 2hBG = 2-hour blood glucose; FPG = fasting plasma glucose; GDM = gestational diabetes mellitus; MNT = medical nutrition therapy.

Table 4
Impact of MNT on the course of pregnancy and pregnancy outcomes ($N = 488$).

Group		MNT (307)	Non-MNT (181)	χ^2	*p*
PIH	Yes	23 (7.49)	12 (6.63)	0.13	0.72
	No	284 (92.51)	169 (93.37)		
VC	Yes	7 (2.28)	4 (2.21)	0.003	0.96
	No	300 (97.72)	177 (97.79)		
Insulin	Yes	63 (20.25)	77 (42.54)	26.99	<0.001
	No	244 (79.48)	104 (57.46)		
Abnormal amniotic fluid	Yes	31 (10.10)	33 (18.23)	6.61	0.01
	No	276 (89.90)	148 (81.77)		
Premature birth	Yes	5 (1.63)	4 (2.21)	0.21	0.65
	No	302 (98.37)	177 (97.79)		
PPROM	Yes	25 (8.14)	24 (13.26)	3.30	0.07
	No	282 (91.86)	157 (86.74)		
Cesarean section	Yes	106 (34.53)	116 (64.09)	40.13	<0.001
	No	201 (65.47)	15 (8.29)		
Macrosomia	Yes	30 (9.77)	50 (27.62)	26.48	<0.001
	No	277 (90.23)	131 (72.38)		
Neonates hypoglycemia	Yes	7 (2.28)	9 (4.97)	2.60	0.11
	No	300 (97.72)	172 (10.61)		

MNT = medical nutrition therapy; PIH = pregnancy induced hypertension syndrome; PPROM = preterm premature rupture of the membranes; VC = vaginal candidiasis.

a normal result, which is higher compared with the group not receiving MNT (66.30%; $p < 0.001$).

Discussion

GDM is one of the most common medical complications during pregnancy. Given both the constant increase in the prevalence of obesity and gestational age and the less stringent diagnostic criteria for GDM, the incidence of GDM has steadily increased in recent years [18]. BMI is an important indicator of the nutritional status, and a higher prepregnant BMI is a risk factor for metabolic abnormalities during pregnancy, among which GDM is the most common [19]. A study by Chan [20] and Ryan [21] also found that pregnant women with excessive body weight gain during pregnancy were at an elevated risk of developing GDM, and that there is a strong correlation between excessive body weight gain during pregnancy and the maternal blood glucose level. Prenatal care for GDM includes MNT, exercise, medication, and blood glucose monitoring. MNT is essential for other treatments, and “individualized nutrition therapy” by nutrition professionals is recommended for pregnant women with GDM. The Evidence-Based Nutrition Practice Guidelines for GDM developed by the American Dietetic Association in 2008 provides the evidentiary basis for nutritional management of pregnant women with GDM [22]. The *China Medical Nutrition Therapy Guideline for Diabetes 2010*, the first guideline for diabetes management in China, is a normative guideline for MNT. Pregnant women who are diagnosed to have GDM in the gestational screening should receive MNT as early as possible to reduce the burden of the pancreas, improve the sensitivity of target tissues to insulin, and enhance its binding with insulin to maintain blood glucose at normal levels, while ensuring the physiological needs of pregnant women and the normal growth and development of the fetuses [23–25].

The incidence of GDM in the hospital where the study was performed has reached 10.2% in the review last year, which was close to the estimate made by Shang and Lin [13]. Globally, the estimated prevalence ranges from 1% to 14% of all pregnancies, depending on the population being studied and the diagnostic tests used. Approximately 6–7% of all pregnancies are complicated by GDM in China, translating into 1,200,000–1,400,000 cases annually. Once GDM has been diagnosed, women frequently go on an overly strict diet owing to a lack of awareness of GDM treatment options and a common fear of insulin. This often leads to inadequate energy intake, negative body weight growth, and other undesirable outcomes that are not conducive to fetal growth and development. As a consequence of insufficient body weight gain, these women then commonly increase food intake in the third trimester, resulting in adverse pregnancy outcomes. Our study also found that pregnant women who did not receive MNT temporarily had negative body weight growth after being diagnosed with GDM, followed by their body weight rebounding. Among them, 42.5% used insulin to control blood glucose levels. The essence of the “individualized treatment” advocated by MNT is to adjust energy intake to individual needs and reasonably arrange meals based on body weight and dynamic changes in blood glucose during pregnancy so as to balance blood glucose and ensure the safety and good health of the mother and the fetus [26–28]. Our study also found that reasonable and effective MNT can control and steady the body weight gain each week from diagnosis to delivery. The mean weekly weight gain of the group of 307 pregnant women receiving MNT was controlled within 0.3 ± 0.1 kg; meanwhile, in the group of 181 pregnant women not receiving MNT, 86 had a significant negative body weight growth from the date of diagnosis to the 32nd week, 26 had zero weight growth, and 69 had continued weight growth after the 32nd week, with an mean weight gain of 0.8 ± 0.2 kg/wk, exceeding the weight gain requirements prescribed by the guideline (0.3–0.5 kg/wk).

Unreasonable weight gain during pregnancy adversely affects pregnancy outcomes [29]. According to our results, MNT can effectively reduce the usage of insulin during pregnancy and the incidence of amniotic fluid abnormalities, cesarean delivery, and huge fetus, which is consistent with previous reports [30]. Women of childbearing age should be prepared to adjust prepregnant weight, and perinatal care physicians should tighten the management of their weight gain during pregnancy. Enhanced and individualized nutritional guidance for high-risk groups such as pregnant women who are underweight or overweight prior to pregnancy is key to reducing the risk of adverse pregnancy outcomes. MNT, as a special lifestyle intervention, is easy to understand but difficult to implement. This is because unlike a general medication or surgical treatment, nutrition therapy needs the involvement of both physicians and patients and timely adjustment based on the effect of its implementation [31,32].

China has recently raised the nutritional requirements of pregnant women to the policy level. The following suggestions have also been made: (1) hospitals should offer outpatient pregnancy nutrition surveillance as early nutrition interventions in pregnancy and personalized nutrition therapy can optimize diets; (2) hospitals should routinely conduct pregnancy nutrition surveillance; (3) extensive nutrition and health education should be offered in hospitals and communities, such as "fetal university," "mom class," and "Mummy Kitchen," to actively promote adequate nutrition and health awareness as well as self-management capabilities for pregnant women and their families, guide their food choices, and support reasonable weight management. In the case of the hospital where the present study had been conducted, pregnancy outpatient services and "mom classes" had been established in 2008 to offer individual and group education for women with GDM. Some problems arose in practice, including a lack of dietitians and appropriate outpatient units, an underappreciation of the time needs of individualized therapy, and little understanding and appreciation of MNT by pregnant women and their families, which means that some pregnant women with GDM do not seek medical treatment at all or receive inappropriate care, resulting in 37.1% of all pregnant women with GDM not receiving MNT during the 5-year study period.

Conflicts of interest

The authors have no conflicts of interest relevant to this article.

Acknowledgments

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References

[1] Poomalar GK. Changing trends in management of gestational diabetes mellitus. World J Diabetes 2015;6:284–95.
[2] Peng S, Zhang J, Liu L, Zhang X, Huang Q, Alamdar A, et al. Newborn meconium and urinary metabolome response to maternal gestational diabetes mellitus: a preliminary case-control study. J Proteome Res 2015;14:1799–809.
[3] Song Y, Yang H. Clinical use of continuous glucose monitoring system in gestational diabetes mellitus and type 2 diabetes complicated with pregnancy. Zhonghua Fu Chan Ke Za Zhi 2014;49:579–83.
[4] Bellamy L, Casas JP, Hingorani AD, Williams D. Type 2 diabetes mellitus after gestational diabetes: a systematic review and meta-analysis. Lancet 2009;373:1773–9.
[5] Mendez-Figueroa H, Dahlke JD, Daley J, Lopes VV, Coustan DR. Prediction of abnormal postpartum glucose tolerance testing in mild gestational diabetes mellitus. J Reprod Med 2014;59:393–400.
[6] Khalil A, Garcia-Mandujano R, Chiriac R, Akolekar R, Nicolaides KH. Maternal hemodynamics at 11–13 weeks' gestation in gestational diabetes mellitus. Fetal Diagn Ther 2012;31:216–20.
[7] Metzger BE, Buchanan TA, Coustan DR, Leiva A, Dunger DB, Hadden DR, et al. Summary and recommendations of the Fifth International Workshop–Conference on Gestational Diabetes Mellitus. Diabetes Care 2007;30:S251–60.
[8] Moses RG, Brand-Miller JC. Dietary risk factors for gestational diabetes mellitus: are sugar-sweetened soft drinks culpable or guilty by association? Diabetes Care 2009;32:2314–5.
[9] Kim SH, Kim MY, Yang JH, Park SY, Yim CH, Han KO, et al. Nutritional risk factors of early development of postpartum prediabetes and diabetes in women with gestational diabetes mellitus. Nutrition 2011;27:782–8.
[10] Behboudi-Gandevani S, Safary K, Moghaddam-Banaem L, Lamyian M, Goshtasebi A, Alian-Moghaddam N. The relationship between maternal serum iron and zinc levels and their nutritional intakes in early pregnancy with gestational diabetes. Biol Trace Elem Res 2013;154:7–13.
[11] Chinese Medical Association Diabetes Society. Chinese type 2 diabetes prevention and treatment guidelines (2010). Chin J Diabetes 2012;20:S1–39 [in Chinese].
[12] American Diabetes Association. Gestational diabetes mellitus. Diabetes Care 2003;26:S103–5.
[13] Shang M, Lin L. IADPSG criteria for diagnosing gestational diabetes mellitus and predicting adverse pregnancy outcomes. J Perinatol 2014;34:100–4.
[14] Pedersen ML, Jacobsen JL, Jorgensen ME. Prevalence of gestational diabetes mellitus among women born in Greenland: measuring the effectiveness of the current screening procedure. Int J Circumpolar Health 2010;69:352–60.
[15] Karcaaltincaba D, Altinbas S, Akyol M, Ensari T, Yalvac S. The relationship between markedly elevated glucose challenge test results and the rate of gestational diabetes mellitus and gestational impaired glucose tolerance. Ann Saudi Med 2012;32:391–6.
[16] Anderwald C, Tura A, Winhofer Y, Krebs M, Winzer C, Bischof MG, et al. Glucose absorption in gestational diabetes mellitus during an oral glucose tolerance test. Diabetes Care 2011;34:1475–80.
[17] Yang W, Lu J, Weng J, Jia W, Ji L, Xiao J, et al. Prevalence of diabetes among men and women in China. N Engl J Med 2010;362:1090–101.
[18] Lagerros YT, Cnattinqius S, Granath F, Hanson U, Wikstrom AK. From infancy to pregnancy: birth weight, body mass index, and the risk of gestational diabetes. Eur J Epidemiol 2012;27:799–805.
[19] Yeung EH, Hu FB, Solomon CG, Chen L, Louis GM, Schisterman E, et al. Life-course weight characteristics and the risk of gestational diabetes. Diabetologia 2010;53:668–78.
[20] Chan BC, Lao TT. Gestational diabetes mellitus in women in the fourth decade—is treatment worthwhile? Gynecol Obstet Invest 2005;60:112–6.
[21] Ryan EA. Clinical diagnosis of gestational diabetes. J Clin Obstet Gynecol 2013;56:774–87.
[22] Feig DS, Zinman B, Wang X, Hux JE. Risk of development of diabetes mellitus after diagnosis of gestational diabetes. CMAJ 2008;179:229–34.
[23] Perucchini D, Fischer U, Spinas GA, Huch R, Huch A, Lehmann R. Using fasting plasma glucose concentrations to screen for gestational diabetes mellitus: prospective population based study. BMJ 1999;319:812–5.
[24] Seghieri G, Tesi F, Anichini R, De Bellis A, Barsotti E, Mari A, et al. Influence of gestational diabetes on the long-term control of glucose tolerance. Diabetologia 2007;50:2234–8.
[25] Forbes S, Godsland IF, Taylor-Robinson SD, Bell JD, Thomas EL, Patel N, et al. A history of previous gestational diabetes mellitus is associated with adverse changes in insulin secretion and VLDL metabolism independently of increased intrahepatocellular lipid. Diabetologia 2013;56:2021–33.
[26] Nehring I, Chmitorz A, Reulen H, Kries R, Ensenauer R. Gestational diabetes predicts the risk of childhood overweight and abdominal circumference independent of maternal obesity. Diabet Med 2013;30:1449–56.
[27] Ziegler AG, Wallner M, Kaiser I, Rossbauer M, Harsunen MH, Lachmann L, et al. Long-term protective effect of lactation on the development of type 2 diabetes in women with recent gestational diabetes mellitus. Diabetes 2012;61:3167–71.
[28] Egeland GM, Meltzer SJ. Following in mother's footsteps? Mother–daughter risks for insulin resistance and cardiovascular disease 15 years after gestational diabetes. Diabet Med 2010;27:257–65.
[29] Baptiste-Roberts K, Nicholson WK, Wang NY, Brancati FL. Gestational diabetes and subsequent growth patterns of offspring: the National Collaborative Perinatal Project. Matern Child Health J 2012;16:125–32.
[30] Russo LM, Nobles C, Ertel KA, Chasan-Taber L, Whitcomb BW. Physical activity interventions in pregnancy and risk of gestational diabetes mellitus: a systematic review and meta-analysis. Obstet Gynecol 2015;125:576–82.
[31] Patel S, Fraser A, Davey Smith G, Lindsay RS, Sattar N, Nelson SM, et al. Associations of gestational diabetes, existing diabetes, and glycosuria with offspring obesity and cardiometabolic outcomes. Diabetes Care 2012;35:63–71.
[32] Romon M, Nuttens MC, Vamberque A, Verier-Mine O, Biausque S, Lemaire C, et al. Higher carbohydrate intake is associated with decreased incidence of newborn macrosomia in women with gestational diabetes. J Am Diet Assoc 2001;101:897–902.