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CLINICAL TRIAL REPORT

Effectiveness of an Individualized Diabetes Health Education Program Using Real-Time Continuous Glucose Monitoring in Improving Blood Glucose: A Pilot Interventional Study on Subjects with Prediabetes

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Background: While lifestyle modification remains fundamental for prediabetes management, the potential added value of real-time continuous glucose monitoring (RT-CGM) in diabetes health education programs warrants investigation. This study evaluated whether an individualized diabetes health education program using RT-CGM could improve glycemic control compared to general dietary guidance in prediabetic individuals.

Methods: In this randomized controlled trial conducted at Guangdong Provincial People's Hospital (initiated September 2022), we enrolled 41 adults (>18 years) with prediabetes, randomly assigning them to either: (1) RT-CGM group (n=20) receiving meal adjustments based on continuous glucose data and energy balance, or (2) control group (n=21) receiving adjustments based solely on energy balance. The study comprised two intensive 14-day education sessions (baseline and 1-year follow-up) with metabolic assessments (HbA1c, fasting blood glucose, BMI, lipid profile, and uric acid) conducted at baseline, 1-year, and 2-year timepoints.

Results: The RT-CGM group demonstrated significantly greater improvements in HbA1c compared to controls at both 1-year ($p=0.007$) and 2-year ($p=0.033$) follow-ups.

Conclusion: Our findings suggest that incorporating RT-CGM into diabetes health education program can enhance glycemic control in prediabetic individuals compared to general dietary guidance alone. These results support the potential clinical utility of RT-CGM in prediabetes management strategies.

Keywords: diabetes self-management education, prediabetes, continuous glucose monitoring, glycosylated hemoglobin

Introduction

Against the backdrop of China's economic development, public health consciousness has markedly increased, particularly regarding proactive health management. This trend coincides with the nation's escalating diabetes prevalence, driving substantial demand for evidence-based health guidance.

Prediabetes represents a critical metabolic intermediate state characterized by impaired fasting glucose and/or glucose intolerance, yet falling below diagnostic thresholds for diabetes. Left unmanaged, this condition carries significant progression risk to overt diabetes mellitus. Clinically, prediabetes frequently clusters with other metabolic abnormalities, including overweight/obesity, dyslipidemia, and hyperuricemia. These metabolic disturbances reflect early systemic dysregulation. When compensatory mechanisms become overwhelmed, they may culminate in overt metabolic disorders

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such as type 2 diabetes mellitus, hypertension, and hyperlipidemia - conditions that frequently exhibit pathophysiological interdependence. According to the *Diabetes Atlas* published by the International Diabetes Federation, 537 million people worldwide had diabetes in 2021, and this number would reach 783 million by 2045.[1] Many diabetes cases are also undiagnosed, accounting for approximately 45% of cases,[2] which illustrates the extent of the prediabetes population. The Report on Nutrition and Chronic Diseases of Chinese Residents (2020) issued by China's National Health Commission revealed that chronic diseases accounted for 88.5% of all-cause mortality in 2019, with longitudinal data demonstrating significant increases in metabolic disorders among adults aged ≥18 years between 2015 and 2020: diabetes prevalence rose from 9.7% to 11.9%, hypertension rates increased from 25.2% to 27.5%, and hypercholesterolemia escalated from 6.3% to 8.2%, collectively illustrating an accelerating burden of metabolic disorders during China's epidemiological transition that demands urgent public health interventions. Despite significant advances in pharmacotherapy, including the development of novel antidiabetic agents and insulin analogs, the global diabetes epidemic continues to escalate unabated. In its 2022 Standards of Medical Care in Diabetes, the American Diabetes Association (ADA) explicitly emphasized that structured lifestyle interventions can significantly improve glycemic control in individuals with diabetes and prevent disease progression in those with prediabetes.[3] Moreover, training on health self-management is particularly important for people with prediabetes.[4,5] Comprehensive diabetes self-management education (DSME) programs have demonstrated efficacy in facilitating patient engagement with lifestyle modifications, which constitutes a cornerstone for achieving optimal glycemic targets and reducing diabetes-related complications. Multiple clinical trials have established that structured DSME programs incorporating dietary modification, aerobic exercise, medication adherence, and glucose monitoring significantly improve glycemic control and reduce diabetes-related complications.[6–8] A disconnect exists between public enthusiasm for healthier diets and the availability of reliable, research-based nutritional advice.

Real-time continuous glucose monitoring (RT-CGM) represents an advanced minimally invasive technology that provides dynamic assessment of interstitial glucose levels through measurements recorded at 5-minute intervals. This system offers 24-hour continuous monitoring with simultaneous data transmission to both patient-facing mobile applications and clinician portals. The collected values demonstrate strong correlation with capillary blood glucose measurements. A standard 14-day monitoring period enables comprehensive evaluation of glycemic variability, facilitating data-driven therapeutic decisions by healthcare providers and enhanced self-management by patients.[9–15] This study aimed to evaluate the efficacy of integrating RT-CGM into personalized diabetes health education programs by examining its impact on long-term glycemic control, as measured by changes in glycosylated hemoglobin (HbA1c) levels among individuals with prediabetes.

Materials and Methods

Ethical Consideration

Ethics approval was obtained from the Ethics Committee of Guangdong Provincial People's Hospital (Guangdong Academy of Medical Sciences), Southern Medical University (KY-Z-2022-079-01). All subjects signed an informed consent form.

Study Subjects

This was a non-blinded, randomized controlled study. It took each study subject two years to complete the experiment. During this period, two sessions of individualized diabetes health education (each lasting 14 days) and two health check-ups were required. Eligible subjects were recruited from adult health checkups at Guangdong Provincial People's Hospital on September 1, 2022. Study participants were recruited from individuals undergoing routine health examinations at our hospital. The inclusion criteria comprised: (1) age ≥18 years; (2) documented glycemic abnormalities (fasting plasma glucose 6.1–6.9 mmol/L and/or 2-hour postprandial glucose 7.8–11.0 mmol/L and/or HbA1c 5.7–6.4%) based on at least one medical record, with single-test eligibility adopted to identify individuals at risk of dysglycemia while facilitating recruitment. Exclusion criteria included: (1) established diabetes; (2) use of weight-loss, antihypertensive, lipid-lowering, or uric acid-lowering medications; (3) hepatic insufficiency/failure; (4) severe cardiorespiratory dysfunction; (5) active malignancies; (6) psychiatric disorders including generalized anxiety; (7) impaired digestive function due to recent gastrointestinal surgery or chronic disorders; (8) stage 3+ chronic kidney disease; (9) hematological disorders (eg, anemia, thalassemia); and (10) pregnancy. We screened 100 potential participants. After excluding 14 decliners and 17 ineligible subjects, 69 were randomized (1:1) to RT-CGM or control groups using a computer-generated random number sequence. Twenty-eight participants discontinued during follow-up, resulting in 41 evaluable subjects (RT-CGM: n=21; control: n=20) completing the 24-month protocol.

Study Design

Baseline Demographic and Clinical Characteristics

Prior to intervention initiation, comprehensive baseline data were collected for all participants, including demographic characteristics (sex, age, education level, and contact information), metabolic parameters [fasting plasma glucose (FPG), HbA1c, body mass index (BMI), lipid profile (total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), and low-density lipoprotein cholesterol (LDL-C)), and uric acid (UA)], and dietary patterns (daily meal frequency including supplementary snacks and late-night meals, and meal timing distribution).

Individualized Diabetes Health Education

60-Minute Didactic Lecture

Our research team included one internal medicine physician as the study initiator, four clinical dietitians responsible for nutritional guidance, and eight nurses plus four research coordinators providing implementation support. Subjects were randomly assigned to either the RT-CGM group or control group, with both groups receiving a standardized 60-minute didactic lecture delivered by a board-certified internist to groups of approximately 10 subjects. The curriculum covered: (1) fundamental knowledge of type 2 diabetes including epidemiology, etiology, clinical manifestations and complications; (2) total daily energy expenditure (TDEE) calculation by multiplying basal metabolic rate (BMR) (Mifflin-St Jeor equation [Formula S1]) by physical activity level(PAL) values (self-reported activity [Table S1]); (3) practical training in food calorie calculation requiring pre-meal documentation of food type/weight with photographic records using China Food Composition Tables Standard Edition; and (4) training on using China Food Composition Tables Standard Edition to look up food glycemic index (GI) values. Following the educational intervention, all subjects received 14 days of dietary guidance from registered dietitians.

RT-CGM Group Protocol

Subjects in the RT-CGM group wore RT-CGM devices (Shenzhen Si Sensor Technology Co., Ltd., China) that measured interstitial glucose levels every 5 minutes for 14 consecutive days (336 hours). Monitoring data were transmitted in real-time to both subjects and researchers through dedicated mobile applications. All subjects calculated their TDEE and maintained detailed dietary records, including weighed food portions and photographic documentation of each meal, which were submitted via the RT-CGM application. Registered nurses or research coordinators verified the accuracy of TDEE calculations and dietary records on days 3, 7, 10, and 14 through WeChat. When calculation errors were identified, research staff provided corrective guidance via voice messages.

At 21:00 daily, registered nurses or research coordinators compiled each subject's daily dietary energy intake, TDEE, and glycemic parameters (TIR/TAR/TBR) for dietitian analysis. The nutritional intervention protocol included: (1) positive feedback when TIR targets were achieved; (2) for TIR ≤70% and TAR ≥17%, identification of meals associated with hyperglycemic periods and recommendations for dietary adjustments the following day; and (3) for TIR ≤70% and TBR ≥12%, guidance to prevent meal skipping or excessive caloric restriction. All communications were delivered by research nurses. By the end of the initial intervention phase, all subjects demonstrated proficiency in TDEE calculation, dietary energy estimation, food GI querying, RT-CGM operation, and understanding of TIR optimization principles.

Control Group Protocol

Subjects in the control group did not wear RT-CGM devices. All subjects were required to calculate their TDEE and maintain detailed dietary records, including weighed food portions and photographic documentation of each meal, which were submitted through WeChat. Registered nurses or research coordinators verified the accuracy of TDEE calculations and dietary records on days 3, 7, 10, and 14 via WeChat to reinforce proper methodology. When calculation errors were identified, research staff provided corrective guidance through voice messages.

At 21:00 daily, registered nurses or research coordinators compiled each subject's dietary energy intake and TDEE data for dietitian analysis. Based on energy balance status, the nutritional intervention included: (1) for subjects with positive energy balance, recommendations to reduce caloric intake; and (2) for subjects with negative energy balance, guidance to increase caloric intake. All communications were delivered by research nurses following the dietitians' recommendations. By the completion of the initial phase, all subjects demonstrated proficiency in TDEE calculation, food GI querying and dietary energy estimation, with the goal of achieving neutral energy balance.

All subjects were instructed to maintain their baseline physical activity levels throughout the study period. After completing the 14-day diabetes education program, subjects from both groups were expected to independently apply the acquired knowledge to manage their glucose levels through dietary control. The first metabolic assessment was scheduled at the 12-month follow-up.

Follow-up Protocol

During the 12-month follow-up period, subjects could consult the research team through WeChat or the RT-CGM application with nurses and research coordinators providing responses within 24 hours regarding TDEE calculation methods, food calorie computation, food GI querying, RT-CGM wearing procedures, and RT-CGM parameter interpretation, while quarterly active follow-ups were conducted via telephone or video call requiring subjects to demonstrate TDEE and food calorie calculation methods, report weekly frequency of food calorie tracking, explain RT-CGM wearing and data interpretation methods (for RT-CGM group only), describe the clinical significance of TIR, TAR and TBR parameters (for RT-CGM group only), report quarterly RT-CGM usage frequency (for RT-CGM group only), and confirm their continued participation willingness.

1-Year Follow-Up

One year after completing the diabetes education program, all subjects returned for metabolic assessments including HbA1c, FPG, BMI, TC, TG, HDL-C, LDL-C, and UA. Within one-week post-assessment, subjects began the second 14-day education session, which repeated the initial program's content and format. Follow-up procedures were identical to the first year's protocol.

2-Year Follow-Up

At 24 months (one year after the second education session), subjects completed the same panel of metabolic tests. The complete study timeline is presented in Figure 1

Laboratory Tests

HbA1c was the main indicator for assessing the effectiveness of the diabetes health education. Metabolic indicators such as FPG, BMI, blood lipids, and UA were used as secondary indicators.

Statistical Analysis

Statistical analysis was performed using SPSS 21 (version 21.0, IBM Corp., Armonk, NY, USA). Normality was tested using P–P plots. Measures with normal or near-normal distribution were described using mean ± standard deviation, and Independent Samples *t*-test were used to compare the means between the two groups. Longitudinal changes in HbA1c levels were analyzed using repeated-measures analysis of variance (ANOVA). Count data were described using frequencies and percentages (%), and comparisons between groups were made using the chi-square test. The test level was set to $\alpha = 0.05$.

Results

Baseline Demographic and Clinical Profiles

There was a total of 41 subjects, with 20 in the RT-CGM group and 21 in the control group. In terms of the basic characteristics of the subjects prior to the experiment, there were no significant differences between the two groups in age (P = 0.107), sex (P = 0.160), education level (P = 0.477), height (P = 0.067), weight (P = 0.656), BMI (P = 0.324), LDL-

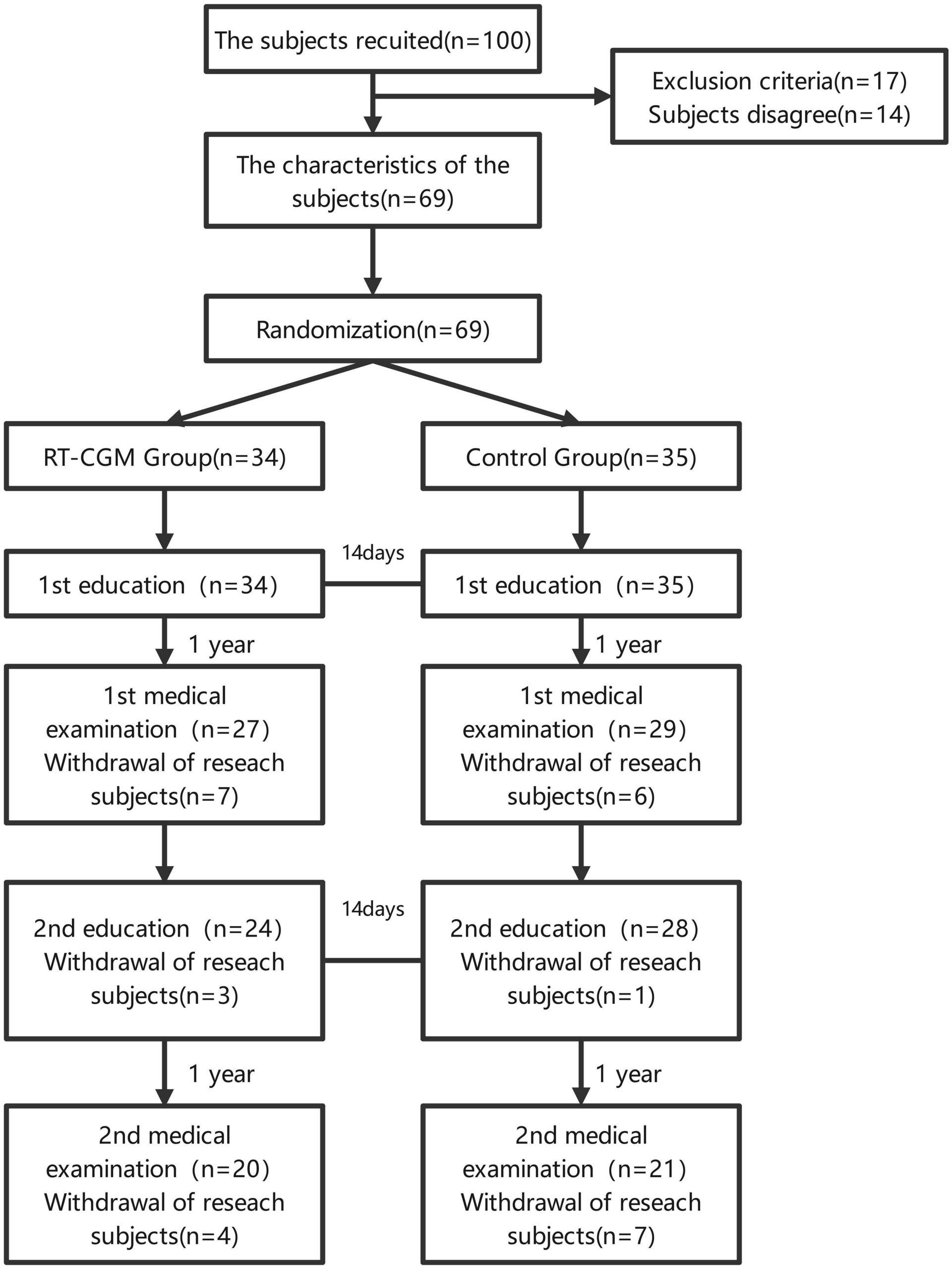

Figure 1 Study Frame.
Abbreviation: RT-CGM, real-time continuous glucose monitoring.

C (P = 0.172), TC (P = 0.528), TG (P = 0.895), UA (P = 0.112), FPG (P = 0.201), and HbA1c (P = 0.193). Statistically significant difference was only seen in HDL-C (P = 0.048) (Table 1).

Results of the First Medical Examination

All participants in both the RT-CGM and control groups underwent standardized physical examinations at the 12-month follow-up visit. There were significant differences between the two groups in HbA1c level (P = 0.007) and UA (P = 0.035). However, no significant differences were seen in weight (P = 0.556), BMI (P = 0.677), HDL-C (P = 0.110), LDL-C (P = 0.157), TC (P = 0.658), TG (P = 0.645), and FPG (P = 0.100) (Table 2).

Table 1 Baseline Characteristics

Variables	RT-CGM Group (n=20)	Control Group (n=21)	X^2 or *t*	*p*-value
Age	55.65±9.48	60.81±10.50	−1.649	0.107
Sex			1.977	0.160
Male	10 (50%)	15 (71.4%)		
Female	10 (50%)	6 (28.6%)		
Education			0.506	0.477
≤High school	3 (15%)	5 (23.8%)		
≥College	17 (85%)	16 (76.2%)		
Height	162.55±6.38	157.81±9.36	1.885	0.067
Weight	60.68±10.47	59.3±9.21	0.449	0.656
BMI	22.88±2.97	23.74±2.56	−1.000	0.324
HDL-C	1.58±0.38	1.57±0.27	2.046	0.048
LDL-C	3.14±1.02	3.55±0.83	−1.39	0.172
TC	5.21±1.26	5.44±1.06	−0.636	0.528
TG	1.24±0.60	1.22±0.50	0.133	0.895
UA	359.46±75.05	401.91±90.85	−1.626	0.112
FPG	5.24±0.76	5.66±1.20	−1.301	0.201
HbA1c	5.86%±0.78%	6.17%±0.74%	−1.325	0.193

Abbreviations: BMI, body mass index; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; TC, total cholesterol; TG, triglycerides; UA, uric acid; FPG, fasting plasma glucose; HbA1c, glycosylated hemoglobin.

Table 2 Differences of the 1st Medical Examination According to Group

Variables	RT-CGM Group (n=20)	Control Group (n=21)	*t*	*p*-value
Weight	61.84±10.86	59.96±9.34	0.595	0.556
BMI	23.28±3.31	23.70±3.05	−0.420	0.677
HDL-C	1.60±0.39	1.42±0.31	1.636	0.110
LDL-C	3.13±0.82	3.49±0.79	−1.444	0.157
TC	5.31±1.11	5.46±0.97	−0.446	0.658
TG	1.37±0.88	1.26±0.51	0.465	0.645
UA	341.84±87.55	406.43±100.69	−2.187	0.035

(*Continued*)

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Table 2 (Continued).

Variables	RT-CGM Group (n=20)	Control Group (n=21)	*t*	*p*-value
FPG	5.40±0.92	6.02±1.40	−1.682	0.100
HbA1c	5.68%±0.66%	6.36%±0.85%	−2.841	0.007

Abbreviations: BMI, body mass index; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; TC, total cholesterol; TG, triglycerides; UA, uric acid; FPG, fasting plasma glucose; HbA1c, glycosylated hemoglobin.

Results of the Second Medical Examination

All participants in both the RT-CGM and control groups underwent standardized physical examinations at the 24-month follow-up timepoint. There were significant differences between the two groups in HbA1c (P = 0.033) and LDL-C (P = 0.042). However, no significant differences were seen in weight (P = 0.427), BMI (P = 0.932), HDL-C (P = 0.687), TC (P = 0.333), TG (P = 0.990), UA (P = 0.112), and FPG (P = 0.756) (Table 3).

Changes in HbA1c

HbA1c is a clinically established marker of average blood glucose levels over the preceding three months. In the RT-CGM group, HbA1c levels showed a downward trend after receiving RT-CGM-based individualized diabetes management. However, no statistically significant differences were found between baseline and follow-up measurements at one and two years (P=0.32; Table 4).

Discussion

This study evaluated the effectiveness of an individualized diabetes health education program incorporating RT-CGM technology for improving glycemic control in individuals with prediabetes. The results demonstrated that this

Table 3 Differences of the 2nd Medical Examination According to Group

Variables	RT-CGM Group (n=20)	Control Group (n=21)	*t*	*p*-value
Weight	63.00±12.11	60.30±9.32	0.802	0.427
BMI	23.74±3.66	23.66±2.91	0.086	0.932
HDL-C	1.49±0.47	1.44±0.25	0.406	0.687
LDL-C	3.09±0.78	3.65±0.92	−2.101	0.042
TC	5.15±1.07	5.48±1.08	−0.979	0.333
TG	1.39±0.74	1.39±0.72	−0.012	0.990
UA	349.84±101.80	402.05±103.48	−1.628	0.112
FPG	5.68±1.15	5.79±1.19	−0.313	0.756
HbA1c	5.74%±0.54%	6.1%±0.50%	−2.216	0.033

Abbreviations: BMI, body mass index; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; TC, total cholesterol; TG, triglycerides; UA, uric acid; FPG, fasting plasma glucose; HbA1c, glycosylated hemoglobin.

Table 4 Difference in HbA1c

Group	pre	1 Year Later	2 Year Later	F	p-value
RT-CGM	5.86%±0.78%	5.68%±0.66%	5.74%±0.54%	1.165	0.320
Control	6.17%±0.74%	6.36%±0.85%	6.1%±0.50%	2.480	0.102

Abbreviation: RT-CGM, real-time continuous glucose monitoring.

intervention led to statistically significant improvements in blood glucose levels among the prediabetic population. Furthermore, the RT-CGM device not only served as a glucose monitoring tool but also appeared to facilitate better dietary habit formation in individuals with prediabetes.

Researchers have attempted to motivate patients to develop good dietary habits through diabetes education. Incorporating RT-CGM devices into DSME programs improves the efficacy of health self-management for people with abnormal blood glucose.[16] During the study, it was observed that subjects could directly see the changes in blood glucose after dietary adjustments, resulting in higher subject compliance. RT-CGM provides real-time glucose monitoring data for clinical reference while establishing a well-defined glycemic management target - TIR. This study used HbA1c to assess the effectiveness of the individualized diabetes health education program using RT-CGM. HbA1c is a reliable physiological indicator of the average blood glucose level over the previous three months. Subjects in the RT-CGM group had lower HbA1c levels in both physical examinations than the control group, and the differences were statistically significant (P = 0.007 and 0.033, respectively). During the experiment, except for the two diabetes health education sessions (28 days in total), we neither supervised nor instructed the subjects, relying solely on the subjects' self-management after receiving the education. Compared with baseline measurements, HbA1c levels in the RT-CGM group demonstrated reductions of 0.18% and 0.12% at the first and second follow-up examinations, respectively; however, these changes did not reach statistical significance (P=0.320). Since the subjects in this study were people with prediabetes whose blood glucose levels were not significantly higher than those of healthy individuals, only a mild decrease in HbA1c levels was observed.

Meanwhile, the experiment showed that in the second physical examination, the LDL-C in the RT-CGM group was lower than that in the control group, and the difference was statistically significant (P = 0.042). LDL-C is one of the most common clinical indicators of blood lipids, and it is strongly correlated with mortality from coronary heart disease. Assessment of LDL-C may facilitate the early identification of atherosclerosis risks and may be used to determine the therapeutic effect of lipid-lowering medications. Diabetes and hyperlipidemia are key risk factors for cardiovascular diseases[17,18] and, at the same time, major challenges for public health issues in developing countries.[19] This study demonstrated that an individualized diabetes health education program adopting RT-CGM can change multiple metabolic indicators by improving dietary composition. However, the decrease in LDL-C in the RT-CGM group was not observed in the first physical examination, and we believe that this was related to the long duration of the individualized diabetes education with RT-CGM. The effect may be more pronounced if the frequency of the individualized diabetes education with RT-CGM is increased from once a year to twice or three times a year. The frequency of individualized diabetes health education using RT-CGM is also a future direction for research.

Our study revealed no statistically significant differences in body weight or BMI between the two groups (p>0.05), which contradicted our initial hypothesis that glycemic improvement would correlate with weight reduction. This paradoxical outcome may be attributed to participants' selective consumption of low-GI foods while maintaining energy balance. Importantly, GI values are independent of caloric content, as some low-GI foods (eg, nuts, avocados) are energy-dense. During trial orientation, participants were explicitly informed that glycemic control was the primary endpoint, potentially biasing their food selection toward low-GI options without intentional caloric restriction. This suggests glycemic load (GL), which reflects both the glycemic impact of carbohydrate quality (via GI) and the actual consumed quantity, may better predict postprandial metabolic responses and thus serve as a superior dietary guidance metric for prediabetes management.

This study has some limitations. First, after receiving individualized diabetes health education, the subjects managed their dietary health on their own for the following year, during which time the changes in the dietary habits and the self-efficacy of the subjects were not quantitatively assessed. Second, the study protocol included mobile app-based consultations and quarterly follow-ups, but did not involve active dietary monitoring or intervention. These two limitations prevented us from assessing the effectiveness of this educational program on self-efficacy in people with prediabetes. We did this because we wanted to see the real changes in biochemical markers as a result of the individualized diabetes health education with RT-CGM at a frequency of once a year. Third, the 40.6% attrition rate (41.2% intervention vs 40.0% control) may affect generalizability and statistical power. The comparable dropout rates between groups indicate the intervention did not differentially affect retention, with most attrition attributable to hospital transfers rather than study-related factors.

Conclusion

This study demonstrated that incorporating RT-CGM devices into diabetes health education for individuals with prediabetes - using dynamic glucose data for personalized feedback and TIR as the primary glycemic target - significantly improved glycemic regulation. The findings indicate this RT-CGM-based approach effectively enhances self-management capabilities in prediabetic populations, suggesting valuable applications for broader diabetes prevention initiatives. While study limitations including participant attrition warrant consideration, future directions will focus on optimizing the individualized education protocol through enhanced RT-CGM utilization strategies and increased educational engagement frequency to maximize program effectiveness.

Data Sharing Statement

The data that support the findings of this study are available upon reasonable request from the corresponding author. Data are not publicly available due to subject privacy and ethical restrictions.

Ethics Approval Statement

The study was conducted in accordance with the guidelines of the Declaration of Helsinki and was approved by the Ethics Committee of Guangdong Provincial People's Hospital (Guangdong Academy of Medical Sciences), Southern Medical University (KY-Z-2022-079-01) on May 10, 2022.

Clinical Trial Registration

http://www.chictr.org.cn/:ChiCTR2200062707.

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Disclosure

The authors declare no conflicts of interest in this work.

References

1. Sun H, Saeedi P, Karuranga S, et al. IDF Diabetes Atlas: global, regional and country-level diabetes prevalence estimates for 2021 and projections for 2045. *Diabet Res Clin Pract*. 2022;183:109119. PubMed: 34879977. doi:10.1016/j.diabres.2021.109119
2. Magliano DJ, Boyko EJDA. *IDF Diabetes Atlas*. Brussels: International Diabetes Federation; 2021.
3. American Diabetes Association Professional Practice Committee. 5. Facilitating behavior change and well-being to improve health outcomes: standards of medical care in diabetes-2022. *Diabetes Care*. 2022;45(Suppl 1):S60–S82. PubMed: 34964866. doi:10.2337/dc22-S005
4. Zhang Y, Pan X, Chen J, et al. Combined lifestyle factors and risk of incident type 2 diabetes and prognosis among individuals with type 2 diabetes: a systematic review and meta-analysis of prospective cohort studies. *Diabetologia*. 2020;63(1):21–33. PubMed: 31482198. doi:10.1007/s00125-019-04985-9

5. Norris SL, Lau J, Smith SJ, Schmid CH, Engelgau MM. Self-management education for adults with type 2 diabetes: a meta-analysis of the effect on glycemic control. *Diabetes Care*. 2002;25(7):1159–1171. PubMed: 12087014. doi:10.2337/diacare.25.7.1159
6. Sarkadi A, Rosenqvist U. Experience-based group education in Type 2 diabetes: a randomised controlled trial. *Patient Educ Couns*. 2004;53 (3):291–298. PubMed: 15186866. doi:10.1016/j.pec.2003.10.009
7. Hara Y, Hisatomi M, Ito H, Nakao M, Tsuboi K, Ishihara Y. Effects of gender, age, family support, and treatment on perceived stress and coping of patients with type 2 diabetes mellitus. *Biopsychosoc Med*. 2014;8:16. PubMed: 25075211. doi:10.1186/1751-0759-8-16
8. Parkin CG, Davidson JA. Value of self-monitoring blood glucose pattern analysis in improving diabetes outcomes. *J Diabetes Sci Technol*. 2009;3 (3):500–508. PubMed: 20144288. doi:10.1177/193229680900300314
9. Wainstein J, Metzger M, Boaz M, et al. Insulin pump therapy vs. multiple daily injections in obese Type 2 diabetic patients. *Diabetic Med*. 2005;22 (8):1037–1046. PubMed: 16026370. doi:10.1111/j.1464-5491.2005.01597.x
10. Wiesli P, Krayenbuhl P, Uthoff H, Seifert B, Schmid C. Omitting breakfast and lunch after injection of different long-acting insulin preparations at bedtime: a prospective study in patients with type 2 diabetes. *Diabetologia*. 2009;52(9):1816–1819. PubMed: 19565212. doi:10.1007/s00125-009-1439-z
11. Bao Y, Zhou J, Zhou M, et al. Glipizide controlled-release tablets, with or without acarbose, improve glycaemic variability in newly diagnosed Type 2 diabetes. *Clin Exp Pharmacol Physiol*. 2010;37(5–6):564–568. PubMed: 20082624. doi:10.1111/j.1440-1681.2010.05361.x
12. Rodriguez LM, Knight RJ, Heptulla RA. Continuous glucose monitoring in subjects after simultaneous pancreas-kidney and kidney-alone transplantation. *Diabetes Technol Ther*. 2010;12(5):347–351. PubMed: 20388044. doi:10.1089/dia.2009.0157
13. Kerssen A, de Valk HW, Visser GHA. Do HbA1c levels and the self-monitoring of blood glucose levels adequately reflect glycaemic control during pregnancy in women with type 1 diabetes mellitus? *Diabetologia*. 2006;49(1):25–28. PubMed: 16341689. doi:10.1007/s00125-005-0057-7
14. Stenninger E, Lindqvist A, Aman J, Ostlund I, Schvarcz E. Continuous subcutaneous glucose monitoring system in diabetic mothers during labour and postnatal glucose adaptation of their infants. *Diabetic Med*. 2008;25(4):450–454. PubMed: 18387079. doi:10.1111/j.1464-5491.2008.02416.x
15. Bailey KJ, Little JP, Jung ME. Self-monitoring using continuous glucose monitors with real-time feedback improves exercise adherence in individuals with impaired blood glucose: a pilot study. *Diabetes Technol Ther*. 2016;18(3):185–193. PubMed: 26885934. doi:10.1089/dia.2015.0285
16. Lee S, Shin D, Kim Y, Lee K. 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;16(18). PubMed: 31505892. doi:10.3390/ijerph16183323
17. Aune D, Schlesinger S, Neuenschwander M, et al. Diabetes mellitus, blood glucose and the risk of heart failure: a systematic review and meta-analysis of prospective studies. *Nutr Metab Cardiovasc Dis*. 2018;28(11):1081–1091. PubMed: 30318112. doi:10.1016/j.numecd.2018.07.005
18. Xing L, Jing L, Tian Y, et al. Epidemiology of dyslipidemia and associated cardiovascular risk factors in northeast China: a cross-sectional study. *Nutr Metab Cardiovasc Dis*. 2020;30(12):2262–2270. PubMed: 32988725. doi:10.1016/j.numecd.2020.07.032
19. Teo KK, Rafiq T. Cardiovascular risk factors and prevention: a perspective from developing countries. *Can J Cardiol*. 2021;37(5):733–743. PubMed: 33610690. doi:10.1016/j.cjca.2021.02.009