Society for Endocrinology
European Society of Endocrinology

Endocrine Connections (2025) **14** e240576
https://doi.org/10.1530/EC-24-0576

Received 12 November 2024
Accepted 11 February 2025
Available online 12 February 2025
Version of Record published 24 February 2025

RESEARCH

Effectiveness of internet-based management in newly diagnosed young adults with type 2 diabetes: a prospective comparative study

Zhi Li[1], Dahang Luo[2] and Zhongjin Li[3]

[1]Department of Endocrinology and Metabolism, The Affiliated Shunde Hospital of Jinan University/The Second People's Hospital of Shunde, Foshan, China
[2]Department of Emergency Medicine, The Affiliated Shunde Hospital of Jinan University/The Second People's Hospital of Shunde, Foshan, China
[3]Department of Pharmacy, The Affiliated Shunde Hospital of Jinan University/The Second People's Hospital of Shunde, Foshan, China

Correspondence should be addressed to Z Li: hyg6181sci@163.com

Abstract

Background: The incidence of type 2 diabetes mellitus (T2DM) is rising among young adults, posing challenges for long-term management after discharge.

Methods: This prospective comparative study included 120 newly diagnosed young adults with T2DM admitted between January and December 2023. Participants were randomized into intervention or control groups (n = 60 each). All patients received standard diabetes education and short-term insulin pump intensive therapy during hospitalization. After discharge, the control group received traditional care, while the intervention group utilized an internet-based management system incorporating continuous glucose monitoring, personalized feedback and remote healthcare team consultations. Primary outcomes included HbA1c, fasting blood glucose (FBG), insulin resistance (HOMA-IR) and β-cell function (HOMA-β and fasting C-peptide). Secondary outcomes included lipid profiles, renal function (urine albumin/creatinine ratio (UACR)), blood pressure, quality of life (SF-36) and depression scores (PHQ-9).

Results: At 12 months, the intervention group had significantly lower HbA1c (6.5 vs 7.2%, P < 0.001) and better improvements in FBG, HOMA-IR, HOMA-β, fasting C-peptide, triglycerides and low-density lipoprotein cholesterol (P < 0.01). Improvements in UACR and blood pressure were minimal (P > 0.05). SF-36 and PHQ-9 scores improved more significantly in the intervention group (P < 0.01). Diabetes remission rates were higher in the intervention group (60 vs 37%, P = 0.028) and remained significant after adjusting for baseline variables (P = 0.015).

Conclusion: The internet-based management system with personalized feedback significantly improved glycemic control and quality of life in young adults with T2DM.

Keywords: personalized feedback; internet-based management; type 2 diabetes; young adults; glycemic control

Introduction

Type 2 diabetes mellitus (T2DM) has traditionally been considered a disease of older adults. However, in recent decades, the incidence of T2DM among young adults aged 18–40 has shown a worrying upward trend (1). This trend is primarily attributed to rising obesity rates, increasingly sedentary lifestyles and poor dietary habits prevalent among this age group (2). T2DM in young adults presents unique challenges, often marked by a more aggressive disease course, early complications and a longer lifetime burden (3).

Published by Bioscientifica Ltd.
https://ec.bioscientifica.com

Endocrine Connections (2025) **14** e240576
https://doi.org/10.1530/EC-24-0576

The management of young adults with T2DM is particularly challenging due to various factors, including competing life priorities, psychosocial issues and the need for long-term adherence to treatment regimens (4). Traditional care models, typically involving infrequent clinic visits and standardized educational programs, often fail to meet the specific needs of this population (5). As a result, young adults with T2DM frequently face poor glycemic control and suboptimal treatment adherence (6).

The rapid development of digital technology offers new opportunities for diabetes management. Internet-based management systems that combine real-time blood glucose monitoring, personalized feedback and educational resources have shown potential in improving outcomes for various chronic diseases (7). However, the effectiveness of such systems in newly diagnosed young adults with T2DM has not been fully explored. This study aims to evaluate the effectiveness of an internet-based management system with personalized feedback in young adults newly diagnosed with T2DM. We hypothesize that this approach will lead to better glycemic control, higher quality of life and improved psychological health compared to standard care. By leveraging technology to provide continuous support and personalized interventions, we aim to address the unique challenges faced by young adults in managing their condition. The findings of this study could have significant implications for clinical practice, offering a more effective and attractive approach to T2DM management in this vulnerable population. In addition, it may provide insights into the role of technology-supported personalized care in improving long-term outcomes for young adults with T2DM.

Methods

Study design

This was a prospective comparative study conducted in the Department of Endocrinology at our hospital from January 2023 to December 2023. Based on the expected effect size (HbA1c difference of 0.5%) and 80% statistical power, each group required 60 participants. Patients were randomly allocated to either the intervention group or the control group in a 1:1 ratio using a computer-generated randomization table. Inclusion criteria were: i) aged 18–40 years; ii) newly diagnosed with type 2 diabetes mellitus (diagnosed within the past 6 months) according to the American Diabetes Association (ADA) criteria (8); and iii) ability to use smartphone and the internet. Exclusion criteria included: i) severe diabetic complications; ii) severe mental illness; and iii) participation in other interventional studies. The study was approved by the Ethics Committee of Shunde Hospital affiliated with Jinan University (approval no. JDSY-LL-2022019), and followed the Declaration of Helsinki. Written informed consent was obtained from all participants before their recruitment.

Intervention

All patients received standard diabetes education and 7-day insulin pump intensive therapy during hospitalization. This treatment is based on the following clinical indications: i) high baseline HbA1c levels (>9%) or severe hyperglycemia (>13.9 mmol/L); ii) evidence of glucose toxicity, including impaired β-cell function and insulin resistance, which may be reversible through short-term intensified insulin therapy; iii) rapid control of blood sugar is needed to prevent acute complications, such as diabetes ketoacidosis or hypertonic hyperglycemia; and iv) newly diagnosed type 2 diabetes mellitus patients, young adults, may benefit from early intensive treatment, which can be alleviated by reducing glucose toxicity and lipid toxicity. This method is supported by previous research, indicating that early intensified insulin therapy can preserve β-cell function and improve long-term blood glucose control (9, 10, 11). After discharge, the control group received standard care, including regular outpatient follow-up and telephone consultations. The intervention group, in addition to standard care, used a customized internet-based management system. Patients used continuous glucose monitoring devices to track blood glucose levels in real time. The blood glucose data were automatically uploaded to the management platform and summarized daily, weekly and monthly. The system paid special attention to the frequency and duration of hyperglycemic (>10 mmol/L) and hypoglycemic (<3.9 mmol/L) events, which were recorded and used as key indicators for subsequent analysis. Based on patients' blood glucose data and body mass index (BMI), the system generated personalized dietary and exercise recommendations, which were updated weekly and pushed to patients through the platform. The system also regularly generated health reports, including trends in glycemic control, hyperglycemic and hypoglycemic events and weight changes, along with suggestions for improvement to help patients optimize management. Patients had access to online educational resources and could consult the healthcare team remotely. The team could review blood glucose data in real time and adjust treatment plans accordingly. The system also reminded patients to schedule regular consultations and follow-ups. The frequency of healthcare team consultations differed between the two groups. In the intervention group, patients had the opportunity to consult the healthcare team remotely through the platform, receiving personalized feedback or guidance 1–2 times per week in addition to quarterly in-person consultations, resulting in an average of 65 interactions over the 12-month period. In the control group, patients received standard care, including monthly in-person visits and bi-monthly telephone consultations, resulting in approximately 22 interactions over the same period. This higher frequency of interaction in the intervention group reflects the accessibility and continuous support provided by the internet-based management system.

Endocrine Connections (2025) **14** e240576
https://doi.org/10.1530/EC-24-0576

Upon discharge, all patients were provided with tailored treatment plans based on their clinical characteristics and glycemic control needs:

Control group: patients in the control group received standard care, which included oral hypoglycemic agents (e.g., metformin as first-line therapy and sulfonylureas or DPP-4 inhibitors, if required). The specific medication and dosage were adjusted during monthly outpatient visits based on glycemic targets and patient tolerance.

Intervention group: patients in the intervention group received a similar pharmacological treatment plan to ensure comparability. However, adjustments to medication were guided not only by in-person evaluations but also by real-time blood glucose monitoring and personalized feedback from the internet-based system.

Both groups followed the ADA guidelines for stepwise diabetes management, and no significant differences in the types of prescribed medications or their dosages were observed at the time of discharge. This ensured that pharmacological treatments were comparable between the groups, allowing for a focused evaluation of the internet-based management system's impact.

Anthropometric measurements

Height was measured to the nearest 0.1 cm using a portable stadiometer. Weight was measured using a calibrated scale with a precision of 0.1 kg. BMI was calculated by dividing the weight in kilograms by the square of the height in meters (kg/m^2).

Biochemical analysis

Blood samples were obtained at the start of the study (upon enrollment), and subsequently at 6 and 12 months during the follow-up period. Participants were instructed to fast for a minimum of 12 h before each scheduled visit. Glycemic control indicators included HbA1c (measured by HPLC) and fasting blood glucose (FBG, measured by the glucose oxidase method). Assessments of glucose metabolism and insulin function included fasting insulin (FINS, measured by chemiluminescent immunoassay), fasting C-peptide (measured by electrochemiluminescent immunoassay), with HOMA-β and HOMA-IR calculated. Lipid profiles, including total cholesterol (TC), triglycerides (TG), low-density lipoprotein cholesterol (LDL-C) and high-density lipoprotein cholesterol (HDL-C), were measured at baseline, 6 months and 12 months using enzymatic or direct methods. HOMA-IR was calculated using the formula: (FBG (mmol/L) × fasting serum insulin (mIU/mL))/22.5. HOMA-β was calculated using the following formula: HOMA-β = 20 × FINS (μU/mL)/FBG (mmol/L) − 3.5. Urine microalbumin and urine creatinine were measured at baseline and 12 months, with the urine albumin/creatinine ratio (UACR) calculated. Blood pressure was measured at each follow-up visit using an Omron HEM-7120 automatic blood pressure monitor, with the patient resting for 5 min before measuring the right arm blood pressure in a seated position. Blood pressure was measured three times at 1-min intervals, with the average value recorded. After collection, blood samples were promptly centrifuged and the serum was isolated and stored at −80°C for later analysis. Urine samples, collected as the first morning void, were stored at −20°C until analysis. All biochemical parameters were analyzed in batches at the hospital's central laboratory, which participates in the National Health Commission's External Quality Assessment Program to ensure the accuracy and comparability of the results.

Psychological and behavioral assessments

At baseline and during follow-up, specifically at enrollment, 3, 6 and 12 months, quality of life was assessed using the Chinese version of the SF-36 questionnaire (12), and depressive symptoms were evaluated using the PHQ-9 questionnaire (13). All questionnaire assessments were conducted by trained research assistants in a quiet and private setting to ensure the accuracy and reliability of the data.

Diabetes remission definition and assessment

Diabetes remission was defined as achieving and maintaining HbA1c levels below 6.5% (14) for at least three months without the use of insulin or additional oral hypoglycemic agents beyond the initial treatment plan provided at discharge. Patients' medication regimens were verified during follow-up visits and through self-reported adherence logs and data from the internet-based management system (for the intervention group).

Statistical methods

Continuous variables following a normal distribution are presented as the means ± standard error of the mean, whereas non-normally distributed data are reported as the medians with interquartile ranges. Categorical variables are summarized as percentages or proportions. Group comparisons were conducted using the Student's *t*-test, Mann–Whitney *U* test or χ^2 test, depending on the data type. Repeated measures ANOVA were used to analyze changes in key outcomes over time. For pairwise comparisons between time points in repeated measures ANOVA, post-hoc analysis was conducted using unpaired *t*-tests. Multivariate logistic regression was applied to evaluate the relationship between baseline glycemic control indicators and the 12-month diabetes remission rates, with adjustments made for potential confounding factors. Odds ratios (ORs) and 95% confidence intervals (CIs) were computed for each standard deviation increment and quartile of glycemic control indicators. All statistical analyses were performed using the SPSS version 25.0 (IBM, USA), R version 3.6.3 and Python

Endocrine Connections (2025) **14** e240576
https://doi.org/10.1530/EC-24-0576

version 3.7. A two-tailed P value of <0.05 was deemed statistically significant.

Results

Baseline characteristics

Table 1 summarizes the baseline characteristics of the participants, showing no statistically significant differences between the intervention and control groups across all assessed variables, including demographic factors (age and sex), anthropometric measurements (BMI), glycemic control markers (HbA1c, FBG, HOMA-IR and fasting C-peptide), lipid profiles (TG, LDL-C and HDL-C), blood pressure (systolic blood pressure (SBP) and diastolic blood pressure (DBP)) and renal function (UACR). These findings confirm that the two groups were well-matched at baseline, ensuring comparability for subsequent analyses.

Metabolic improvements and long-term effects of the intervention

During the 12-month follow-up period, repeated measures ANOVA revealed significant main effects of time (P < 0.001) and group (P = 0.010) on glycemic and metabolic parameters, and significant time × group interaction effects for HbA1c (P = 0.003), FBG (P = 0.008), HOMA-IR (P = 0.015) and HOMA-β (P = 0.022). Both groups experienced reductions in HbA1c and FBG levels over 12 months, but the intervention group achieved significantly greater reductions at 3 months (P = 0.018), 6 months (P = 0.005) and 12 months (P < 0.001). Specifically, the intervention group demonstrated an average decrease in HbA1c of (−1.8%) at 12 months compared to (−1.2%) in the control group. Similar trends were observed for FBG, where the intervention group showed greater reductions across all time points (P < 0.01). Insulin sensitivity and β-cell function, assessed through HOMA-IR and HOMA-β, improved significantly in both groups, with the intervention group achieving a greater degree of improvement (P < 0.05). Fasting C-peptide levels, an indicator of β-cell function, significantly increased in the intervention group at 6 months (+0.32 ng/mL, P = 0.008) and 12 months (+0.51 ng/mL, P < 0.001). Both groups also demonstrated reductions in lipid profiles, including TC, TG and LDL-C, but the intervention group showed significantly larger decreases in TG (P = 0.012) and LDL-C (P = 0.020) over 12 months. HDL-C exhibited a trend toward improvement in the intervention group, although the change was not statistically significant (P = 0.092). Renal function, as assessed by UACR, demonstrated consistent improvements in the intervention group over 12 months, with a modest reduction observed compared to baseline, while the control group showed minimal changes, and no statistically significant differences were detected between groups. Blood pressure exhibited slight declines in both groups. At 12 months, the intervention group experienced an average reduction in SBP of approximately −0.9 mmHg and DBP of −0.6 mmHg, while the control group showed negligible changes. These findings indicate that while the internet-based intervention effectively improved glycemic control, insulin sensitivity and lipid profiles, its impact on renal function and blood pressure was less pronounced and not statistically significant. Dynamic changes over the four time points (baseline, 3, 6 and 12 months) were analyzed to provide further insights (P > 0.05). Detailed results for key parameters, including their dynamic changes over four time points (baseline, 3, 6 and 12 months). These results are detailed in Fig. 1.

Table 1 Baseline characteristics of the intervention and control groups.

Variable	Intervention group (n = 60)	Control group (n = 60)	P
Age (years)	28.5 ± 0.80	29.1 ± 0.76	0.72
Sex (male %)	52%	50%	0.85
BMI (kg/m^2)	26.8 ± 0.55	27.2 ± 0.53	0.65
HbA1c (%)	8.2 ± 0.17	8.1 ± 0.18	0.80
FBG (mmol/L)	9.1 ± 0.32	9.3 ± 0.34	0.76
HOMA-IR	3.2 ± 0.19	3.3 ± 0.18	0.84
Fasting C-peptide (ng/mL)	2.0 ± 0.12	2.0 ± 0.13	0.78
TG (mmol/L)	2.3 ± 0.15	2.4 ± 0.16	0.81
LDL-C (mmol/L)	3.3 ± 0.10	3.4 ± 0.11	0.77
HDL-C (mmol/L)	1.0 ± 0.19	1.1 ± 0.20	0.83
SBP (mmHg)	120.4 ± 2.1	120.2 ± 2.3	0.74
DBP (mmHg)	80.1 ± 1.8	80.2 ± 1.7	0.79
UACR (mg/g)	14.8 ± 1.8	15.0 ± 1.7	0.81

Continuous variables are expressed as the mean ± SEM, while categorical variables are presented as percentages. P-values were derived using independent t-tests for continuous variables and chi-square tests for categorical variables. P < 0.05 was considered statistically significant. BMI, body mass index; HbA1c, glycated hemoglobin; FBG, fasting blood glucose; HOMA-IR, homeostasis model assessment of insulin resistance; TG, triglycerides; LDL-C, low-density lipoprotein cholesterol; HDL-C, high-density lipoprotein cholesterol; SBP, systolic blood pressure; DBP, diastolic blood pressure; UACR, urinary albumin-to-creatinine ratio.

Quality of life and psychological health

At the 12-month follow-up, the intervention group exhibited a significant increase in SF-36 overall health scores, rising from 65.2 ± 1.33 to 78.4 ± 1.17 (P < 0.01), whereas the control group's scores increased from 64.7 ± 1.42 to 70.5 ± 1.39 (P < 0.01). The enhancement observed in the intervention group was notably greater than that in the control group (P < 0.01).

In terms of psychological health, PHQ-9 scores in the intervention group decreased from 8.4 ± 0.54 to 5.3 ± 0.48 (P < 0.01), compared to a reduction from 8.2 ± 0.53 to 6.9 ± 0.52 in the control group (P < 0.05).

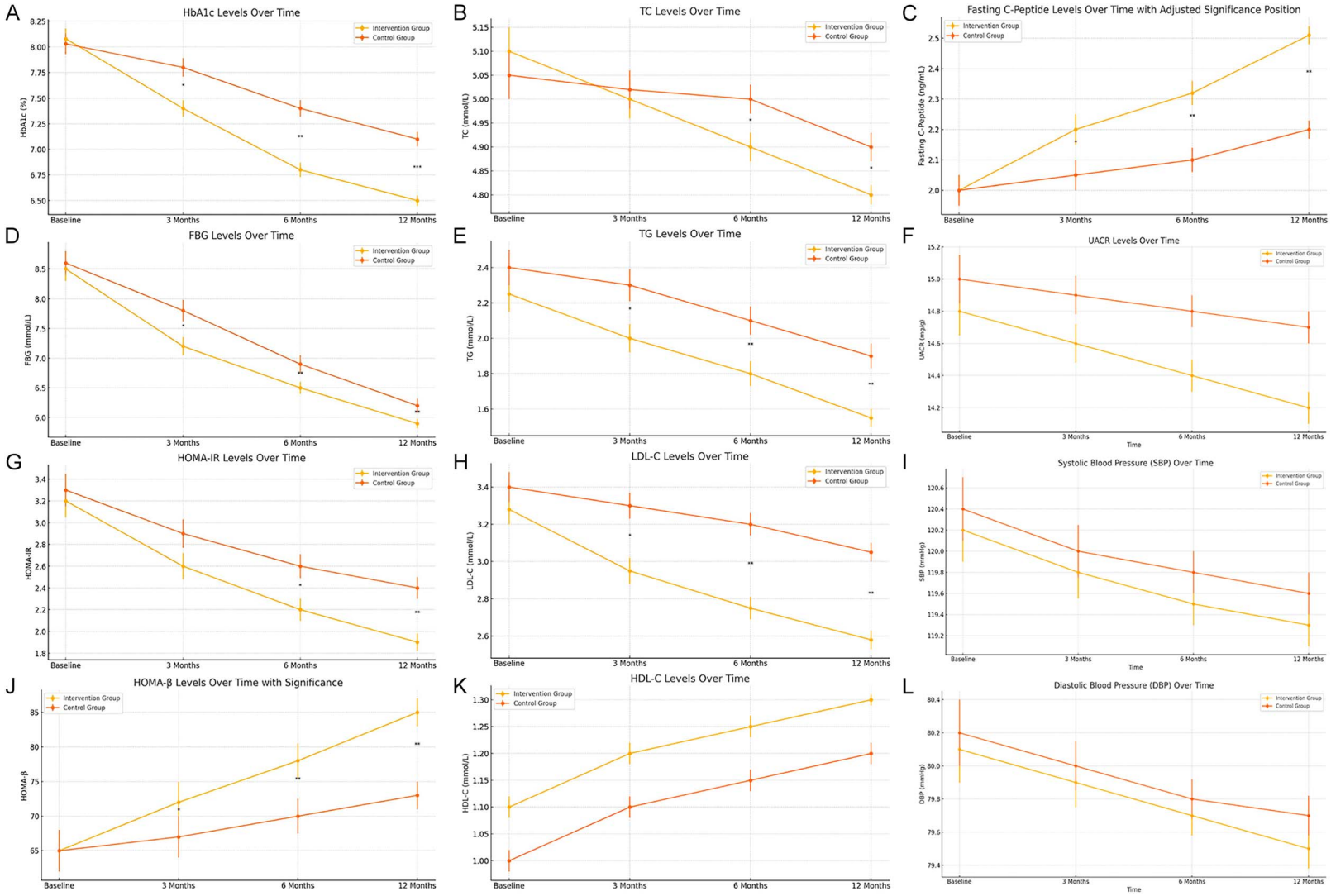

Figure 1

Changes in glycemic, metabolic, renal and cardiovascular parameters over time. Dynamic changes in key clinical parameters, including glycemic control, lipid profiles, renal function and blood pressure, are shown for the intervention and control groups over the 12-month follow-up period. Data are presented as the means ± SEM, and statistical significance for group differences at each time point is denoted by $*P < 0.05$ and $**P < 0.01$, as determined by repeated measures ANOVA. (A) HbA1c, glycated hemoglobin; (B) TC, total cholesterol; (C) fasting C-peptide levels with adjusted significance positions; (D) FBG, fasting blood glucose; (E) TG, triglycerides; (F) UACR, urinary albumin-to-creatinine ratio; (G) HOMA-IR, homeostasis model assessment of insulin resistance; (H) LDL-C, low-density lipoprotein cholesterol; (I) SBP, systolic blood pressure; (J) HOMA-β, homeostasis model assessment of β-cell function; (K) HDL-C, high-density lipoprotein cholesterol; (L) DBP, diastolic blood pressure.

Endocrine Connections (2025) **14** e240576
https://doi.org/10.1530/EC-24-0576

Table 2 Quality of life (SF-36) and psychological health (PHQ-9) scores at baseline and 12 months.

Group	SF-36 score	PHQ-9 score	*P*(SF-36)	*P*(PHQ-9)
Intervention baseline (*n* = 60)	65.2 ± 1.33	8.4 ± 0.54	-	-
Intervention 12 months (*n* = 60)	78.4 ± 1.17	5.3 ± 0.48	<0.01	<0.01
Control baseline	64.7 ± 1.42	8.2 ± 0.53	-	-
Control 12 months	70.5 ± 1.39	6.9 ± 0.52	<0.01	<0.05
Between groups comparison	-	-	<0.01	<0.05

Continuous variables are expressed as the mean ± SEM. The *P* represents the significance of the differences within and between groups. Group comparisons were conducted using independent *t*-tests; $P < 0.05$ was considered statistically significant.

The intervention group demonstrated a significantly more substantial improvement in psychological health compared to the control group ($P < 0.05$) (Table 2).

Diabetes remission rates

Among the 120 participants, 36 patients (60%) in the intervention group and 22 patients (37%) in the control group achieved diabetes remission at the 12-month follow-up ($P = 0.015$) (Table 3).

Diabetes remission rate analysis

Throughout the 12-month follow-up, the diabetes remission rate was significantly higher in the intervention group compared to the control group. In the unadjusted model (Model 1), the intervention group exhibited a notable improvement in remission rates, with an OR of 0.58 (95% CI 0.35–0.95, $P = 0.028$). This effect persisted even after adjustments were made in the subsequent models. Specifically, in Model 2, which accounted for age, BMI and gender, the OR was 0.65 (95% CI 0.42–0.88, $P = 0.015$). In Model 3, which further adjusted for blood lipid levels, HOMA-IR, physical activity, family history of diabetes and other confounding factors, the OR was 0.68 (95% CI 0.45–0.91, $P = 0.012$) (Table 4).

These results indicate that the internet-based personalized management system has a significant clinical benefit in achieving diabetes remission, especially after controlling for multiple potential confounding factors.

Adverse events and hyperglycemia/hypoglycemia events

Over the 12-month follow-up period, both the intervention and control groups experienced adverse events, including episodes of hyperglycemia and hypoglycemia. The intervention group had a significantly lower incidence of hypoglycemia compared to the control group, with an OR of 0.65 (95% CI 0.43–0.98, $P = 0.035$). Similarly, the incidence of hyperglycemia was also reduced in the intervention group, with an OR of 0.75 (95% CI 0.50–1.10, $P = 0.045$) (Table 5).

Table 3 Diabetes remission rates.

Group	Patients achieving remission	Remission rate (%)	*P*
Intervention (*n* = 60)	36	60	0.018
Control (*n* = 60)	22	37	-

The *P* represents the significance of the differences between groups.

These results suggest that the internet-based personalized management system demonstrated certain advantages in blood glucose control and effectively reduced the incidence of adverse events, particularly hyperglycemia and hypoglycemia, providing a safer management option for young adults with type 2 diabetes mellitus.

Discussion

This study sought to assess the effectiveness of an internet-based management system with personalized feedback for newly diagnosed young adults with type 2 diabetes mellitus. The findings revealed significant improvements in core glycemic control indicators, including HbA1c, FBG, HOMA-IR and β-cell function (HOMA-β and fasting C-peptide), in the intervention group compared to the control group. These results suggest that the internet-based management system not only supports effective glycemic control but also enhances the underlying mechanisms of glucose metabolism, such as improved insulin sensitivity and β-cell function. Furthermore, the intervention group demonstrated superior outcomes in diabetes remission rates, quality of life (SF-36) and psychological health

Table 4 Logistic regression analysis of diabetes remission rate.

Model	OR	95% CI	*P*
Model 1	0.58	0.35–0.95	0.028
Model 2	0.65	0.42–0.88	0.015
Model 3	0.68	0.45–0.91	0.012

ORs for diabetes remission were computed using logistic regression analysis. Model 1 is unadjusted. Model 2 includes adjustments for age, BMI and gender. Model 3 incorporates additional adjustments for blood lipid levels, HOMA-IR, physical activity, family history of diabetes and other pertinent factors. A *P*-value of less than 0.05 was considered statistically significant.

Table 5 Comparison of adverse events between the intervention and control groups during the 12-month follow-up.

Event	Intervention group OR (95% CI)	Control group OR (95%CI)	*P*
Hypoglycemia	0.65 (0.43–0.98)	1.00 (reference)	0.035
Hyperglycemia	0.75 (0.50–1.10)	1.00 (reference)	0.045

ORs were calculated using logistic regression analysis. The control group serves as the reference category for comparison. Statistical significance was determined at $P < 0.05$.

(PHQ-9), highlighting the broader benefits of personalized, technology-based care in addressing both physical and psychosocial challenges faced by young adults with type 2 diabetes mellitus.

Numerous studies have highlighted the advantages of personalized interventions and internet-based management systems in diabetes care (15, 16, 17). Consistent with our findings, other research has shown that personalized internet interventions can significantly reduce HbA1c levels. For instance, one study reported an average decrease of 0.7% in HbA1c levels among patients using an internet-based diabetes management system (18). This finding supports our results, indicating the critical role of internet management systems in the long-term glycemic control of diabetes patients.

Moreover, existing literature suggests that internet-based management systems not only improve glycemic control but also positively impact patients' psychological health and quality of life. Study found that diabetic patients receiving online psychological support experienced significant reductions in depressive symptoms and notable improvements in quality of life (19, 20, 21). Our findings align with this, further confirming the beneficial effects of personalized feedback on overall patient health.

The intervention group in our study showed a significantly higher diabetes remission rate than the control group, which is consistent with previous research conclusions. A study indicated that early intensive interventions not only enhance the remission rate of diabetes but also reduce the risk of long-term complications (22). This result suggests that early and continuous personalized interventions may achieve better glycemic control by improving insulin sensitivity and reducing insulin resistance. In addition, the intervention group experienced significantly fewer hyperglycemia and hypoglycemia events compared to the control group, indicating that real-time monitoring and feedback mechanisms effectively prevent blood glucose fluctuations, thereby enhancing patient safety (23).

Despite the strong evidence supporting the use of internet-based management systems in young adults with type 2 diabetes mellitus, this study has certain limitations. The relatively small sample size and the single-center design may constrain the generalizability of the findings. In addition, the 12-month follow-up period is insufficient for evaluating long-term effects. The implementation of an internet-based management system also involves additional costs, including the purchase of continuous glucose monitoring devices, the development and maintenance of the management platform and the resources required for remote healthcare support. These costs may limit the widespread adoption of such systems, particularly in low-resource settings. Future research should incorporate larger sample sizes and multicenter studies with extended follow-up periods to better validate these results. Further investigation is also warranted into other potential mechanisms, including the influence of social support and behavioral changes on treatment outcomes.

Conclusion

In conclusion, this study demonstrates that an internet-based management system with personalized feedback offers significant clinical benefits in improving glycemic control, quality of life and psychological health in young adults with type 2 diabetes mellitus. This system presents a promising management option for young T2DM patients, with the potential to enhance long-term health outcomes. Future research should continue to explore the application of this system across different populations to further optimize its effectiveness and ensure its broader applicability.

Declaration of interest

The authors declare that there is no conflict of interest that could be perceived as prejudicing the impartiality of this work.

Funding

This work did not receive any specific grant from any funding agency in the public, commercial or not-for-profit sector.

Author contribution statement

Z Li wrote the main manuscript. D Luo and Z Li prepared the data collection. Z Li prepared tables. Z Li and D Luo analyzed and interpreted the results. All authors reviewed the results and approved the final version of the manuscript. All authors would be informed each step of the manuscript processing including submission, revision, revision reminder, etc.

Consent for publication

All patients signed a written informed consent form to publish their research data.

Data availability

All data generated or analyzed during this study are included in the article.

Ethics approval

This study was approved by the Ethics Committee of the The Affiliated Shunde Hospital of Jinan University (JDSY-LL-2022019). Informed consent was obtained from all the participants. All methods were carried out in accordance with the Declaration of Helsinki.

References

1 Magliano DJ, Islam RM, Barr ELM, *et al.* Trends in incidence of total or type 2 diabetes: systematic review. *BMJ* 2019 **366** l5003. (https://doi.org/10.1136/bmj.l5003)

2 American Diabetes Association. Standards of medical care in diabetes—2018 abridged for primary care providers. *Clin Diabetes* 2018 **36** 14–37. (https://doi.org/10.2337/cd17-0119)

3 Holman RR, Paul SK, Bethel MA, *et al.* 10-year follow-up of intensive glucose control in type 2 diabetes. *N Engl J Med* 2008 **359** 1577–1589. (https://doi.org/10.1056/nejmoa0806470)

4 Zhang P, Zhang X, Brown J, *et al.* Global healthcare expenditure on diabetes for 2010 and 2030. *Clin Pract* 2010 **87** 293–301. (https://doi.org/10.1016/j.diabres.2010.01.026)

5 Monnier L, Colette C, Dunseath GJ, *et al.* The loss of postprandial glycemic control precedes stepwise deterioration of fasting with worsening diabetes. *Diabetes Care* 2007 **30** 263–269. (https://doi.org/10.2337/dc06-1612)

6 Mannucci E, Monami M, Balzi D, *et al.* Adherence to chronic antihyperglycaemic treatment in the elderly: a retrospective cohort study. *J Clin Endocrinol Metab* 2014 **99** 1077–1083.

7 Defronzo RA, Banerji M, Bray GA, *et al.* Actos now for the prevention of diabetes (ACT NOW) study. *BMC Endocr Disord* 2009 **9** 17. (https://doi.org/10.1186/1472-6823-9-17)

8 Gerstein HC, Pogue J, Mann JF, *et al.* The relationship between dysglycaemia and cardiovascular and renal risk in diabetic and non-diabetic participants in the HOPE study: a prospective epidemiological analysis. *Diabetologia* 2005 **48** 1749–1755. (https://doi.org/10.1007/s00125-005-1858-4)

9 Weng J. Short-term intensive insulin therapy could be the preferred option for new onset Type 2 diabetes mellitus patients with HbA1c > 9%. *J Diabetes* 2017 **9** 890–893. (https://doi.org/10.1111/1753-0407.12581)

10 Liu L, Ke W, Wan X, *et al.* Insulin requirement profiles of short-term intensive insulin therapy in patients with newly diagnosed type 2 diabetes and its association with long-term glycemic remission. *Diabetes Res Clin Pract* 2015 **108** 250–257. (https://doi.org/10.1016/j.diabres.2015.02.011)

11 Xu W & Weng J. Current role of short-term intensive insulin strategies in newly diagnosed type 2 diabetes. *J Diabetes* 2013 **5** 268–274. (https://doi.org/10.1111/1753-0407.12054)

12 Lipscombe LL & Booth GL. Impact of diabetes on cardiovascular disease in women and men: a comparison of incidence and outcomes. *Diabetologia* 2016 **58** 543–554. (https://doi.org/10.2337/diacare.23.7.962)

13 Rotella F & Mannucci E. Diabetes mellitus as a risk factor for depression: a meta-analysis of longitudinal studies. *Diabetes Res Clin Pract* 2013 **99** 98–104. (https://doi.org/10.1016/j.diabres.2012.11.022)

14 Riddle MC, Cefalu WT, Evans PH, *et al.* Consensus report: definition and interpretation of remission in type 2 diabetes. *J Clin Endocrinol Metab* 2022 **39** e14669. (https://doi.org/10.1111/dme.14669)

15 Han SJ & Kim DJ. Complications of type 2 diabetes mellitus in newly diagnosed type 2 diabetes patients. *Diabetes Metab J* 2016 **40** 314–323. (https://doi.org/10.1007/s00125-004-1625-y)

16 Einarson TR, Acs A, Ludwig C, *et al.* Prevalence of cardiovascular disease in type 2 diabetes: a systematic literature review of scientific evidence from across the world in 2007–2017. *Cardiovasc Diabetol* 2018 **17** 83. (https://doi.org/10.1186/s12933-018-0728-6)

17 Ley SH, Hamdy O, Mohan V, *et al.* Prevention and management of type 2 diabetes: dietary components and nutritional strategies. *Lancet* 2014 **383** 1999–2007. (https://doi.org/10.1016/s0140-6736(14)60613-9)

18 ElSayed NA, Aleppo G, Aroda VR, *et al.* 9. Pharmacologic approaches to glycemic treatment: standards of care in diabetes—2023. *Diabetes Care* 2023 **46** (Supplement 1) S140–S157. (https://doi.org/10.2337/dc23-s009)

19 Karter AJ, Warton EM, Lipska KJ, *et al.* Development and validation of a tool to identify patients with type 2 diabetes at high risk of hypoglycemia-related emergency department or hospital use. *JAMA Intern Med* 2015 **175** 1111–1120. (https://doi.org/10.1001/jamainternmed.2017.3844)

20 Flood D, Seiglie JA, Dunn M, *et al.* The state of diabetes treatment coverage in 55 low-income and middle-income countries: a cross-sectional study of nationally representative, individual-level data in 680,102 adults. *Lancet Healthy Longev* 2021 **2** e340–e351. (https://doi.org/10.1016/s2666-7568(21)00089-1)

21 Gregg EW, Zhuo X, Cheng YJ, *et al.* Trends in lifetime risk and years of life lost due to diabetes in the USA, 1985–2011: a modelling study. *Lancet Diabetes Endocrinol* 2014 **2** 867–874. (https://doi.org/10.1016/s2213-8587(14)70161-5)

22 Zimmet P, Alberti KG, Magliano DJ, *et al.* Diabetes mellitus statistics on prevalence and mortality: facts and fallacies. *Nat Rev Endocrinol* 2016 **12** 616–622. (https://doi.org/10.1038/nrendo.2016.105)

23 Cho NH, Shaw JE, Karuranga S, *et al.* IDF diabetes atlas: global estimates of diabetes prevalence for 2017 and projections for 2045. *Diabetes Res Clin Pract* 2018 **138** 271–281. (https://doi.org/10.1016/j.diabres.2018.02.023)