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Study on the long-term and short-term effects of community-based health self-management group activities on comprehensive control of type 2 diabetes☆

Zhang Xia, Fan Mao, Yingying Jiang, Wenlan Dong, Jianqun Dong*

Department of Comprehensive Prevention, Control and Evaluation, National Center for Chronic and Noncommunicable Disease Control and Prevention, Chinese Center for Disease Control and Prevention, Beijing, China

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ABSTRACT

Background: Diabetes self-management is an important measure to reduce the adverse impact of the disease and improve the outcome in patients with diabetes. Existing diabetes self-management studies mainly focus on the evaluation of short-term intervention effects, but rarely report the long-term effects.

Objective: To evaluate the short- and long-term effects of self-management group activities on comprehensive glycemic control in patients with type 2 diabetes in the community.

Methods: In 2014, 500 adults with type 2 diabetes were recruited from Fangshan District, Beijing, and were randomly divided into a control group(n = 241) and an intervention group(n = 259). Both groups received routine diabetes follow-up services. The intervention group also received a three-month self-management group activities. We conducted four surveys at different times(at baseline, three months, two years and five years post-intervention) to collect patient demographics, disease condition, comprehensive glycemic control indicators〔body mass index(BMI), blood pressure, fasting plasma glucose(FPG), glycated hemoglobin(HbA1c), high-density lipoprotein cholesterol(HDL-C), triacylglycerol(TG), low-density lipoprotein cholesterol(LDL-C)〕. Generalized estimating equations were used to analyze the main effect of the self-management activities and the interaction effect of the activities with post-intervention time.

Results: After adjusting for potential confounders, the main effects of the self-management activities on BMI, systolic blood pressure, diastolic blood pressure, FPG, HbA1c, HDL-C, TG an LDL-C were not statistically significant($P > 0.05$). The main effects of post-intervention time on various indicators were statistically significant($P < 0.05$). Specifically, BMI, systolic blood pressure, diastolic blood pressure, FPG, HbA1c, HDL-C and LDL-C increased, and TG decreased in the patients after intervention. We found the self-management activities and the post-intervention time had an interaction effect on BMI〔β(95 %CI)=-0.33(-0.62, -0.05)〕, FPG〔β(95 %CI)=-1.03(-1.71, -0.35)〕, and TG〔β(95 %CI)=-0.54(-0.93, -0.14)〕: the BMI of the intervention group was 0.31 kg/m^2 lower than that of the control group at baseline, but was 0.64 kg/m^2 lower than that of the control group at three months post-intervention; the FPG of the intervention group was 0.19 mmol/L higher than that of the control group at baseline, but was 0.84 mmol/L lower than that of the control group at two years post-intervention; the TG of the intervention group was 0.03 mmol/L higher than that of the control group at baseline, but was 0.51 mmol/L lower than that of the control group at five years post-intervention.

Conclusion: Self-management group activities have a short-term effect on controlling BMI, and may have a long-term effect on controlling FPG and TG in patients with type 2 diabetes.

Introduction

In recent years, the number of patients with diabetes has been increasing rapidly. It is estimated that there were 460 million people with diabetes worldwide in 2019, and this number is expected to rise to 700 million by 2045. In 2019, China had the highest number of patients with diabetes globally, with 120 million individuals. This number is projected to increase to 150 million by 2045, indicating a severe

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* Corresponding author.
E-mail address: dongjianqun@ncncd.chinacdc.cn (J. Dong).

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epidemic situation.[1] The long duration and difficulty of curing of diabetes necessitates that patients become the primary caretakers of their own health, and self-management is a crucial means to reduce disease impact and improve outcomes. Self-management can enhance patients' awareness and self-efficacy regarding diabetes, promote the formation of healthy behaviors, and ultimately achieve the goals of blood glucose control and improved quality of life.[2-5] However, research on diabetes self-management is still insufficient, with few long-term effect evaluations and follow-up studies. Most existing research focuses on short-term effects (within 6 months), and the long-term effects of self-management remain unclear.[6] Although some studies have observed that self-management group activities can reduce patients' blood glucose levels at 12–18 months post-intervention,[7-8] the same intervention effects were not observed in other studies,[9] and there is no consensus on the long-term effects on laboratory indicators like blood pressure and lipids.[10-11] Therefore, based on a community diabetes self-management trial conducted in 2014 in Fangshan District, Beijing, this study conducted a 5-year follow-up with patients. Using generalized estimating equations, it analyzed the impact of community self-management group activities on diabetes patients' blood glucose, blood pressure, lipids, and BMI. It also examined the interaction effects of self-management group activities with different post-intervention times, aiming to provide recommendations for the improvement and promotion of self-management group activities.

Methods

Study subjects

The data for this study were extracted from a community-based health self-management trial conducted in 2014 in the Fangshan District of Beijing. The trial commenced in March 2014, recruiting patients with type 2 diabetes from 17 communities/villages across 4 streets in Fangshan District through methods such as posting flyers, phone notifications, and door-to-door mobilization. The inclusion criteria were: (1) diagnosis of type 2 diabetes based on the "Chinese Type 2 Diabetes Prevention and Control Guidelines (2013 Edition)"[12]; (2) aged 18 years or older. The exclusion criteria included: (1) being in the acute phase of the disease or having serious illnesses; (2) having a mental disorder; (3) being a pregnant woman; (4) suffering from diabetic nephropathy or other severe complications; (5) currently participating in another study. A total of 510 patients were recruited, 10 of whom refused to participate, resulting in a final sample of 500 patients. Using simple randomization method, these patients were divided into the control group (n = 241) and intervention group (n = 259). All study participants provided informed consent.

Intervention methods

Both groups of patients received routine health management services as national public health service requirements in China, with the intervention group additionally engaging in three months of health self-management group activities.

Routine health management services

In accordance with national public health service requirements, patients visited community health service centers quarterly for diabetes follow-up services, which included: (1) follow-up assessments involving blood pressure and fasting plasma glucose (FPG), BMI, and inquiries about disease conditions, lifestyle, and medication usage; (2) tailored interventions, including medication guidance, adjustments to medication plans, referral recommendations, and health education; (3) health examinations, which encompassed routine physical examinations and assessments of oral health, vision, hearing, and physical function. The specific service items were based on the "National Basic Public Health Service Standards (2011 Edition)".[13]

Self-Management group activities

For the intervention group, patients were divided into 17 groups based on their community/village, with each group consisting of 15–18 patients. The group activities were held weekly, lasting between 1.5 to 2.0 h per session, with a total of 8 sessions completed over three months. The workflow of the group activities included several components: reviewing the content from the previous session, reporting on the completion of self-management plans, addressing any issues encountered, learning new contents for the current session, sharing experiences related to that content, demonstrating self-management skills for the current activity, practicing these skills among group members, and developing a self-management plan for the current activity. The themes of the group activities covered a broad range of topics, including blood glucose monitoring, understanding and managing acute and chronic complications, dietary adjustments, healthy exercise, diabetes medication, managing negative emotions and mastering communication skills, and developing good lifestyle habits. Each session was organized and conducted by two group leaders, with specific contents derived from the guide "Self-Management Practices for Chronic Disease Patients - Diabetes".[14]

Data collection methods

Baseline surveys were conducted before the intervention, post-intervention surveys were conducted at the end of the three-month self-management group activities, and follow-up surveys were conducted two years (October-November 2016) and five years (October-November 2019) after the intervention.

(1) Demographic and disease information: Data were collected using the "Community Diabetes Patient Health Survey Questionnaire" developed by the research team, through face-to-face interviews. The collected information included gender, age, educational level, marital status, per capita monthly household income, duration of diabetes, diabetes treatment methods, and participation in the New Rural Cooperative Medical Insurance. (2) Physical measurements: These included measurements of height, body mass, systolic and diastolic blood pressure. Height and body mass were measured using a stadiometer and scale with precision up to 0.1 cm and 0.1 kg, respectively, and BMI was calculated accordingly. Blood pressure was measured using an Omron HEM-1000 electronic blood pressure monitor. Measurements were taken three times with a one-minute interval between each, and the average of the last two measurements was used. (3) Laboratory tests: 5.5 ml of fasting venous blood was collected from each patient, and local laboratories used the Toshiba 40FR fully automatic biochemistry analyzer and Rongsheng reagent kits (enzyme method) to test FPG, HbA1c, HDL-C, TG, and LDL-C.

Quality control

Prior to the four survey occasions, a standardized questionnaire, research plan, and operation manual were developed. All interviewers received uniform training that covered demonstrations of standard physical measurement techniques. Only those who passed an assessment were permitted to conduct the surveys. During the surveys, a standardized questionnaire was employed. Interviewers performed an initial check of the completed questionnaires, followed by a secondary review by quality control personnel. Uniform instruments were used for physical examinations of the patients. Regular guidance was provided at the survey sites to ensure correct procedures were followed and to address any issues promptly. The self-management group activities implemented a sign-in attendance system to ensure patient participation rates in group activities. After each group session, an activity journal was recorded to monitor and maintain the quality of the activities.

Statistical methods

Data were entered twice using EpiData 3.1 software and underwent data cleaning and matching to form the final database. Analysis was performed using SAS 9.4 statistical software. Categorical data were represented by relative numbers, and comparisons between groups were conducted using the Chi-square test. Age, BMI, systolic pressure, diastolic pressure, HDL-C, and LDL-C, which approximated a normal distribution, were expressed as mean±standard deviation and compared between groups using the independent samples *t*-test. The duration of diabetes, FPG, HbA1c, and TG, which were not normally distributed, were expressed as median (interquartile range) and compared between groups using the Wilcoxon rank-sum test. A generalized estimating equation for repeated measures data was used, setting the working correlation matrix as unstructured.[15] This method analyzed the main effects of the self-management group activities on BMI, blood pressure, blood glucose, and lipid levels, both before and after adjustment for covariates, and it also examined the interaction effects between the self-management group activities and the post-intervention time. A two-sided test was used, with a significance level of $\alpha = 0.05$.

Results

Comparison of basic conditions of patients in both groups at different time points

In 2014, 241 patients in the control group and 259 patients in the intervention group completed the baseline survey and the survey after 3 months of intervention. The comparison of gender, age, educational level, marital status, per capita monthly household income, duration of diabetes, diabetes treatment methods, and New Rural Cooperative Medical Insurance coverage showed no statistically significant differences between the two groups (P > 0.05). (2) In 2016, 139 patients in the control group and 204 patients in the intervention group completed the 2-year follow-up survey. A statistically significant difference was found in the coverage of the New Rural Cooperative Medical Insurance between the groups (P < 0.05); however, there were no statistically significant differences in other metrics (P > 0.05). (3) In 2019, 175 patients in the control group and 187 in the intervention group completed the 5-year follow-up survey. Reasons for loss to follow-up of 138 patients (27.6 %) included refusal to participate (32 cases), death (36 cases), inability to contact (5 cases), inability to move freely (5 cases), relocation (2 cases), hospitalization (2 cases), lack of time to participate (1 case), and unknown reasons (55 cases). The comparison of various basic conditions between the two groups showed no statistically significant differences (P > 0.05, Table 1).

Comparison of comprehensive diabetes control between the two groups at different times

Before the intervention, there were no statistically significant differences in BMI, systolic pressure, diastolic pressure, FPG, HbA1c, HDL-C, TG, and LDL-C between the two groups (P > 0.05). Results from the generalized estimating equation analysis indicated that there were no statistically significant differences in BMI, systolic pressure, diastolic pressure, FPG, HbA1c, HDL-C, TG, and LDL-C between the two groups before and after the intervention (P > 0.05). However, the effects of time after the intervention on patients' BMI, systolic pressure, diastolic pressure, FPG, HbA1c, HDL-C, TG, and LDL-C were all statistically significant (P < 0.05, Table 2).

Main effects and interaction effects of self-management group activities and post-intervention time on comprehensive diabetes control indicators

Considering that loss to follow-up could disrupt the balance established by randomization, further analysis was conducted, adjusting for patients' basic characteristics and laboratory test indicators, to explore the main effects and interaction effects of self-management group activities and post-intervention time. The results demonstrated: (1) BMI control: An interaction effect between group and time on BMI control was observed. After the intervention, the difference in BMI between the intervention group and the control group changed by -0.33 kg/m^2 from the pre-intervention difference [95 % CI (-0.62, -0.05)]. Specifically, at baseline, the BMI in the intervention group was 0.31 kg/m^2 lower than that in the control group, and three months post-intervention, it was 0.64 kg/m^2 lower. (2) FPG control: There was an interaction effect between group and time on FPG control. Two years post-intervention, the difference in FPG between the groups differed by -1.03 mmol/L from the pre-intervention difference [95 % CI (-1.71, -0.35)]. Initially, the intervention group's FPG was 0.19 mmol/L higher than the control group, and two years post-intervention, it was 0.84 mmol/L lower. (3) TG control: Five years post-intervention, the difference in TG between the groups changed by -0.54 mmol/L from the pre-intervention difference [95 % CI (-0.93, -0.14)]. At baseline, the intervention group's TG was 0.03 mmol/L higher than the control group, and five years post-intervention, it was 0.51 mmol/L lower. (4) Control of other indicators: The interaction between self-management group activities and time did not show statistical significance for other indicators (P > 0.05). (5) Main effect of time post-intervention: The main effect of time post-intervention was significant (P < 0.05) across all indicators. Compared to baseline, there was an increase in patients' BMI, systolic pressure, diastolic pressure, FPG, HbA1c, HDL-C, LDL-C, and a decrease in TG. (6) Main effect of self-management group activities: The main effect of the self-management group activities on all indicators was not significant (P > 0.05, Table 3).

Discussion

The World Health Organization (WHO) emphasizes that patient-centered health education is a crucial method for effective disease management. Through health education, patients can manage their own diseases, prevent the occurrence of complications, and improve their quality of life.[16] Diabetes self-management education is recognized as an effective approach for alleviating the burden of diabetes.[17-18] Diabetes self-management education aids patients in managing their disease from three perspectives: knowledge, belief, and behavior. In terms of knowledge, self-management education can significantly increase patients' awareness of diabetes.[5] Regarding belief, self-efficacy is a vital indicator measuring patients' confidence in managing their disease, and self-management education can increase patients' self-efficacy by nearly 20 %, significantly enhancing their confidence in managing their condition.[2] In terms of behavior, community randomized controlled trials have shown that self-management education helps patients develop healthy behaviors such as self-checking their feet, adhering to medication prescriptions, and regularly monitoring blood glucose.[4] Therefore, diabetes self-management education can have a comprehensive positive impact on patients, surpassing traditional health education that remains at the level of knowledge dissemination. This form of education not only provides information but also, more importantly, enhances patient engagement in daily life through increased self-efficacy and behavioral change, which is crucial for the long-term management of chronic conditions like diabetes.

Previous studies have demonstrated that diabetes self-management education can reduce patients' BMI, waist circumference, HbA1c, FPG, TC, and LDL-C levels.[7,19-21] This study followed 500 patients with type 2 diabetes for five years. The results indicated that without considering the impact of time, there were no differences between the intervention and control groups in BMI, systolic blood pressure, diastolic blood pressure, FPG, HbA1c, HDL-C, TG, and LDL-C. This aligns with the findings from two other follow-up studies.[22-23] When considering the impact of time on intervention effects, an interaction between self-management group activities and post-intervention time was observed.

Table 1
Comparison of basic characteristics between two groups in different times.

Item	Number of cases	Gender〔n(%)〕		Age (X±s, year)	Educational level〔n(%)〕				Educational level〔n(%)〕	
		Male	Female		Elementary school and below	Junior high school	High school/ technical school/ college and above	College and above	Married/ cohabiting	Unmarried/ Widowed
Baseline and post-intervention										
Control group	241	90(37.3)	151(62.7)	61.4±8.1	67(27.8)	121(50.2)	43(17.8)	10(4.2)	217(90.0)	24(10.0)
Intervention group	259	84(32.4)	175(67.6)	62.1±7.1	69(26.6)	122(47.1)	51(19.7)	17(6.6)	231(89.2)	28(10.8)
Value of test statistic		1.33[a]		0.93[b]	1.88[a]				0.10[a]	
P value		0.25		0.35	0.60				0.76	
2 years post-intervention										
Control group	139	51(36.7)	88(63.3)	63.1±7.9	43(30.9)	68(48.9)	24(17.3)	4(2.9)	120(86.3)	19(13.7)
Intervention group	204	57(27.9)	147(72.1)	64.0±7.1	57(27.9)	96(47.1)	38(18.6)	13(6.4)	181(88.7)	23(11.3)
Value of test statistic		2.93[a]		1.05[b]	2.44[a]				0.44[a]	
P value		0.09		0.29	0.49				0.51	
5 years post-intervention										
Control group	175	64(36.6)	111(63.4)	66.2±7.5	44(25.1)	93(53.1)	33(18.9)	5(2.9)	144(82.3)	31(17.7)
Intervention group	187	57(30.5)	130(69.5)	66.6±7.1	49(26.2)	91(48.7)	35(18.7)	12(6.4)	161(86.1)	26(13.9)
Value of test statistic		1.51[a]		0.45[b]	2.84[a]				0.99[a]	
P value		0.22		0.65	0.42				0.32	

Item	Monthly per capita household income〔n(%)〕				Duration of diabetes〔M(QR), year〕	Type of diabetes treatment〔n(%)〕				New Rural Cooperative Medical Insurance〔n(%)〕
	<1 000 Yuan	1 000–2 999 Yuan	3 000–5 000 Yuan	>5 000 Yuan		Oral medication	Insulin injection	Oral medication+ Insulin injection	No	
Baseline and post-intervention										
Control group	71(29.5)	118(49.0)	47(19.5)	5(2.0)	7(9)	169(70.1)	20(8.3)	39(16.2)	13(5.4)	126(52.3)
Intervention group	86(33.2)	119(46.0)	40(15.4)	14(5.4)	8(9)	184(71.1)	14(5.4)	34(13.1)	27(10.4)	128(49.4)
Value of test statistic	5.62[a]					-0.25[c]	6.30[a]			0.41[a]
P value	0.13					0.80	0.10			0.52
2 years post-intervention										
Control group	55(39.6)	63(45.3)	19(13.7)	2(1.4)	10(10)	87(62.6)	19(13.7)	22(15.8)	11(7.9)	96(69.1)
Intervention group	73(35.8)	88(43.1)	29(14.2)	14(6.9)	10(9)	140(68.6)	13(6.4)	36(17.7)	15(7.3)	104(51.0)
Value of test statistic	5.64[a]				0.90[c]	5.37[a]				11.12[a]
P value	0.13				0.37	0.15				<0.01
5 years post-intervention										
Control group	56(32.0)	47(26.8)	60(34.3)	12(6.9)	12(8)	118(67.4)	13(7.4)	37(21.2)	7(4.0)	37(21.1)
Intervention group	55(29.4)	50(26.7)	62(33.2)	20(10.7)	12(9)	126(67.4)	10(5.4)	38(20.3)	13(6.9)	30(16.0)
Value of test statistic	1.74[a]					0.67[c]	2.07[a]			1.56[a]
P value	0.63					0.50	0.56			0.21

Note: [a] indicates the x^2 value, [b]indicates the t value, and [c] indicates the Z value.

Over time, both groups showed an increasing trend in BMI and FPG and a decreasing trend in TG. However, in the short term (three months post-intervention), the increase in BMI in the intervention group was less than that in the control group. Additionally, the increase in FPG after two years was lower in the intervention group than in the control group, and the reduction in TG after five years was greater in the intervention group than in the control group. Thus, the results of this study suggest that, compared to conventional health interventions, diabetes self-management group activities have a short-term effect in slowing the increase in BMI and demonstrate sustained long-term effects in mitigating the rise in FPG and reducing TG. These findings underscore the importance of implementing diabetes self-management education as part of comprehensive diabetes care strategies to enhance patient outcomes over both short and long terms. The self-management group activities in this study constituted a comprehensive intervention program, covering monitoring, diet, exercise, medication, psychology, and lifestyle habits, thereby providing holistic support for the development of healthy behaviors in patients. Additionally, these activities were designed based on peer support theory and empowerment theory.[4] The group leaders and members, hailing from the same community and familiar with each other, facilitated the sharing of disease prevention experiences and skills, maximizing the effect of peer support. During the self-management group activities, an emphasis was placed on "empowerment," allowing patients the rights and freedom to create their own management plans, thus stimulating their initiative in self-management. Therefore, the self-management group activities represent a comprehensive, interactive, and cost-effective intervention measure[24] with significant potential for community-wide adoption.

This study did not observe an impact of the self-management group activities on patients' blood pressure, HbA1c, HDL-C, or LDL-C, which is consistent with previous research findings.[21,23,25] This may be related to the difficulty in maintaining long-term effects of self-management. Existing research has shown that while self-management can improve HbA1c levels in the short term, the effects of such interventions gradually decreased over time.[26-27] This study involved a three-month self-management group activity intervention, after which no reinforcement or consolidation interventions were conducted. As time progressed, the lack of supervision and encouragement might have led to the failure to sustain self-management behaviors, hence no improvement in the aforementioned indicators was observed. This highlights the critical

Table 2
Comprehensive control of diabetes after education between the two groups.

Group	BMI(X±s, kg/m^2)				Systolic blood pressure(X±s, mm Hg)			
	Pre-intervention	Post-intervention	2 years post-intervention	5 years post-intervention	Pre-intervention	Post-intervention	2 years post-intervention	5 years post-intervention
Control group	26.1±3.2	26.7±3.3	26.7±3.1	26.3±3.2	134±16	137±16	138±16	138±15
Intervention group	26.0±3.5	26.2±3.3	26.5±3.2	26.4±3.4	134±17[a]	135±17	138±18	140±19
Z value	Z_{group}=-0.87, Z_{time}=6.02				Z_{group}=-0.33, Z_{time}=5.92			
P value	P_{group}=0.38, P_{time} < 0.01				P_{group}=0.74, P_{time} < 0.01			
Group	Diastolic blood pressure(X±s, mm Hg)				FPG〔X±s, mmol/L〕			
	Pre-intervention	Post-intervention	2 years post-intervention	5 years post-intervention	Pre-intervention	Post-intervention	2 years post-intervention	5 years post-intervention
Control group	79±10	81±9	79±10	80±8	6.8(2.8)	7.5(3.6)	9.1(5.0)	8.2(3.7)
Intervention group	78±10	79±10	78±10	81±9	6.9(3.1)[a]	7.3(3.2)	8.1(4.0)	8.4(4.2)
Z value	Z_{group}=-1.23, Z_{time}=3.52				Z_{group}=-0.82, Z_{time}=12.23			
P value	P_{group}=0.22, P_{time} < 0.01				P_{group}=0.41, P_{time} < 0.01			
Group	HbA〔M(QR), %〕				HDL-C(X±s, mmol/L)			
	Pre-intervention	Post-intervention	2 years post-intervention	5 years post-intervention	Pre-intervention	Post-intervention	2 years post-intervention	5 years post-intervention
Control group	6.3(3.2)	6.9(3.4)	8.0(4.6)	7.1(2.1)	1.12±0.27	1.21±0.29	1.35±0.28	1.15±0.31
Intervention group	6.1(3.0)	6.9(3.0)	7.3(3.7)	7.1(2.2)	1.14±0.29[a]	1.25±0.33	1.38±0.31	1.16±0.32
Z value	Z_{group}=-0.35, Z_{time}=11.19				Z_{group}=1.52, Z_{time}=8.00			
P value	P_{group}=0.73, P_{time} < 0.01				P_{group}=0.13, P_{time} < 0.01			
Group	TG〔M(QR), mmol/L〕				LDL-C(X±s, mmol/L)			
	Pre-intervention	Post-intervention	2 years post-intervention	5 years post-intervention	Pre-intervention	Post-intervention	2 years post-intervention	5 years post-intervention
Control group	2.04(1.19)	2.06(1.18)	2.05(1.32)	1.69(1.24)	2.83±0.91	3.10±0.95	3.16±0.97	3.56±1.00
Intervention group	2.00(1.43)	1.97(1.26)	2.01(1.45)	1.65(1.22)	2.85±0.84[a]	3.03±0.90	3.10±0.96	3.42±0.96
Z_{value}	Z_{group}=-0.95, Z_{time}=-3.79				Z_{group}=-0.81, Z_{time} = 12.71			
P_{value}	P_{group}=0.34, P_{time} < 0.01				P_{group}=0.42, P_{time} < 0.01			

Note: BMI = body mass index, FPG = fasting plasma glucose, HbA1c = glycated hemoglobin, HDL-C = high-density lipoprotein cholesterol, TG = triacylglycerol, LDL-C = low-density lipoprotein cholesterol; 1 mm Hg = 0.133 kPa.
[a]indicates comparison with control group data for the same period, $P > 0.05$.

need to establish mechanisms for the long-term continuation of group activities.

This study also found that over time, both the intervention and control groups exhibited rising trends in BMI, blood pressure, FPG, HbA1c, and LDL-C. Data from the China Glycated Hemoglobin Monitoring Network indicate that the blood glucose control rates for diagnosed type 2 diabetes patients in 2009, 2010, 2011, and 2012 were 35.28 %, 32.33 %, 31.77 %, and 30.15 %, respectively, showing a declining trend,[28] which aligns with the trends observed in this study. The "China Guidelines for the Prevention and Treatment of Type 2 Diabetes (2020 edition)" states that strict blood glucose control can reduce the risk of further development of early diabetic microvascular complications. However, for patients with a longer duration of the disease, older age, multiple cardiovascular risk factors, or existing cardiovascular disease, blood glucose control alone has a weaker effect in reducing cardiovascular events and mortality risk. Comprehensive treatment measures, including blood pressure management, lipid regulation, and antiplatelet therapy, can reduce the risk of cardiovascular events and mortality in these patients.[29] Despite the emphasis on the importance of comprehensive diabetes control in the "China Guidelines for the Prevention and Treatment of Type 2 Diabetes (2007 edition)" ,[30] the control rates for various indicators among patients are still not ideal. This may be associated with poor self-management awareness among patients, low involvement of community doctors in disease management,[31] and insufficient awareness among medical staff about the prevention of cardiovascular diseases in patients.[32] This indicates that the comprehensive control of diabetes in China remains a serious issue, and there is a need for further strengthening in this area.

This study employed generalized estimating equations (GEE) for analysis, which correct for correlations between multiple measurements, ensuring the scientific reliability of the results.[15] However, there are some limitations to this study: First, patient attrition could potentially disrupt the balance of the randomized groups, introducing unknown biases. Second, the study did not collect data on the use of antihypertensive and lipid-lowering medications, which means it was not possible to adjust for medication use, potentially affecting the analysis results for blood pressure and lipids. Third, the study participants were recruited from the Fangshan area and may not represent the national level, so the generalizability and application of the study conclusions should be approached with caution.

Table 3
Main and interactive effects of self-management group education and different time after education.

Item	BMI		Systolic Blood Pressure		Diastolic blood pressure		FPG	
	Main effect	Interaction effect	Main effect	Interaction effect	Main effect	Interaction effect	Main effect	Interaction effect
Group (control group as reference)								
Intervention group	-0.19(-0.78, 0.40)	-0.31(-1.85, 1.23)	-0.33(-2.47, 1.81)	0.24(-2.57, 3.05)	-0.36(-1.58, 0.87)	-0.52(-2.19, 1.16)	0.01(-0.39, 0.40)	0.19(-0.24, 0.62)
Time (baseline as reference)								
Post-Intervention	0.39(0.24, 0.53)[a]	0.53(0.26, 0.79)[a]	1.40(0.03, 2.78)[a]	2.34(0.59, 4.09)[a]	1.64(0.89, 2.38)[a]	1.17(0.08, 2.27)[a]	0.64(0.41, 0.87)[a]	0.82(0.48, 1.16)[a]
2 years post-intervention	0.65(0.38, 0.92)[a]	-1.57(-3.70, 0.56)	1.90(-0.18, 3.99)	2.46(-0.80, 5.72)	1.07(-0.11, 2.25)	0.15(-1.82, 2.12)	1.82(1.48, 2.15)	2.43(1.87, 2.99)[a]
5 years post-intervention	0.41(0.02, 0.79)[a]	-5.20(-10.67, 0.27)	4.50(2.20, 6.81)[a]	4.09(0.91, 7.28)[a]	4.09(2.91, 5.27)[a]	2.80(1.04, 4.56)[a]	1.64(1.20, 2.07)[a]	1.26(0.75, 1.78)[a]
Group x time (referenced to group x baseline)								
Group x post-intervention	—	-0.33(-0.62, -0.05)[a]	—	-1.79(-4.32, 0.75)	—	-0.18(-1.65, 1.30)	—	-0.35(-0.80, 0.11)
Group x 2 years post-intervention	—	-0.01(-0.45, 0.44)	—	-0.96(-4.90, 2.98)	—	-0.37(-2.77, 2.02)	—	-1.03(-1.71, -0.35)[a]
Group x 5 years post-intervention	—	0.09(-0.42, 0.61)	—	0.81(-3.50, 5.12)	—	1.45(-0.79, 3.70)	—	0.68(-0.01, 1.37)
Item	HbA		HDL-C		TG		LDL-C	
	Main effect	Interaction effect	Main effect	Interaction effect	Main effect	Interaction effect	Main effect	Interaction effect
Group (control group as reference)								
Intervention group	0.09(-0.20, 0.38)	0.09(-0.29, 0.48)	0.02(-0.03, 0.06)	0.02(-0.03, 0.06)	-0.05(-0.25, 0.15)	0.03(-0.24, 0.29)	-0.06(-0.19, 0.07)	0.01(-0.14, 0.15)
Time (baseline as reference)								
Post-Intervention	0.47(0.27, 0.67)[a]	0.51(0.25, 0.77)[a]	0.11(0.09, 1.13)[a]	0.10(0.07, 0.13)[a]	-0.22(-0.35, -0.09)[a]	-0.22(-0.42, -0.03)[a]	0.20(0.13, 0.28)[a]	0.25(0.15, 0.35)[a]
2 years post-intervention	1.21(0.96, 1.46)[a]	1.39(1.03, 1.74)[a]	0.25(0.23, 0.28)[a]	0.25(0.21, 0.29)[a]	-0.39(-0.56, -0.23)[a]	-0.43(-0.66, -0.20)[a]	0.25(0.15, 0.35)[a]	0.23(0.09, 0.37)[a]
5 years post-intervention	0.80(0.51, 1.09)[a]	0.65(0.31, 0.99)[a]	0.04(0.01, 0.08)[a]	0.05(0.01, 0.09)[a]	-0.51(-0.73, -0.29)[a]	-0.22(-0.54, 0.10)[a]	0.65(0.53, 0.78)[a]	0.74(0.58, 0.91)[a]
Group x time (referenced to group x baseline)								
Group x post-intervention	—	-0.08(-0.47, 0.31)	—	0.01(-0.02, 0.05)	—	-0.01(-0.26, 0.25)	—	-0.09(-0.23, 0.05)
Group x 2 years post-intervention	—	-0.29(-0.73, 0.14)	—	0.01(-0.04, 0.06)	—	0.04(-0.25, 0.33)	—	0.02(-0.16, 0.20)
Group x 5 years post-intervention	—	0.27(-0.16, 0.71)	—	-0.01(-0.07, 0.05)	—	-0.54(-0.93, -0.14)[a]	—	-0.17(-0.37, 0.04)

Note: Data in the table are β (95 % CI).
[a]indicates P < 0.05; both main effects and interaction effects models adjusted for gender, age, education, marital status, per capita monthly household income, duration of diabetes mellitus, diabetes mellitus treatment, and participation in the New Rural Cooperative Medical Insurance, and FPG, HbA1c additionally adjusted for BMI, systolic blood pressure, diastolic blood pressure, HDL-C, TG LDL-C, systolic blood pressure, diastolic blood pressure additionally adjusted for BMI, FPG, HbA1c, HDL-C, TG, LDL-C, HDL-C, TG, LDL-C additionally adjusted for BMI, systolic blood pressure, diastolic blood pressure, FPG, HbA1c, BMI additionally adjusted for FPG, systolic blood pressure, diastolic blood pressure, HbA1c, HDL-C, TG, LDL-C.

Conclusion

In summary, there is an interaction effect between self-management group activities and post-intervention time. The activities can slow the increase in BMI in the short term and have a certain long-term effect on improving FPG and TG. More research is needed in the future to validate the long-term effects of diabetes self-management interventions.

Declarations

Not applicable.

Authors' contributions

Conceptualization, X.Z.; Methodology, X.Z.; Data curation, M.F., J.Y. and D.W.; Formal analysis, X.Z.; Funding acquisition, D.J.; Project administration, M.F. and J.Y.; Resources, D.J.; Supervision, M.F., J.Y. and D.W.; Validation, D.J.; Writing—original draft, X.Z.; Writing—review and editing, D.J. All authors have read and agreed to the published version of the manuscript.

Ethics approval and consent to participate

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Consent for publication

Not applicable.

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Authors' other information

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Competing interests

The authors declare that they have no competing interests.

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References

1. Saeedi P, Petersohn I, Salpea P, et al. Global and regional diabetes prevalence estimates for 2019 and projections for 2030 and 2045: results from the International Diabetes Federation Diabetes Atlas. *Diabetes Res Clin Pract*. 2019;157:107843. doi:10.1016/j.diabres.2019.107843.
2. Qi L, Dong WL, Mao F, et al. Impact of self-management group activities on self-efficacy and its influencing factors among diabetic patients. (Chinese). *Chin J Public Health*. 2016;32(5):628–631. doi:10.11847/zgggws2016-32-05-17.
3. Association American Diabetes. Standards of medical care in diabetes-2014. *Diabetes Care*. 2014;37(s1):14–80. doi:10.2337/dc14-S014.
4. Jiang YY, Zhang XX, Mao F, et al. Evaluation of the effects of a community-based type 2 diabetes patient self-management randomized controlled study. (Chinese). *Chinese J Prevent Med*. 2019;53(2):206–211. doi:10.3760/cma.j.issn.0253-9624.2019.02.016.
5. Yao JY, Wang J, Li XY. Analysis of the effects of self-management group activities on community diabetes management. (Chinese). *Chin J Prev Contr Chron Dis*. 2018;26(8):635–637. doi:10.16386/j.cjpccd.issn.1004-6194.2018.08.020.
6. Gao CC, Zhou LS. Research focus and trending of diabetes self-management abroad. (Chinese). *J Nursing Sci*. 2017;32(3):18–22. doi:10.3870/j.issn.1001-4152.2017.03.018.
7. Debussche X, Besançon S, Balcou-Debussche M, et al. Structured peer-led diabetes self-management and support in a low-income country: the ST2EP randomised controlled trial in Mali. *PLoS One*. 2018;13(1):e0191262. doi:10.1371/journal.pone.0191262.
8. Spencer MS, Kieffer EC, Sinco B, et al. Outcomes at 18 months from a community health worker and peer leader diabetes self-management program for Latino adults. *Diabetes Care*. 2018;41(7):1414–1422. doi:10.2337/dc17-0978.
9. Tang TS, Funnell MM, Noorulla S, et al. Sustaining short-term improvements over the long-term: results from a 2-year diabetes self-management support (DSMS) intervention. (Chinese). *Diabetes Res Clin Pract*. 2012;95(1):85–92. doi:10.1016/j.diabres.2011.04.003.
10. Captieux M, Pearce G, Parke HL, et al. Supported self-management for people with type 2 diabetes: a meta-review of quantitative systematic reviews. *BMJ Open*. 2018;8(12):e024262. doi:10.1136/bmjopen-2018-024262.
11. Norris SL, Engelgau MM, Narayan KM. Effectiveness of self-management training in type 2 diabetes: a systematic review of randomized controlled trials. *Diabetes Care*. 2001;24(3):561–587. doi:10.2337/diacare.24.3.561.
12. Diabetes Branch of the Chinese Medical Association. Guidelines for the prevention and treatment of type 2 diabetes in China (2013 edition). (Chinese). *Chinese J Diabet*. 2014;6(7):447–498. doi:10.3760/cma.j.issn.1674-5809.2014.07.004.
13. Ministry of Health of the People's Republic of China. National Basic Public Health Service Specifications (2011 edition). (Chinese). (2011-05-24) [2020-09-04]. Available from: http://www.gov.cn/zwgk/2011-05/24/content_1870181.htm.
14. Dong JQ. Self-management practices for chronic diseases - Diabetes. (Chinese). Beijing: People's Medical Publishing House; 2014.
15. Feng GS. Common statistical analysis methods for repeated measures data. (Chinese). Chinese Journal of Preventive Medicine. 2020;54(7):804–12. doi:10.3760/cma.j.cn112150-20200514-00728.
16. *Global Report On Diabetes*. Geneva: World Health Organization; 2016:46–61.
17. Washington G, Wang-Letzkus MF. Self-care practices, health beliefs, and attitudes of older diabetic Chinese Americans. *J Health Hum Serv Adm*. 2009;32(3):305–323.
18. Zhao ZH, Tong YH, Yang QM. Research and progress on diabetes self-management at home and abroad. (Chinese). *Shanghai Nursing*. 2015;15(4):68–71.
19. Mohamed H, Al-Lenjawi B, Amuna P, et al. Culturally sensitive patient-centred educational programme for self-management of type 2 diabetes: a randomized controlled trial. *Prim Care Diabetes*. 2013;7(3):199–206. doi:10.1016/j.pcd.2013.05.002.
20. Aponte J, Jackson TD, Wyka K, et al. Health effectiveness of community health workers as a diabetes self-management intervention. *Diab Vasc Dis Res*. 2017;14(4):316–326. doi:10.1177/1479164117696229.
21. Cortez DN, Macedo MM, Souza DA, et al. Evaluating the effectiveness of an empowerment program for self-care in type 2 diabetes: a cluster randomized trial. *BMC Public Health*. 2017;17(1):41. doi:10.1186/s12889-016-3937-5.
22. Smith SM, Paul G, Kelly A, et al. Peer support for patients with type 2 diabetes: cluster randomised controlled trial. *BMJ*. 2011;342:d715. doi:10.1136/bmj.d715.
23. Khunti K, Gray LJ, Skinner T, et al. Effectiveness of a diabetes education and self management programme (DESMOND) for people with newly diagnosed type 2 diabetes mellitus: three-year follow-up of a cluster randomised controlled trial in primary care. *BMJ*. 2012;344:e2333. doi:10.1136/bmj.e2333.
24. Zhang XX. *Study On the Effect of Self-Management Intervention For Community Diabetes patients. (Chinese)*. Beijing: Chinese Center for Disease Control and Prevention; 2015.
25. Odgers-Jewell K, Ball LE, Kelly JT, et al. Effectiveness of group-based self-management education for individuals with type 2 diabetes: a systematic review with meta-analyses and meta-regression. *Diabet Med*. 2017;34(8):1027–1039. doi:10.1111/dme.13340.
26. Mei LL, Mao F, Jiang YY, et al. Analysis of influencing factors of self-management effect and self-efficacy in diabetes patients of communities. (Chinese). *Chin J Prev Contr Chron Dis*. 2019;27(12):885–889. doi:10.16386/j.cjpccd.issn.1004-6194.2019.12.002.
27. Liu HJ, Shi HM, Xing LL. Long-term effect of peer support intervention on diabetes-related knowledge level and self-management in type 2 diabetic patients. (Chinese). *Chinese General Pract*. 2019;22(34):4240–4245. doi:10.12114/j.issn.1007-9572.2019.00.695.
28. Kong XM, Xing XY. Attention to the "alternative" influencing factors of blood glucose control in diabetic patients. (Chinese). *Chinese J Diabet*. 2017;9(3):148–152. doi:10.3760/cma.j.issn.1674-5809.2017.03.002.
29. Diabetes Branch of the Chinese Medical Association. Guidelines for the prevention and treatment of type 2 diabetes in China (2020 edition). (Chinese). *Chinese J Diabet*. 2021;13(4):322. doi:10.3760/cma.j.cn115791-20210221-00095.
30. Diabetes Branch of the Chinese Medical AssociationGuidelines for the prevention and treatment of type 2 diabetes in China (2007 edition). (Chinese). *National Med J China*. 2008;88(18):1241. doi:10.3321/j.issn:0376-2491.2008.18.002.
31. Qin MY, Liang YR, Gong X. Research on Diabetes Management and Influencing Factors among Middle-aged and the Elderly Diabetes Patient. (Chinese). *Chinese Primary Health Care*. 2019;33(9):46–50. doi:10.3969/j.issn.1001-568X.2019.09.0017.
32. Li Y. *Survey On the Status of Lipid Control and the Application of Statins Among Type 2 Diabetes Patients in China. (Chinese)*. Luzhou: Southwest Medical University; 2017.