Effect of the internet combined with exercise-based individualized nursing intervention in patients with gestational diabetes mellitus

Yaer Chen1, Chunbo Qiu1, Jie Chen1, Lu Li1, Jichao Xu1 and Zhiren Sheng2*

Abstract

Background: Gestational diabetes mellitus (GDM) is the most frequent medical complication of pregnancy. This condition is manifested by glucose intolerance resulting in hyperglycemia of variable severity during pregnancy. One of the most important clinical tools for efficiently regulating maternal blood glucose is strictly monitoring blood glucose levels. However, due to a lack of appropriate intervention tools, managing the occurrence of GDM is still unfeasible. This study aimed to determine clinical efficacy of the internet combined with exercise-based individualized nursing intervention in patients with gestational diabetes mellitus (GDM).

Methods: In total, 139 patients with GDM were divided into two groups, with 79 patients in the observation group (internet combined with exercise-based individualized nursing intervention) and 60 patients in the control group (routine nursing intervention only). The two groups were given specified nursing intervention for 8 weeks and then compared for changes in their blood glucose, blood lipids, blood pressure, insulin resistance (IR), and rate of adverse pregnancy outcomes. Additionally, the psychological state was analyzed, and their nursing satisfaction with the care from nurses that they received was investigated before and after the nursing intervention.

Results: Compared with the control group, the following indices of the observation group were lowered: blood glucose-related indices (FBG and 2 h PG), blood lipids and blood pressure associated indices (TG, TC, and HbA1c, DBP, SBP, and MAP), and IR-related indices (FINS, 2 h INS, and HOMA -IR) (all P < 0.05). The observation group also showed a lower rate of adverse pregnancy outcomes than the control group (7.59% vs. 20.00%; P < 0.05). In addition, SAS and SDS scores of the observation group were both lower than the control group (P < 0.05). Accordingly, the nursing satisfaction score also displayed that the observation group (93.67%) had a higher satisfaction outcome than the control group (76.67%; P < 0.05).

Conclusions: Internet combined with exercise-based individualized nursing intervention in GDM patients can effectively improve their blood glucose, IR, and psychological status, thus significantly improving their pregnancy outcomes and mental condition.

Keywords: Internet combined with exercise-based individualized nursing, Gestational diabetes mellitus, Glucose tolerance, Insulin resistance

*Correspondence: 498769997@qq.com

1 Department of Nursing, Affiliated Hospital of Ningbo University School of Medicine, No. 247, Renmin Road, Ningbo 315000, Zhejiang, China

© The Author(s) 2021. Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article’s Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article’s Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit http://creativecommons.org/licenses/by/4.0/. The Creative Commons Public Domain Dedication waiver (http://creativecommons.org/publicdomain/zero/1.0/) applies to the data made available in this article, unless otherwise stated in a credit line to the data.
**Introduction**

Gestational diabetes mellitus (GDM) is defined as carbohydrate intolerance that begins or manifests during pregnancy [1]. GDM disrupts 18% of pregnant women globally, and most of them suffer from GDM due to impaired glucose tolerance (GT) during pregnancy [2]. Women with GDM face a higher risk of hypertension during pregnancy and are more likely to have early birth. GDM is linked to a number of fetal problems, including macrosomia, neonatal hypoglycemia, congenital abnormalities, and prenatal death [3, 4]. GDM is also associated with an increased risk of developing type 2 diabetes in the mother [5]. To better ensure the health and safety of both mother and fetus, it is imperative to strictly control the blood glucose levels of pregnant women during pregnancy [6]. In clinical practice, pregnant women are generally recommended to do more exercise and follow a more regular diet once they are found to have high blood glucose, and in some cases, they are advised to take drugs if they still cannot reach the targeted blood glucose levels [7]. However, long-term administration of drugs adversely affects both mother and the fetuses [8]. Therefore, effective intervention measures and scientific guidance are safe and recommended therapy to lower the blood glucose level of pregnant women.

Previous studies have shown that nursing intervention can help alleviate the GDM of patients [9, 10]. Lv et al. [11] suggested the positive role of comprehensive nursing intervention in the pregnancy outcome of patients with GDM, which implies the importance of nursing intervention to patients with GDM. The internet combined with nursing services is a novel, innovative nursing mode proposed in China in recent years [12]. Under such a nursing mode, patients can enjoy professional guidance and get help from the medical staff at home anytime, which is a favorable treatment for those who require effective continuous treatment and nursing [13]. In addition, exercise-based individualized nursing is a new nursing mode under which nurses provide various comprehensive services to the patients [14]. Some studies have pointed out the significant effect of exercise-based individualized nursing in patients with type 2 diabetes mellitus in clinical practice [15, 16]. However, the application of the internet combined with exercise-based individualized nursing intervention in patients with GDM is not well defined. Therefore, this study analyzed the effect of such a combined nursing intervention on glucose tolerance (GT) and insulin resistance (IR) in patients with GDM to offer an effective tool and guidance for future clinical nursing intervention for GDM.

**Methods**

**Participants**

A total of 139 patients with GDM admitted to our hospital between July 2019 and February 2021 were enrolled in this study and randomly divided into two groups according to the numerical random table method. Among them, 79 patients were given the internet combined with exercise-based individualized nursing intervention as the observation group, while the rest were given routine nursing intervention only as the control group. This study was carried out with permission from the Ethics Committee of our hospital (Approval number: 2019-03G7002) and informed consent forms signed by all enrolled individuals.

Inclusion criteria were as follows: Age > 20; Patients meeting the diagnostic criteria of GDM according to the examination results in our hospital [17]; patients who were pregnant for the first time; patients with detailed case data; and those who or whose legal guardian signed informed consent forms based on voluntary participation.

The exclusion criteria were based on: Patients with comorbid chronic diseases; cardiovascular or cerebrovascular diseases or organ dysfunction; patients with drug allergies; consciousness disturbance or communication obstacle; and those with multiple pregnancies.

**Nursing intervention**

The control group was given routine nursing intervention. Specifically, the nursing staff was arranged to pay close attention to the patients’ blood glucose and blood pressure levels, inform the patients and their families of daily precautions such as diet adjustment and moderate exercise. If necessary, the staff was required to urge the patients to take drugs according to the doctor’s advice and call back the patients to understand their basic situation and provide corresponding guidance according to their condition.

The observation group was given the internet combined with exercise-based individualized nursing intervention. In brief, patients and their families were enabled to make an online appointment to raise questions and obtain answers through a network platform provided by the hospital. Specialists and nurses would formulate targeted nursing intervention measures according to each patient’s own situation. At discharge time, each patient was instructed to receive reminders about daily precautions and exercise on the internet on time. In addition, the nursing staff were arranged to post guidance on psychology, physiology, and blood glucose control on the internet, and to pay real-time attention to the patients’ requirements and blood glucose levels and thus take
corresponding adjustment measures on time to ensure the continuity of patients' treatment in hospital and at home. Moreover, the patients were encouraged to maintain a good state of mind and were given practical assistance in lowering blood glucose. The staff was also arranged to design targeted exercise schemes for patients according to their gestational age, such as simple brisk walking, walking with raised arms, and maternity exercises. Patients were advised to stop the exercise when they had slight sweating. The patients were reminded to take a walk every day, 30 min each time, under the premise of ensuing heart rate < 120 times/min after exercise. Furthermore, the nursing staff was required to emphasize safety precautions to each patient before exercise and help patients avoid dangerous and violent actions in time to protect pregnant women and fetuses from being hurt. During exercise, timely water replenishing was necessary to prevent hypoglycemia.

The patients in both groups received the specified nursing intervention for 8 weeks, and the parameters were measured before the intervention and at 37 weeks gestation.

Assessment of blood glucose and other measurements

Blood glucose detection
Venous blood was sampled from each patient in the two groups, and their fasting blood glucose (FBG) and 2-h postprandial blood glucose (2 h PG) levels were measured via an automatic blood glucose analyzer.

Blood lipid detection
An automatic biochemistry analyzer was adopted for the determination of changes in patients' triglyceride (TG), total cholesterol (TC), glycated haemoglobin (HbA1c), low-density lipoprotein—cholesterol (LDL-C) and high-density lipoprotein—cholesterol (HDL-C) levels.

Blood pressure measurement
An ambulatory blood pressure detector was used for measuring changes in patients' systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial pressure (MAP).

IR detection
The automatic biochemistry analyzer was used for measuring the fasting insulin (FINS), 1 h postprandial insulin (1 h INS), and 2 h INS, and then the homeostatic model assessment (HOMA)-IR index was calculated.

Outcome measures
The self-rating depression scale (SDS) [18] and self-rating anxiety scale (SAS) [19] were used to assess the patients' psychological state. SDS and SAS are the commonly used norm-referenced scales. Both are 20 item Likert scales, in which items tap psychological and physiological symptoms and are rated by respondents according to how each applied to them within the past week, using a 4-point scale ranging from 1 (none, or a little of the time) to 4 (most, or all of the time) [20].

Adverse pregnancy outcomes were measured by evaluating the incidence of risk events such as uterine pregnancy, polyhydramnios, and premature delivery.

Patients' nursing satisfaction was assessed by a self-made nursing satisfaction questionnaire of our hospital. The questionnaire had a total score of 100 points, with a score above 90 points indicating high satisfaction, a score between 71 and 90 points indicating moderate satisfaction, a score between 51- and 70-points indicating improvement requirement, and a score below 50 points denoting dissatisfaction. The overall satisfaction was calculated as follows = (number of patients with high satisfaction + number of patients with moderate satisfaction)/ total number of patients × 100%.

Statistical analysis
The data was analyzed using SPSS statistical software version 20 (IBM), and figures were drawn using Graphpad7. Enumeration data, expressed as a rate, was compared between the two groups using the chi-square test. Measurement data, expressed as the mean ± SD, was compared between the groups via the t-test. P < 0.05 value was considered as statistically significant.

Results

Baseline data comparison
When compared the clinical baseline data of the two groups of patients and various indicators before the nursing intervention, no statistical differences were seen between the two groups (P > 0.05) (Table 1).

Blood glucose outcomes
Before nursing intervention, there was no significant difference in the FBG and 2 h PG levels between the control and observation groups (P > 0.05) (Table 1); however, after nursing intervention, a significant reduction in both FBG and 2 h PG levels was observed in the two groups (P < 0.05). Notably, a substantial improvement was seen in both FBG and 2 h PG levels in the observation group after nursing intervention compared to the control group (P < 0.05) (Table 2).

Glucose tolerance outcomes
No prominent difference was seen for blood glucose tolerance between the two groups before nursing intervention (P > 0.05; Table 1). After nursing intervention, the levels of TG, TC, and HbA1c in the observation
group were prominently lower than those in the control group (P < 0.05) (Fig. 1A–C), whereas no notable difference was found between the two groups in the LDL-C and HDL-C levels (P > 0.05) (Fig. 1D, E).

**Blood pressure outcomes**

For blood pressure outcomes, no significant change was observed between the two groups before nursing intervention (P > 0.05) (Table 1). In contrast, as shown in Fig. 2A, the observation group had a reduced level of DBP compared to the control group after nursing intervention. Similarly, significantly lower levels of SBP and MAP were noticed in the observation group compared to the control group (Fig. 2B, C) (P < 0.05).

**Insulin resistance outcomes**

Before the nursing intervention, no considerable change was noted for the levels of FINS, 1 and 2 h INS and HOMA-IR between the control and observation groups (P > 0.05) (Table 1). After nursing intervention, the two groups were not greatly different in the 1 h INS levels (P > 0.05) (Fig. 3B), but the FINS, 2 h INS and HOMA-IR levels of the observation group were all lower than those in the control group (P < 0.05) (Fig. 3A, C and D).

**Adverse pregnancy outcomes**

The observation group showed a rate of adverse pregnancy outcome of 7.59% with 3 cases of cesarean section, 1 case of polyhydramnios, and 2 cases of fetal distress. In contrast, the control group displayed an adverse pregnancy outcome of 20.00% with 6 cesarean section cases, 3 cases of polyhydramnios, and 2 cases of fetal distress. The difference was statistically significant when the observation group was compared to the control group (P < 0.05) (Table 3).

**Psychological state outcomes before and after nursing intervention**

Before nursing intervention, no noticeable differences were seen in the SAS and SDS scores between the two groups (P > 0.05). However, a significant change was observed in both groups’ SAS and SDS scores after nursing intervention compared to before nursing intervention (P < 0.05). Of note, the SAS and SDS scores in the observation group were substantially improved compared to the control group after nursing intervention (P < 0.05) (Fig. 4).

**Nursing satisfaction**

According to the investigation on nursing satisfaction, the observation group expressed a notably higher satisfaction score than the control group (93.67% vs 71.67%), and the difference was considerably high (P < 0.05) (Table 4).

---

**Table 1** Comparison of clinical baseline data between the two groups before nursing intervention

|                | Observation group | Control group | t or χ² | P   |
|----------------|------------------|--------------|--------|-----|
| Age (years)    | 29.1 ± 4.7       | 28.6 ± 4.5   | 0.633  | 0.528|
| Gestational week | 14.92 ± 5.93    | 15.24 ± 6.37 | 0.305  | 0.761|
| TG (mmol/L)    | 3.14 ± 0.62      | 3.12 ± 0.65  | 0.185  | 0.854|
| TC (mmol/L)    | 6.84 ± 0.52      | 6.91 ± 0.53  | 0.780  | 0.437|
| HbA1c (%)      | 9.14 ± 0.74      | 9.22 ± 0.81  | 0.606  | 0.546|
| LDL-C (mmol/L) | 2.41 ± 0.28      | 2.43 ± 0.31  | 0.398  | 0.691|
| HDL-C (mmol/L) | 3.84 ± 0.34      | 3.81 ± 0.30  | 0.542  | 0.589|
| DBP (mmHg)     | 114.62 ± 8.42    | 115.14 ± 8.19| 0.365  | 0.716|
| SBP (mmHg)     | 142.63 ± 10.54   | 144.94 ± 9.86| 1.316  | 0.191|
| MAP (mmHg)     | 110.14 ± 7.63    | 110.06 ± 8.34| 0.059  | 0.953|
| FINS (mU/L)    | 22.81 ± 3.81     | 22.56 ± 4.04 | 0.373  | 0.710|
| 1 h INS (mU/L) | 114.63 ± 22.86   | 112.94 ± 25.16| 0.413  | 0.680|
| 2 h INS (mU/L) | 48.44 ± 6.96     | 49.17 ± 7.53 | 0.591  | 0.555|
| HOMA-IR        | 4.89 ± 0.32      | 4.93 ± 0.30  | 0.750  | 0.455|

**Table 2** Comparison of blood glucose levels in the two groups before and after nursing intervention (mmol/L)

|                | Before nursing intervention | After nursing intervention | t  | P   |
|----------------|-----------------------------|-----------------------------|----|-----|
| FBG (mmol/L)  | 7.24 ± 0.68                 | 9.12 ± 0.59                 | 0.165| 0.869|
| 2 h PG (mmol/L)| 5.56 ± 0.54                 | 6.81 ± 0.67                 | 14.750| < 0.001|
| Control group | 7.26 ± 0.74                 | 9.09 ± 0.63                 | 0.165| 0.869|
| 2 h PG (mmol/L)| 6.98 ± 0.59                 | 8.12 ± 0.72                 | 14.750| < 0.001|
| t              | 0.869                       | 0.288                       | < 0.001 | < 0.001|

(*) indicates a significant difference for P < 0.05 between before and after the nursing intervention. (#) indicates a significance for P < 0.05 between the control and observation groups.
Discussion

The results of this study supported the positive effects of the internet combined with exercise-based individualized nursing intervention in patients with gestational diabetes mellitus. It reduced blood pressure, blood lipids level, and most importantly, it significantly lessened the high blood glucose levels and adverse pregnancy outcomes of the GDM patients. In addition, it also positively modulated patients’ psychological state and enhanced patients’ satisfaction with the services provided by the nurses.

Insulin resistance (IR) and glucose tolerance (GT) are the main pathological bases of GDM [21]. Strictly monitoring blood glucose levels is one of the crucial clinical means for effectively controlling maternal blood glucose [22]. However, due to the lack of effective intervention means, it is still unfeasible to effectively manage
Fig. 3  Comparison of insulin resistance between the two groups. A Comparison of FINS. B 1 h INS. C 2 h INS. D HOMA-IR. The asterisk (*) indicates significance for $P < 0.05$ between the control and observation groups after nursing intervention.

Table 3  Comparison of adverse pregnancy outcomes

|                        | Cesarean section | Polyhydramnios | Fetal distress | Premature delivery | Rate of adverse pregnancy outcome |
|------------------------|------------------|----------------|---------------|--------------------|-----------------------------------|
| Observation group      | 3 (3.80%)        | 1 (1.27%)      | 2 (2.53%)     | 0 (0.00%)          | 6 (7.59%)                         |
| Control group          | 6 (10.00%)       | 3 (5.00%)      | 2 (3.33%)     | 1 (1.67%)          | 12 (20.00%)                       |
| $\chi^2$               |                  |                |               |                    | 4.655                             |
| $P$                    |                  |                |               |                    | 0.031                             |

Fig. 4  Comparison of psychological state between the two groups. A Comparison of SAS score. B SDS score. The asterisk (*) indicates significance for $P < 0.05$ between before and after care groups. (&) indicates significance for $P < 0.05$ between the control and observation groups after nursing intervention.
the occurrence of GDM. In recent years, thanks to the continuous improvement in nursing interventions, the high-quality nursing intervention has become one of the crucial modes for patients’ recovery and health [23]. In agreement with the above findings, our study results displayed that the observation group had notably lower blood glucose levels, higher GT, and better blood pressure and IR than the control group. These results imply the remarkable impact of the internet combined with exercise-based individualized nursing intervention in improving patients’ blood glucose with GDM. As we all know, the treatment of GDM requires a long cycle, and it is necessary to gradually improve the sugar metabolism level in the body through drugs [24]. In this process, patients may carry out some activities not conducive to blood glucose control due to the lack of medical and health-associated knowledge that greatly compromises GDM treatment [25]. Therefore, for patients with GDM, in addition to stable and effective blood glucose control, patient guidance to help them understand the related knowledge of blood glucose and pay attention to the changes in their glucose metabolism is also necessary [26].

In actual daily life, nursing staff are unlikely to accompany patients to guide them in seeking advantages and avoiding disadvantages all the time. Therefore, real-time guidance to patients has become one of the keys to the prognosis of GDM. The implementation of internet-based nursing can effectively address this situation. With society’s modernization, the internet has become an inseparable part of people’s lives [27]. It enables us to realize direct real-time communication between doctors and patients. Using this methodology, patients can get a timely and rapid response from the medical staff once they encounter unsolvable problems related to diseases. Medical staff can also provide the most professional solution and suggestions to the patients on time. It can greatly lower the adverse risks faced by patients with GDM. According to one earlier study, it has been shown that internet nursing can reduce the incidence of adverse events in patients with chronic diseases [28]. In our study, we also found that the implementation of internet-based nursing intervention significantly reduced adverse events in GDM patients, highlighting the significance of internet nursing in clinical application.

In patients with GDM, the increase in blood glucose and blood lipids due to obesity is one of the primary risk factors of GDM [29]. The most effective and safe way to reduce the risk of obesity is effective exercise. Moreover, proper exercise can improve the human body’s metabolism, immune function, and cardiopulmonary ability. In the present study, the guidance and attention given to the GDM patients by introducing nursing intervention did not only help them to have better blood glucose metabolism but also guided them to have a better body function and a higher success rate of childbirth. Other studies have also confirmed the beneficial outcomes of exercise-based nursing intervention in many diseases such as chronic obstructive pulmonary disease [30], Parkinson’s disease [31], colon cancer [32], osteoporosis [33] and others. The results of these studies are in complete agreement with those of our experimental data. In our study, the observation group had better pregnancy outcomes than the control group, and the reasons may also be consistent with our above analysis, which fully demonstrates that the internet combined with exercise-based individualized nursing intervention can yield positive results in the GDM patients.

Modern clinical nursing services are no longer limited to the patients’ diseases only but also provides importance to the patients’ psychological state. Many studies have shown that most patients usually feel fear, rebellion, and conflict with the medical staff because of the pain caused by the disease and the lack of knowledge related to the disease [34–36]. Such a negative psychological state may not only greatly compromise a patient’s treatment compliance, resulting in tension between doctors and patients, but can also directly minimize the clinical treatment effect. Therefore, in modern nursing services, nursing staff are required to actively communicate with patients to reduce the communication gap between the doctors and patients and build up patients’ confidence to overcome fear related to diseases. According to the results of this study, the SDS and SAS scores in the observation group were notably lower than those in the control group. Most

| Table 4 Comparison of nursing satisfaction between the two groups |
|------------------|------------------|
|                | Very satisfied | Moderate satisfied | Room for improvement | Dissatisfied | Nursing satisfaction |
| Observation group | 58 (73.42%) | 16 (20.25%) | 4 (5.06%) | 1 (1.27%) | 74 (93.67%) |
| Control group    | 19 (31.67%) | 27 (45.00%) | 11 (18.33%) | 3 (5.00%) | 46 (76.67%) |
| χ²               |              |                |                 |              |
| P                |              |                |                 |              | 0.004 |

|                |              |                |                 |              |

In actual daily life, nursing staff are unlikely to accompany patients to guide them in seeking advantages and avoiding disadvantages all the time. Therefore, real-time guidance to patients has become one of the keys to the prognosis of GDM. The implementation of internet-based nursing can effectively address this situation. With society’s modernization, the internet has become an inseparable part of people’s lives [27]. It enables us to realize direct real-time communication between doctors and patients. Using this methodology, patients can get a timely and rapid response from the medical staff once they encounter unsolvable problems related to diseases. Medical staff can also provide the most professional solution and suggestions to the patients on time. It can greatly lower the adverse risks faced by patients with GDM. According to one earlier study, it has been shown that internet nursing can reduce the incidence of adverse events in patients with chronic diseases [28]. In our study, we also found that the implementation of internet-based nursing intervention significantly reduced adverse events in GDM patients, highlighting the significance of internet nursing in clinical application.

In patients with GDM, the increase in blood glucose and blood lipids due to obesity is one of the primary risk factors of GDM [29]. The most effective and safe way to reduce the risk of obesity is effective exercise. Moreover, proper exercise can improve the human body’s metabolism, immune function, and cardiopulmonary ability. In the present study, the guidance and attention given to the GDM patients by introducing nursing intervention did not only help them to have better blood glucose metabolism but also guided them to have a better body function and a higher success rate of childbirth. Other studies have also confirmed the beneficial outcomes of exercise-based nursing intervention in many diseases such as chronic obstructive pulmonary disease [30], Parkinson’s disease [31], colon cancer [32], osteoporosis [33] and others. The results of these studies are in complete agreement with those of our experimental data. In our study, the observation group had better pregnancy outcomes than the control group, and the reasons may also be consistent with our above analysis, which fully demonstrates that the internet combined with exercise-based individualized nursing intervention can yield positive results in the GDM patients.

Modern clinical nursing services are no longer limited to the patients’ diseases only but also provides importance to the patients’ psychological state. Many studies have shown that most patients usually feel fear, rebellion, and conflict with the medical staff because of the pain caused by the disease and the lack of knowledge related to the disease [34–36]. Such a negative psychological state may not only greatly compromise a patient’s treatment compliance, resulting in tension between doctors and patients, but can also directly minimize the clinical treatment effect. Therefore, in modern nursing services, nursing staff are required to actively communicate with patients to reduce the communication gap between the doctors and patients and build up patients’ confidence to overcome fear related to diseases. According to the results of this study, the SDS and SAS scores in the observation group were notably lower than those in the control group. Most
importantly, the results of the two groups’ nursing satisfaction imply that the internet combined with exercise-based individualized nursing intervention is beneficial to GDM patients’ and it has a great application prospect in the clinical practice.

**Strengths and limitations**

To date, there has been no evidence of interventions that provide GDM patients with exercise-based individualized nursing intervention via the internet, which is already being used by the health system for other purposes. As a result, its adoption would not incur a high financial cost, which is one of the main strengths of this study. Furthermore, because the intervention would be offered by the same nursing experts who work in the hospital every day, it would not result in major workload increases for professionals. Additionally, none of the participants expressed any concern or anxiety as a result of the online communication, indicating that the intervention did not add to the nursing staff’s workload.

Although we observed the most anticipated improvements in GDM patients, our study has several limitations that warrant consideration. First, we did not evaluate the long-term prognosis of the two groups due to the short experimental period. Second, there was no follow-up after 37 weeks gestation, which should be considered in a future study. Third, a larger sample was not recruited since the study was presented to the hospital directors as an attempt to assess the feasibility and acceptability of the intervention in addition to the main measure of interest.

**Conclusions**

To summarize, for patients with GDM, the internet combined with exercise-based individualized nursing intervention can effectively improve their GT and IR and significantly enhance their pregnancy outcomes and psychological state, which is worthy of clinical promotion.

**Acknowledgements**

Not applicable.

**Authors’ contributions**

ZS conceived and designed the study. YC, CQ, JC, LL, and JX acquired, analyzed, and interpreted the data. YC, CQ, and JC drafted and edited the manuscript. All authors aided in revising this manuscript for intellectual content and approved the final version to be published. All authors read and approved the final manuscript.

**Funding**

This work was supported by the third batch of science and technology projects in Ningbo’s “Science and Technology Innovation 2025” major special project (NO.1352019B10035).

**Availability of data and materials**

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

**Declarations**

**Ethics approval and consent to participate**

Ethics approval was obtained from the Affiliated Hospital of Ningbo University School of Medicine Ethics Committee (Approval No. 2019-03G7002).

**Consent for publication**

Not applicable.

**Informed consent**

All patients agreed and signed informed consent.

**Competing interests**

The authors report no competing interests.

**Author details**

1. Department of Obstetrics, Affiliated Hospital of Ningbo University School of Medicine, Ningbo 315000, Zhejiang, China. 2. Department of Nursing, Affiliated Hospital of Ningbo University School of Medicine, No. 247, Renmin Road, Ningbo 315000, Zhejiang, China.

Received: 8 July 2021 Accepted: 14 October 2021

Published online: 30 October 2021

**References**

1. Plows JF, et al. The pathophysiology of gestational diabetes mellitus. JUMS. 2018. https://doi.org/10.3390/jums19113342.
2. McIntyre HD, et al. Gestational diabetes mellitus. Nat Rev Dis Primers. 2019;5(1):1–7.
3. Szumlowicz ED, Josephson JL, Metzger BE. Gestational Diabetes Mellitus. Endocrinol Metab Clin North Am. 2019;48(3):479–93.
4. Johns EC, et al. Gestational diabetes mellitus: mechanisms, treatment, and complications. Trends Endocrinol Metab. 2018;29(1):743–54.
5. Seji TL, Brown AJ, Feinglos MN. Gestational diabetes mellitus. Clin Diab. 2005;23(1):17–24.
6. ACOG Practice Bulletin No. 190. Gestational diabetes mellitus. Obstet Gynecol. 2018. 131(2): e49-e64.
7. Mahajan A, et al. Evidenced-based nutrition for gestational diabetes mellitus. Curr Diab Rep. 2019;19(10):94.
8. Ross EJ, et al. Developmental consequences of fetal exposure to drugs: what we know and what we still must learn. Neuropsychopharmacology. 2015;40(1):61–87.
9. Mensah GP, et al. Guidelines for the nursing management of gestational diabetes mellitus: an integrative literature review. Nurs Open. 2020;7(1):78–90.
10. Xu T, et al. Healthcare interventions for the prevention and control of gestational diabetes mellitus in China: a scoping review. BMC Pregnancy Childbirth. 2017;17(1):171.
11. Yu S, et al. Effects of nutritional nursing intervention based on glycemic load for patient with gestational diabetes mellitus. Ginekol Pol. 2019;90(1):46–9.
12. Zhou K, et al. Benefits of a WeChat-based multimodal nursing program on early rehabilitation in postoperative women with breast cancer: a clinical randomized controlled trial. Int J Nurs Stud. 2020;106:103565.
13. Sawyer A, Kaim A. The effectiveness of an app-based nurse-mediated program for new mothers with depression and parenting problems (eMums Plus): pragmatic randomized controlled trial. J Med Internet Res. 2019;21(6):e13689.
14. Azam G, Soh KL. Effect of a nurse-led diabetes self-management education program on glycosylated hemoglobin among adults with type 2 diabetes. J Diabetes Res. 2018;2018:4930157.
15. Colberg SR, et al. Physical activity/exercise and diabetes: a position statement of the American Diabetes Association. Diabetes Care. 2016;39(11):2065–79.
16. Lee SK, et al. Effect of diabetes education through pattern management on self-care and self-efficacy in patients with type 2 diabetes. Int J Environ Res Public Health. 2019. https://doi.org/10.3390/ijerph16183323.
17. Zhu W-W, Yang H-X. Diagnosis of gestational diabetes mellitus in China. Diabetes Care. 2013;36(6):e76–e76.
18. Zung WW. A self-rating depression scale. Arch Gen Psychiatry. 1965;12:63–70.
19. Zung WW. A rating instrument for anxiety disorders. Psychosomatics. 1971;12(6):371–9.
20. Dunstan DA, Scott N, Todd AK. Screening for anxiety and depression: reassessing the utility of the Zung scales. BMC Psychiatry. 2017;17(1):329–329.
21. Alejandro EU, Mamerto TP. Gestational diabetes mellitus: a harbinger of the vicious cycle of diabetes. UMS. 2020. https://doi.org/10.3390/ijms21145003.
22. Rasmussen L, et al. Diet and healthy lifestyle in the management of gestational diabetes mellitus. Nutrients. 2020;12(10):3050.
23. Brown Will SE. Perioperative nursing care in obstetrics and gynecology. AORN J. 2019;110(2):130–3.
24. Kijmanawat A, Panburana P, Reutrakul S. Effects of probiotic supplements on insulin resistance in gestational diabetes mellitus: a double-blind randomized controlled trial. J Diabetes Investig. 2019;10(1):163–70.
25. Martis R, et al. Enablers and barriers for women with gestational diabetes mellitus to achieve optimal glycaemic control – a qualitative study using the theoretical domains framework. BMC Pregnancy Childbirth. 2018;18(1):91.
26. Juan J, Yang H. Prevalence, prevention, and lifestyle intervention of gestational diabetes mellitus in China. Int J Environ Res Public Health. 2020. https://doi.org/10.3390/ijerph17249517.
27. Ihler F, Canis M. The role of the internet for healthcare information in otorhinolaryngology. Laryngorhinootologie. 2019;98(S 01):S290-S333.
28. Omboni S, Campolo L, Panzeri E. Telehealth in chronic disease management and the role of the Internet-of-Medical-Things: the Tholomeus® experience. Expert Rev Med Devices. 2020;17(7):659–70.
29. Catalano PM. The impact of gestational diabetes and maternal obesity on the mother and her offspring. J Dev Orig Health Dis. 2010;14(4):208–15.
30. McDonald VM, Roberts M, Inder K, et al. The respiratory nurse in pulmonary rehabilitation. In: Clini E, et al., editors. Textbook of pulmonary rehabilitation. Cham: Springer International Publishing; 2018. p. 183–94.
31. Shin JY, Hendrix CC. Management of patients with Parkinson disease. Nurse Pract. 2013;38(10):34–43.
32. Wheeler A. The modern role of the clinical nurse specialist in colorectal cancer in a district general hospital. Current Colorectal Cancer Reports. 2014;10(2):140–6.
33. Walker J. The role of the nurse in the management of osteoporosis. Br J Nurs. 2010;19(19):1243–7.
34. Currier JM, et al. Spiritual struggles and mental health outcomes in a spiritually integrated inpatient program. J Affect Disord. 2019;249:127–35.
35. Kang M, et al. Exploring behaviours of concern including aggression, self-harm, sexual harm and absconding within an Australian inpatient mental health service. Australas Psychiatry. 2020;28(4):394–400.
36. Van Keer R-L, et al. Conflicts between healthcare professionals and families of a multi-ethnic patient population during critical care: an ethnographic study. Crit Care. 2015;19(1):441.

Publisher’s Note
Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.