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Analysis of the Application Effectiveness of the Pregnancy Dietary Compliance Index Scoring Tool

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Abstract: This study aims to conduct a dietary index score assessment for individuals with high-risk factors for gestational hyperglycemia (such as overweight, obesity, family history of diabetes, history of macrosomia, and gestational diabetes mellitus), starting from early pregnancy, and to provide personalized nutrition management based on the score to reduce pregnancy complications and adverse pregnancy outcomes. A total of 194 pregnant women who underwent routine prenatal examinations at our hospital from September 2022 to September 2023 were selected. They were randomly divided into a study group and a control group, with 97 cases in each group. The control group received simple nutritional guidance, mainly focusing on the requirements for various nutrients and nutritional supplements during each trimester. The study group received nutrition guidance based on the dietary index score, as well as personalized guidance on health education, weight management, pregnancy exercise, and lifestyle. The incidence of gestational diabetes mellitus in the intervention group was significantly lower than that in the control group, and the difference was statistically significant ($P< 0.05$). The incidence of macrosomia was 1.03% in the intervention group and 8.25% in the control group, with a statistically significant difference ($P< 0.05$). The incidence of small-for-gestational-age infants was 2.06% in the intervention group and 10.31% in the control group, with a statistically significant difference ($P< 0.05$). For pregnant women with high-risk factors, early pregnancy nutrition management based on the dietary compliance index score can quickly screen for nutritional risks and provide targeted personalized nutrition management, thereby reducing the risk of pregnancy complications and adverse pregnancy outcomes and promoting the health of mothers and infants during pregnancy.

Keywords: Dietary index scoring; Personalized nutrition management; Reduction; Pregnancy complications; Adverse pregnancy outcomes

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1. Introduction

Pregnancy is a special period that most women may experience, during which pregnant women are influenced by the fetus, hormone secretion, and overweight or obesity. Additionally, factors such as improper diet, irregular

lifestyle, and hormonal fluctuations can lead to abnormal blood sugar levels, often resulting in gestational hyperglycemia and excessive weight gain during pregnancy, thereby causing the birth of macrosomic infants. Gestational hyperglycemia is a common complication that occurs in women after pregnancy, with a noticeable increase in recent years. Its main risks include macrosomia, premature rupture of membranes, premature birth, and concurrent pregnancy-induced hypertension. Macrosomic infants are prone to hypoglycemia and hyperbilirubinemia after birth, which severely affects the health of both mother and fetus.

According to existing research, factors contributing to macrosomia during pregnancy are associated with genetics, parity, excessive weight gain during pregnancy, lack of exercise, poor control of gestational blood sugar, and overdue pregnancy. Studies have shown that the most effective methods for preventing and managing macrosomia involve rational calorie intake, adjusting dietary structure, moderate and regular exercise, and maintaining a healthy lifestyle [1]. Among these, personalized management (including dietary and exercise guidance, health education, and lifestyle interventions) has been proven to be the most effective approach. This study targeted individuals in the early stages of pregnancy who had high-risk factors for hyperglycemia, such as a body mass index (BMI) > 24, early pregnancy blood sugar > 5.1 mmol/L, obesity, family history of diabetes, previous history of gestational diabetes, and history of macrosomic delivery. These individuals voluntarily participated in different modes of nutritional management, and ultimately achieved favorable outcomes. Herein, the following part summarizes the research findings.

2. Materials and methods

2.1. General information

A total of 194 pregnant women undergoing routine antenatal examinations at our hospital from September 2022 to September 2023 were selected, with 97 allocated to the intervention group and 97 to the control group. Each pregnant woman provided informed consent. This study was approved by the Ethics Committee of Danyang Maternal and Child Health Hospital, with approval number 0020.

2.2. Inclusion and exclusion criteria

2.2.1. Inclusion criteria

(1) Gestational age less than 14 weeks;
(2) Presence of high-risk factors for gestational diabetes without pre-existing diabetes;
(3) Singleton pregnancy;
(4) Absence of primary hypertension, preeclampsia, renal diseases, hyperthyroidism, tumors, and other conditions;
(5) Volunteers participating in this survey provided informed consent.

2.2.2. Exclusion criteria

(1) Gestational age ≥ 14 weeks;
(2) Lack of data on fasting plasma glucose (FPG) or 75 g oral glucose tolerance test;
(3) Multiple pregnancies.

2.3. Intervention methods

2.3.1. Personalized nutrition management

The control group received routine prenatal nutrition guidance, mainly focusing on advising the requirements for various nutrients and nutritional supplements during pregnancy. The research group underwent personalized

precision nutrition management according to the nutrition plan developed by a nutritionist. In addition to dietary guidance, personalized guidance was also provided on aspects such as early and mid-term pregnancy dietary index scoring, disease health education, exercise, and lifestyle. The specific methods were as follows:

(1) Conducting investigations on the diet of pregnant women using dietary index scoring and a 3-day 24-hour dietary recall, with detailed records of the medical history and laboratory tests of pregnant women. Based on the actual situation of pregnant women and combined with the dietary index scoring (total score and core score), targeted dietary arrangements and recommendations were made [2]. This evaluation system is based on the principles of prenatal nutrition in the "Dietary Guidelines for Chinese Residents (2022)" [3], with 13 dietary survey questions and a total score of 100 points, including 5 core questions. The evaluation system employs a dual scoring system, namely total score and core score, with different scoring weights. There are slight differences between early and mid-to-late pregnancy. The index used in this study was revised based on the "Chinese Dietary Guidelines for Pregnant Women (2022)" [3], whereas the index applied by Professor Wang Zhixu and others from Nanjing Medical University in existing literature was based on the "Chinese Dietary Guidelines for Pregnant Women (2016)".

The "Chinese Dietary Guidelines for Pregnant Women (2022)" recommends consuming more than 12 types of food per day on average, and over 25 types per week. Therefore, in the scoring standards for pregnancy, this paper revised the minimum and maximum score criteria for the first and second questions. The guidelines suggest that pregnant women in early pregnancy should consume a total of 150 g of fish, poultry, lean meat, and eggs per day. Therefore, in the scoring standard for early pregnancy, this study revised the originally recommended 100 g to 150 g. The guidelines recommend that pregnant women in mid-pregnancy should consume a total of 150–200 g of fish, poultry, lean meat, and eggs per day, and in late pregnancy 175–225 g. Therefore, in the scoring standard for mid-to-late pregnancy, the study revised the originally recommended 175 g for both mid and late pregnancy to 150–200 g for mid-pregnancy and 175–225 g for late pregnancy. There are a total of 13 questions, with a response time of 5–10 minutes under the guidance of professionals, which is simple, intuitive, and convenient to operate. Targeted nutritional guidance is provided based on the compliance index scores of pregnant women to improve their awareness of diseases and nutritional deficiencies, strengthen their compliance, and enhance their execution.

(2) Calculate pre-pregnancy BMI, where BMI = weight (kg) / height (m^2); Calculate daily total energy according to height and BMI.

(3) Carbohydrates account for 45–60% of daily energy intake, protein 15–20%, and fat 25–30%. Energy supply for breakfast, lunch, and dinner is 10–15%, 30%, and 30%, with snacks contributing 5–10%. Energy distribution for meals is divided into 5–6 meals per day.

(4) Regular follow-up visits were conducted for enrolled pregnant women, including monitoring of weight gain, fetal development, changes in psychological status, pregnancy complications, and pregnancy outcomes.

2.3.2. Exercise and lifestyle guidance

(1) Exercise guidance is one of the components of personalized nutrition management. The intensity of exercise includes moderate-intensity aerobic exercises (such as brisk walking, prenatal exercises, prenatal yoga, etc.), combined with resistance training (such as lifting dumbbells, using resistance bands, etc.). The criteria for judging exercise intensity are:

(a) Being able to talk during exercise but unable to sing normally, and not exceeding the maximum heart rate (maximum heart rate = 170 - age);

(b) Frequency and duration of exercise: Exercising for half an hour after each meal, starting from 10

minutes and gradually increasing to 30 minutes;

(c) Appropriate assessment of exercise volume: Slight sweating after exercise, heart rate < maximum heart rate, and no discomfort. If frequent uterine contractions, fetal movements, vaginal bleeding, or other discomfort occur during exercise, it is necessary to stop exercising immediately.

(2) Educate them to develop good lifestyle habits, avoid staying up late, maintain regular schedules, and go to bed and wake up early.

2.4. Observation indicators

Observation indicators are divided into two parts: pregnancy nutrition indicators and delivery indicators.

(1) Pregnancy nutrition indicators: Fasting blood glucose, glycated hemoglobin, total cholesterol, triglycerides, low-density lipoprotein cholesterol, and high-density lipoprotein cholesterol are tested in early, middle, and late pregnancy. A 75 g oral glucose tolerance test (OGTT) is conducted during gestational weeks 22 to 28. The diagnostic criteria for gestational diabetes mellitus (GDM) are fasting and 1-hour and 2-hour postprandial blood glucose levels of 5.1, 10.0, and 8.5 mmol/L, respectively, during the 75 g OGTT [4]. Any value reaching or exceeding these standards is diagnosed as GDM.

(2) Delivery indicators: The delivery method and newborn weight are recorded. Newborns weighing more than 4 000 g are classified as macrosomic infants, while newborns with birth weights below the 10^{th} percentile of average birth weight for the same gestational age or below 2 standard deviations from the mean birth weight for the same gestational age are classified as small-for-gestational-age infants.

2.5. Statistical analysis

This study established a database using EPIDATA 3.02 software after double-entry verification and used SPSS 24.0 software for statistical analysis. The significance level was set at $\alpha = 0.05$, with $P < 0.05$, indicating statistically significant differences. When the data fits in the normal distribution, continuous variables were described using: Mean ± standard deviation (SD), and the independent samples *t*-test was used to compare differences between groups. Categorical variables were described using rates or composition ratios, and the chi-square test was used to compare differences between groups. When the data did not satisfy normal distribution, continuous variables were described using M (P25, P75), and the Mann-Whitney U test was used to compare differences between groups. Categorical variables were described using rates or composition ratios, and the chi-square test was used to compare differences between groups.

2.6. Ethics approval and consent to participate

The study was carried out in accordance with the Helsinki Declaration principles and was approved by the Ethics Committee of Danyang Maternal and Child Health Hospital (0020). Informed consent was obtained from all subjects involved in the study.

2.7. Consent for publication

All authors agreed to publish the article in the Archives of Gynecology and Obstetrics. Written informed consent has been obtained from the patients to publish this paper.

3. Result

3.1. Basic characteristics of the two groups of pregnant women

The ages of the two groups of pregnant women ranged from 17 to 44 years old, with no statistically significant

differences in mean age or BMI between the control group and the intervention group ($P > 0.05$), indicating comparability. Specific details are shown in **Table 1**.

Table 1 Comparison of basic conditions of pregnant women in two groups

Group	*n*	Age	BMI (kg/m^2)
Control	97	29.10 ± 5.01	23.09 ± 3.76
Intervention	97	28.37 ± 4.13	22.48 ± 3.90
t-value		1.11	1.11
*P**-value		0.27	0.27

* Level of significance ≤ 0.05

3.2. Comparison of nutritional indicators in early, middle, and late pregnancy among two groups of pregnant women

The study showed statistically significant differences ($P < 0.05$) in 1-hour and 2-hour blood glucose levels during the second trimester between two groups of pregnant women, as detailed in **Table 2**. Additionally, there were significant differences ($P < 0.05$) in the incidence of gestational diabetes mellitus between the intervention and the control group, as presented in **Table 3**.

Table 2 Comparison of nutrition-related biochemical indexes in early, middle and late pregnancy between the two groups

	Intervention		Control		*t*-value	*P**-value
	Mean	SD	Mean	SD		
First trimester						
FPG	4.75	0.50	4.78	0.62	0.41	0.68
HbA1c	5.16	0.38	5.22	0.63	0.79	0.43
TC	4.14	0.74	4.05	0.80	-0.82	0.41
TG	1.33	1.09	1.24	0.55	-0.71	0.48
HDL	1.81	2.09	1.63	0.32	-0.84	0.41
LDL	2.26	0.54	2.20	0.65	-0.68	0.50
Hb	129.28	10.72	131.71	12.25	-1.47	0.14
Second trimester						
FPG	4.82	0.41	4.86	0.49	0.61	0.54
1-hour post-load plasma glucose	7.60	1.70	8.22	2.13	2.24	0.03
2-hour post-load plasma glucose	6.58	1.34	7.06	1.76	2.14	0.03
HB	113.81	18.69	115.61	18.71	0.67	0.50
GWG	6.42	3.55	7.03	3.82	1.15	0.25
HbA1c	4.76	0.38	4.78	0.41	0.24	0.81
TC	6.33	1.01	6.17	1.12	-1.01	0.31
TG	2.55	0.85	2.57	0.81	0.17	0.88
HDL	1.71	0.32	1.72	0.33	0.19	0.85
LDL	3.46	0.78	3.31	0.87	-1.24	0.22

Table 2 (Continued)

	Intervention		Control		*t*-value	*P**-value
	Mean	SD	Mean	SD		
Third trimester						
FPG	4.59	0.44	4.69	0.44	1.51	0.13
HbA1c	4.86	0.46	4.89	0.43	0.39	0.70
TC	6.45	1.06	6.48	1.20	0.17	0.86
TG	3.17	0.97	3.13	0.98	-0.25	0.80
HDL	1.63	0.32	1.68	0.31	1.12	0.26
LDL	3.67	0.89	3.80	2.19	0.55	0.59
HB	119.59	8.63	119.10	9.56	-0.37	0.71
Gestational age at delivery	39.37	0.83	39.18	1.26	-1.28	0.20

*Level of significance ≤ 0.05

FPG, Fasting Plasma Glucose; HbA1c, Hemoglobin A1c; TC, Total Cholesterol; TG, Triglyceride; HDL, High Density Lipoprotein; LDL, Low Density Lipoprotein; HB, Hemoglobin; GWG, Gestational Weight Gain

Table 3. Comparison of diagnosis of gestational diabetes in the second trimester between the two groups

GDM	Intervention	Control	*P**-value
No	66	48	0.009
Yes	31	49	

* Level of significance ≤ 0.05

3.3. Comparison of delivery methods and macrosomia between the two groups

In terms of delivery methods, in the intervention group, 34.5% underwent cesarean section without indication, while the rest had cesarean section with indications such as uterine scar, macrosomia, fetal distress, placenta previa, failed induction, etc. In the control group, 30.90% of pregnant women had cesarean section without indication, and the rest had cesarean section with indications. In the intervention group, 43.30% of pregnant women had a vaginal delivery, while in the control group, 43.30% of pregnant women had a vaginal delivery. The difference between the two groups was not statistically significant ($P > 0.05$). Additionally, there was a difference in the occurrence of macrosomia between the two groups, with a rate of 1.03% in the intervention group and 8.25% in the control group. This difference was statistically significant ($P < 0.05$). Refer to **Table 4**.

Table 4 Comparison of delivery modes and macrosomia between the two groups

	Intervention	Control	*P**-value
Delivery method			
Cesarean delivery	54	53	
Normal vaginal delivery	42	42	0.840
Emergency cesarean section	1	2	
Macrosomia			
Yes	1	8	0.041
No	96	89	

*Level of significance ≤ 0.05

3.4. Comparison of small gestational age infants between the two groups

Small for gestational age (SGA) is defined as newborns whose birth weight is below the 10th percentile of the average weight for the same gestational age or below 2 standard deviations from the mean weight for the same gestational age. The results indicate a significant and statistically meaningful difference in the incidence of premature infants between the intervention and control groups ($P< 0.05$). Refer to **Table 5**.

Table 5 Comparison of small delivery for gestational age between the two groups

SGA	Intervention	Control	*P**-value
No	95	87	0.017
Yes	2	10	

*Level of significance ≤ 0.05

4. Discussion

Currently, the incidence of macrosomia is continuously increasing, posing risks to maternal health and safety during childbirth, as well as increasing the risk of dystocia, thereby posing significant threats to the health of fetuses and newborns. However, the exact mechanism underlying macrosomia remains incompletely elucidated. Existing research indicates a close association between the occurrence of macrosomia and maternal factors such as age, parity, diabetes mellitus, BMI, and nutritional status during pregnancy [5-7]. Moreover, excessive maternal nutrient intake during pregnancy is identified as a significant contributing factor to the increased risk of macrosomia, with excessive maternal weight gain during pregnancy being closely correlated with its occurrence [8-10]. It has been found that macrosomia is a major adverse outcome of GDM, with 5% of newborns from GDM pregnancies being diagnosed as macrosomic infants. The underlying mechanism may involve prolonged exposure of the fetus to hyperglycemia, leading to hyperinsulinemia and subsequent fetal overgrowth. Studies have demonstrated decreased insulin secretion in women with GDM, which impairs the inhibition of fat breakdown and synthesis, exacerbating metabolic abnormalities and leading to fetal metabolic dysregulation [11-13].

The results of this study indicate that precise nutritional interventions throughout the entire pregnancy period for women in the intervention group resulted in significantly decreased 1-hour and 2-hour blood glucose levels during the glucose tolerance test compared to the control group. The incidence of GDM was markedly lower in the intervention group compared to the control group, and likewise, the occurrence of macrosomia was significantly reduced in the intervention group. Therefore, individualized nutritional management for pregnant women from early pregnancy appears to be an effective approach in preventing GDM and macrosomia. Additionally, this study conducted statistical analysis on premature births and found a significant difference between the two groups, with a lower incidence of premature births in the intervention group, possibly attributed to the influence of the intervention factors.

From the perspective of this study's findings, individualized nutritional management during pregnancy does not exhibit statistically significant differences in the mode of delivery for pregnant women. This may be due to an increasing number of pregnant women with advanced age and high-risk factors, wherein a proportion of these women opt for cesarean section due to the perceived risks associated with vaginal delivery. Fear of childbirth and concerns about the risks involved in the process of vaginal delivery lead some women to firmly choose cesarean section. Furthermore, a few women may opt for cesarean section due to difficulties in vaginal delivery caused by excessive maternal weight gain during pregnancy. The proportion of vaginal deliveries converted to cesarean section in this study was relatively low, with one case in the intervention group and

two cases in the control group. Future efforts should focus on enhancing the dissemination of knowledge on childbirth and improving weight management to enhance compliance and conduct further research.

5. Conclusion

Individualized nutritional management for high-risk pregnant women from early pregnancy, combined with targeted nutritional guidance using the Dietary Guidelines Adherence Index (DGAI), can reduce the risk of pregnancy-related complications such as GDM and further decrease the occurrence of macrosomia and premature births. The DGAI can also serve as an initial screening tool for assessing pregnancy nutrition, given its convenience, simplicity, and acceptability among pregnant women, making it suitable for widespread application in primary care settings to promote maternal and infant health.

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Disclosure statement

The authors declare no conflict of interest.

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