

Original Article

The effect of individualized exercise prescriptions combined with dietary management on blood glucose in the second-and-third trimester of gestational diabetes mellitus

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Abstract: Objective: To explore the effect of individualized exercise prescriptions plus dietary management on blood glucose in the second-and-third trimester of gestational diabetes mellitus (GDM). Methods: We collected and reviewed the clinical data of 106 patients in their second-and-third trimester who had GDM in our hospital from September 2017 to September 2018. They were equally divided into a test group and a control group with a random number table method. All patients took oral metformin tablets, and the control group received routine clinical care. The test group received individualized exercise prescriptions plus dietary management. Then we compared the intervention effects between the two groups. Results: After the intervention, the FBG, 2-h PBG, and IR indexes in the test group were considerably lower than those in the control group ($P < 0.001$). After the intervention, both groups had lower HbA1c values than before, and those in the test group were obviously lower than the control group ($P < 0.001$). There was no clear difference in BMI between the two groups before and after intervention ($P > 0.05$). The BMI had clearly increased after intervention in both groups, and the increment in the test group was significantly lower than the control group (all $P < 0.05$). The medication compliance and nursing satisfaction were significantly higher than in the control group (all $P < 0.05$). The self-efficacy and the self-management ability scores in the test group were significantly higher than the control group ($P < 0.05$). Conclusion: In the second-and-third trimester of pregnancy with GDM, individualized exercise prescriptions plus dietary management can effectively control the blood glucose and keep BMI within a healthy range, thus improving the compliance and the clinical satisfaction of maternal care, fulfilling self-management, and reducing the risks of childbirth. It is worth promoting because of its enormous efficacy.

Keywords: Individualized exercise prescription, dietary management, gestational diabetes mellitus, the second-and-third trimester

Introduction

Gestational diabetes mellitus (GDM) is defined as when maternal carbohydrate metabolism is normal before pregnancy or there is potentially impaired glucose tolerance, and diabetes occurs during pregnancy, which often occurs in the second-and-third trimester. The carbohydrate metabolism of most women with GDM is also dysregulated after delivery, which will increase the probability of getting type 2 diabetes in the future as well as raise the risk of future abortion, polyhydramnios, and diabetic

ketoacidosis, thus leading to the restriction of fetal growth. So it must be taken seriously [1, 2]. Studies have shown [3] that over 80% of women with GDM can control blood sugar and reduce the risk of childbirth through life style intervention. With the continuous improvement of the domestic economy, women's nutritional status during pregnancy has been significantly improved. Still, an unreasonable diet during pregnancy and excessive energy intake can lead to insulin resistance (IR). Metformin tablets were often employed in clinical treatment in the past, but the drug was only suitable for

patients with GDM whose exercise therapy was not well controlled. Given this, scientific dietary management is an important measure to control the blood glucose level of patients with GDM within a normal range [4]. Exercise is a more effective intervention method for patients with GDM without medical contraindications. Investigations have revealed [5] that proper exercise during pregnancy can improve insulin sensitivity and promote a body's utilization of glucose, thereby improving IR, enhancing cellular glucose metabolism, and reducing the occurrence of GDM. In China, there are not many studies on the effect of individualized exercise prescriptions combined with dietary management on blood glucose in the second-and-third trimester of GDM. Therefore, this study applied an individualized exercise prescription combined with dietary management to women with GDM to explore the program's clinical feasibility and provide effective solutions for blood sugar control.

Materials and methods

General materials

The clinical data of 106 patients with GDM in their second-and-third trimester in our hospital from September 2017 to September 2018 were reviewed retrospectively. They were equally divided into a test group and a control group with a random number table method. The mean age in the test group was (26.35±2.31 years), with average fasting blood glucose (FBG) in the hospital of (8.45±0.47) mmol/L and an average weight of (54.28±2.41) kg. Among them, there were 34 primiparous women and 19 postpartum women. In the control group, the mean age was (26.42±2.28) years, with the average FBG in the hospital of (8.41±0.53) mmol/L and an average weight of (54.30±2.38) kg. Among them, there were 32 primiparous women and 21 postpartum women. There was no significant difference in the general data of the two groups and they were comparable ($P>0.05$).

Inclusion criteria

- ① Women who were diagnosed with GDM [6] during pregnancy without any drug treatment;
- ② Women who had single birth;
- ③ Women who had a certain level of education and cor-

responding reading and writing skills; ④ This study was approved by the ethics committee of our hospital; ⑤ And the mothers and their family members were aware of the purpose and process of this study and signed an informed consent form.

Exclusion criteria

- ① Women who had diseases of the heart, brain, liver, kidney and other organs;
- ② Women who had cognitive disorders such as mental;
- ③ Women who had artificial conception;
- ④ Women who had exercise contraindications;
- ⑤ Women who recently had taken drugs that may affect the normal secretion of insulin.

Methods

The control group was treated with oral metformin tablets (National drug code: H20023370 Manufacturer: Sino-American Shanghai Squibb Pharmaceutical Co., Ltd. Specification: 0.5 g*20 tablets), once/d, 1.0 g/once. Then routine care intervention was implemented, and the blood sugar levels of pregnant women were checked in the hospital. They were informed of the daily diet precautions in an oral form. Exercise guidance was given to pregnant women with the cycle of one month.

The individualized exercise prescription combined with dietary management and oral metformin tablets were given to the test group. Specific steps were as follows: (1) Individualized exercise prescriptions: ① We used the International Physical Activity questionnaire [7] to evaluate the maternal exercise status, including the exercise form, intensity, weekly exercise frequency and each exercise time, etc.; according to their exercise, the individualized exercise prescriptions were developed. ② Exercise form. The exercise method of whole-body endurance exercise combined with local resistance exercise was adopted. In general, endurance exercise included brisk walking, walking, yoga, etc., and local resistance exercise mainly consisted of swimming and upper limb exercises. ③ The strict control of exercise time. One hour after the meal was the best time to exercise. It is recommended that the women should exercise at least 3 days or more a week with over 30 minutes of moderate-intensity every day.

Individualized exercise prescriptions plus dietary management in gestational diabetes

(2) Dietary management: ① A specialized dietitian calculated the total daily caloric energy intake based on the maternal exercise intensity, body weight, blood sugar level, etc. The caloric energy supply in the second trimester was increased by 600-900 kJ per day, with a daily increase of 900-1400 kJ in the third trimester. ② A specialized dietitian calculated the daily intake ratio of fat, carbohydrates, and protein required by the pregnant women, and then appropriately adjusted their daily dietary structure so that fat, carbohydrates, and protein respectively accounted for 25-30%, 45-55%, 15-25% of the total caloric energy. It was recommended to eat more fish, eggs, lean meat, and other foods, and pregnant women drank 200-500 ml of dairy products every day and ate more fresh vegetables to ensure the intake of dietary fiber, vitamins, and minerals. ③ Pregnant women took reasonable meals. The total amount of food needed per day was divided into 4-6 small meals, going by the principle of frequent small meals. ④ A specialized dietitian distributed and explained the *Food Exchange Table* [8] to the pregnant women and urged them to record their daily diet in detail and carry out free GDM one-day meal activities. ⑤ A specialized dietitian provided nutrition knowledge, and health education to pregnant women, informed them of the importance of dietary management and encouraged them to adhere to scientific dietary management programs. ⑥ The blood glucose of pregnant women was regularly tested, and a specialized dietitian adjusted the diet plan according to the test results. There was a month of total intervention time.

Evaluation indexes

Blood glucose level and IR indexes: Five ml of venous blood was taken in the early morning with an empty stomach before and after the intervention from both groups. A high-efficiency centrifuge (Avanti JXN-30/26) produced by Beckman was used to separate at 3000 r/min for 10 minutes. Then the automatic biochemical analyzer produced by Nanjing Beiden Medical Co., Ltd. was used to measure the maternal FBG and the 2 h postprandial blood glucose level (2 h PBG). An automatic chemiluminescence immunoassay analyzer produced by Shenzhen Yongnian Technology Co., Ltd. was used to detect the maternal fasting insulin (FINS). $IR = ((FBG) \times FINS) / 22.5$, the larger the IR

indexes were, the stronger their ability to utilize insulin.

Glycated hemoglobin test (HbA1c): High performance liquid chromatography was used to test the HbA1c level before and after intervention and the normal value is 4-6%.

Body Mass Index (BMI): $BMI = \text{weight} / (\text{height})^2$, the BMI values in the two groups before and after intervention were measured, and the increment in BMI values was calculated. According to the *Dietary Guidelines for Chinese Residents* [9], $BMI < 18.5 \text{ kg/m}^2$ was a light weight, $18.5 \text{ kg/m}^2 \leq BMI < 24 \text{ kg/m}^2$ was a healthy weight, and $24 \text{ kg/m}^2 \leq BMI < 28 \text{ kg/m}^2$ was overweight, $BMI \geq 28 \text{ kg/m}^2$ was obese.

Compliance and satisfaction survey: During the hospitalization, nurses observed the compliance of pregnant women. They actively participated in the treatment until the end of the hospitalization, which was defined as good compliance. Nurses informed patients of truly filling out the *GDM Clinical Satisfaction* questionnaire, prepared by our hospital, including service attitude, nursing quality, service items, etc., with a full score of 100. A range of 85-100 was very satisfied, 70-84 was satisfied, and less than 69 was dissatisfied. Total satisfaction rate = (very satisfied + satisfied) / total * 100%.

Self-efficacy and self-management behaviors: Our hospital's self-efficacy and self-management behaviors with GDM questionnaire was used to evaluate the self-efficacy and self-management behaviors of pregnant women after intervention. The self-efficacy score scale included compliance behaviors, physical exercises, blood glucose monitoring, local care, daily diet and prevention, and abnormal blood sugar, with a full score of 120 and 20 points for each item. The score was proportional to self-efficacy; the self-management behavior score scale contained daily life behavior management, self-monitoring and regulation, and self-protection behavior management, with a full score of 45 and 15 points for each item. The score was proportional to the level of self-management.

Weight and Apgar score of the newborns: All newborns were weighed after birth, and assessed by the Apgar score at birth and 5 min-

Table 1. Comparison of FBG, 2 h PBG, and IR ($\bar{x} \pm s$)

	n	FBG (mmol/L)	2-h PBG (mmol/L)	IR (μ U/mL)
Test group	53	5.26 \pm 0.32	7.12 \pm 0.18	2.24 \pm 0.29
Control group	53	7.24 \pm 0.65	9.08 \pm 0.13	3.58 \pm 0.63
t		19.896	64.264	14.066
P		<0.001	<0.001	<0.001

Table 2. Comparison of HbA1c before and after intervention ($\bar{x} \pm sd$, %)

Group	n	Before intervention	After intervention
Test group	53	8.87 \pm 0.52	5.67 \pm 0.12***
Control group	53	8.89 \pm 0.48	7.85 \pm 0.31***
t		0.837	47.73
p		0.206	<0.001

Note: Compared with before intervention, ***represents P<0.001.

Table 3. Comparison of BMI value before and after intervention ($\bar{x} \pm sd$, kg/m²)

Group	n	Before intervention	After intervention	Increase
Test group	53	18.49 \pm 1.21	23.22 \pm 0.43	4.73 \pm 0.78
Control group	53	18.51 \pm 1.18	24.57 \pm 0.74	6.06 \pm 0.44
t		0.086	11.483	10.812
p		0.932	0.000	0.000

utes after birth. Apgar score mainly included neonatal muscle tone, appearance, pulse, ventilator response to stimulation content, a total of 10 points. A score ≥ 7 was considered a normal newborn. A score of 4-6 indicated mild asphyxia, while a score of <3 indicated severe asphyxia.

Statistical methods

All the experimental data were statistically analyzed and processed by SPSS 21.0 software. The enumeration data were expressed by n (%) with the Chi-squared test, and the measurement data were expressed by ($\bar{x} \pm sd$) with the t test. P<0.05 indicated a statistical difference.

Results

Comparison of the FBG, 2 h PBG, and IR values after intervention

The results revealed that the test group had lower FBG, 2 h PBG, and IR values, than the control group (P<0.05). See **Table 1**.

Comparison of HbA1c before and after intervention

Studies revealed that both groups had lower HbA1c values after intervention than before intervention (P<0.05), and the HbA1c value in the test group after the intervention was lower than that in the control group (P<0.05). See **Table 2**.

Comparison of BMI value before and after intervention

Studies revealed that no significant difference was seen before intervention (P<0.05), and the increase in the BMI value of the test group was considerably lower than the control group (P<0.05). See **Table 3**.

Comparison of compliance and satisfaction

Studies revealed that the test group had higher numbers of good compliance and overall satisfaction than the control group (P<0.05). See **Table 4**.

Comparison of self-efficacy and the self-management scores after intervention

It was revealed in the present study that the self-efficacy and the self-management scores after intervention in the test group were better than those in the control group (P<0.05). See **Table 5**.

Comparison of the newborns

Studies revealed that the test group had lower neonatal weight than the control group (P<0.05). Apgar scores at birth and 5 min after birth were comparable between the two groups (P>0.05). See **Table 6**.

Discussion

As a common pregnancy complication, GDM increases fetal mortality. Studies have pointed out [10] that the increase in fetal mortality is mainly related to the blood glucose level of the

Table 4. Comparison of compliance and satisfaction [n (%)]

Group	Good compliance (number)	Satisfaction			Total satisfaction rate
		Very satisfied	Satisfied	Dissatisfied	
Test group (n=53)	49 (92.45%)	29 (54.72%)	22 (41.51%)	2 (3.77%)	96.23% (51/53)
Control group (n=53)	41 (77.36%)	21 (9.62%)	23 (43.40%)	9 (16.98%)	83.02% (44/53)
χ^2	4.711				4.970
p	0.030				0.026

Table 5. Comparison of the self-efficacy and the self-management scores after intervention ($\bar{x} \pm s$, score)

Group	n	Self-efficacy	Self-management
Test group	53	95.32±12.03	41.21±1.53
Control group	53	89.56±11.74	36.42±1.32
t		2.495	17.257
p		0.014	0.000

Table 6. Comparison of the newborns ($\bar{x} \pm s$)

	n	Neonatal weight	Apgar score at birth	Apgar score at 5 min of birth
Test group	53	3.06±0.37	9.92±0.02	9.97±0.04
Control group	53	3.27±0.42	9.93±0.04	9.96±0.03
t		3.377	1.628	1.456
p		0.002	0.107	0.148

mothers. Excessive blood sugar will increase the viscosity of the blood, cause vasoconstriction, and increase the risk of cardiovascular disease in mothers. Besides, high blood sugar levels lead to the growth and reproduction of pathogenic microorganisms, which is prone to cause reproductive tract infections or skin infections [11, 12]. What's more, high levels of maternal blood sugar can cause excessive growth of a fetus, fetal macrosomia disease, and excessive amniotic fluid, which increases the burden on maternal organs. Therefore, it is critical for women with GDM to control their blood sugar within a reasonable range to reduce the risk of delivery and ensure the safety of mother and child [13].

An individualized exercise prescription was made according to the actual exercise of the patients with GDM. It was comprehensively based on the mothers' personal preferences, physical condition, and other factors, and an individualized exercise plan was developed. Some studies reveal that [14], performing appropriate physical exercises during pregnan-

cy effectively controls weight gain, accelerates body calorie consumption, and fundamentally reduces the occurrence of GDM. However, strenuous activity should be avoided in case of affecting the fetus. It is clinically proven [15] that a scientific dietary structure can control the blood glucose level of women with GDM within a reasonable range. Health and nutrition knowledge can help mothers better realize the importance of self-dietary management and actively follow the dietary intervention. On the one hand, an appropriate diet ensures the daily energy intake and the normal growth and development of the fetus. On the other hand, dietary management strictly controls the daily total calorie intake and scientifically calculates fat, carbohydrates, and protein intake ratios, going by the principle of frequent small meals, which prevents excess glucose, effectively controls and adjusts maternal blood sugar levels, and reduces neonatal complications [16, 17].

This study confirmed that the IR index in the test group after intervention was lower. IR refers to a decrease in the sensitivity of the target organs to insulin action. IR is the pathogenic basis of type 2 diabetes, and the key factor in a variety of metabolic diseases in the human body. The IR index describes the degree of IR, the higher the IR index, the stronger the insulin resistance. This further indicates that as a patients' insulin function declines, it will likely cause abnormal blood glucose metabolism and influence their health [18]. A study [19] pointed out that exercise combined with dietary intervention was able to control the blood glucose level of the elderly patients with diabetes within a reasonable range, and the IR index after intervention was significantly lower compared to the control group. This is intended to show that individualized exercise prescriptions com-

bined with dietary management can effectively control patients' blood sugar levels and improve insulin function.

The limitation of this study is as follows. Metformin has been gradually used in the management of GDM, and many recent studies have shown that metformin may be a good choice for GDM because of the lower risk of pregnancy-induced hypertension. However, the advantages of metformin in terms of glycemic control, pregnancy-induced hypertension syndrome incidence, and gestational age at birth are unclear and should be verified in further trials.

In summary, an individualized exercise prescription plus dietary management helps women with GDM in the second-and-third trimester to control their blood glucose level and BMI value within a reasonable range, which facilitates improving their self-management ability during pregnancy and changes the outcome of delivery. The effect is significant and worthy of being promoted.

Disclosure of conflict of interest

None.

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