Behavioral interventions to improve self-management in Iranian adults with type 2 diabetes: a systematic review and meta-analysis

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Abstract

Purpose The aim of this study was to systematically-review published experimental studies to determine the effectiveness of behavioral interventions on self-management in Iranian adults with type 2 diabetes.

Method Pub Med, Web of Science, Science Direct, Ovid Medline, EBSCO, ProQuest, Google Scholar, and the Scientific Information Database (SID) were searched for English and Persian language studies published between 2009 and 2017. The primary outcome of this review was to assess the effects of behavioral interventions on glycosylated hemoglobin. Changes in the blood pressure, Lipid profiles, BMI, Self-efficacy, knowledge, attitude, practice, Self-care behaviors, social support, anxiety, and depression were the secondary outcomes.

Results Comprehensive search procedures resulted in twenty-three experimental studies with 2208 participants. Eleven studies were included in the Meta-analysis. Compared with the control group, behavioral interventions significantly lower glycosylated hemoglobin -0.61% (95% CI $-0.80, -0.41$). To explore the effects of the study intervention (regarding what aspects of the intervention are most effective), we then conducted a stratified analysis for HbA1c. Larger effects were found in interventions with a longer duration and higher intensity, delivered in the group format, interventions offered to individuals with higher baseline HbA1c, and interventions delivered by a multidisciplinary team. Moreover, behavioral interventions were effective in improving blood glucose, lipid profiles, knowledge, attitude, practice, self-efficacy, quality of life, and self-care.

Conclusion In line with other behavioral studies, our study shows that behavioral interventions improve self-management in Iranian adults with type 2 diabetes.

Keywords Type 2 diabetes · Behavioral interventions · Type 2 diabetes education · Iran · Systematic review · Meta-analysis

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Introduction

Type 2 diabetes mellitus (T2DM) is one of the most common endocrine disorders affecting almost 6% of the global population [1–3]. According to the latest global estimates, the number of individuals with diabetes increase from 176 million in 2000 to 370 million in 2030, with more than four-fifths of them living in developing countries [4]. The incidence of type 2 diabetes varies very significantly between populations. About 60% of the diabetics in the world live in Asia. Notably, the largest relative increase in the total prevalence of T2DM will occur in the Middle East, sub-Saharan African and India [5]. In the upcoming decades, the Middle East is likely to have the greatest burden of diabetes. Countries with the largest numbers of adults with diabetes in the regions of the Middle East are Egypt (7.8 million), Pakistan (7 million) and Iran (4.6 million) [6].

The prevalence of diabetes in Iran is anticipated to rise to 9.2 million by 2040 [7]. In Iran, T2DM predominantly affects the economically productive age group (45 to 64 years old), unlike the situation in many developed countries where the mean age of patients with T2DM is generally over 65 years [5, 8]. With the dramatic improvement in average life expectancy in recent years, the occurrence of diabetes at younger ages has become a major public health problem in Iran [9]. For all patients with diabetes, appropriate glycemic control is required in order to prevent or delay the progression of diabetes complications. The American Diabetes Association (ADA) recognize diabetes self-management education (DSME) is a critical element of care for diabetes patients and is necessary in order to improve glycemic control and reduce diabetes complications [10]. The DSME has been defined as “the ongoing process of facilitating the knowledge, skill, and ability necessary for diabetes self-care” [11]. The DSME can be delivered in many forms. There is currently no agreement on a single best-known education program that is superior to the rest. Over time, educational programs have shifted from an emphasis on the didactic approaches to an emphasis on patient empowerment [12] and it is clear now that behavioral interventions have shown efficacy for improving patient outcomes [13]. Behavioral interventions are interventions designed to affect the actions that patients take with the regards to their health [14]. Behavioral interventions have to potential to enhance diabetes self-management behaviors. Behavioral interventions are generally complex and can be judged on their capacity to general well-being through modifying biological, behavioral, motivational, emotional, and cognitive outcomes. For that to happen, effective interventions are needed to enhance patient’s levels of knowledge and understating about diabetes and its management. Such interventions are designed to encourage patients to modify their eating and activity habits to prevent the disastrous complication of diabetes.

There have been several studies attempting to address the issue of the benefits of behavioral interventions in improving

adherence to self-care behaviors and glycated hemoglobin [15–18]. Over the past decades, the score of behavioral interventions to manage diabetes-related risk behaviors have been developed and evaluated. Although well-conducted systematic reviews of behavioral interventions have been published, none have systematically extracted and described the key components of successful behavioral interventions in detail, especially in Iran. To date, there is limited knowledge on the impact of such interventions on the prevention and control of T2DM in Iran, despite being one of the most popular ones. To address this gap in knowledge, we sought to perform a systematic review and meta-analysis to evaluate the effect of behavioral interventions on self-management in Iranian adults with type 2 diabetes.

Type of outcomes measured

Our primary outcome was HbA1c values. The secondary outcomes were changes in blood pressure, Lipid profiles (LDL, HDL, Cholesterol level, Triglyceride), BMI, Self-efficacy, knowledge, attitude, practice, Self-care behaviors, social support, anxiety, and depression.

Method

Search methods for identification of studies

The search was performed in Pub Med, Web of Science, Science Direct, Ovid Medline, EBSCO, ProQuest, Google Scholar, and the Scientific Information Database (SID), for English and Persian language articles published between 2009 and 2017. The medical subject headings (Mesh) terms used for the search were “type 2 diabetes” and “behavioral intervention” or “health education” or “behavioral change” or “type 2 diabetes education” and “Iran”. All potentially relevant articles were reviewed as full text. Abstracts, dissertations and conference papers were excluded because they contain insufficient data. Only experimental studies were included in the review. Studies were excluded if (1) they assessed only patients with type 1 diabetes, (2) involved patients under age of 18 years, (3) targeted exclusively at health care providers, (4) and studies with the sample size of less than 30. The Preferred Reporting Items for Systematic reviews and Meta-Analysis (PRISMA) statement [19] was used to guide the conduct and reporting of our study. The flow chart of study selection is presented in Fig. 1.

Data extraction

Two independent reviewers (GA, SA) undertook data extraction and critically appraised the studies. The reviewers were blinded for the name of authors, journals and the outcomes of

Fig. 1 PRISMA flow chart for study selection

the studies. Reviewers resolved disagreements through discussion and consensus.

Risk of bias assessment

Two review authors independently (GA, SA) assessed the risk of bias in each included study using the Cochrane's Risk of Bias assessment tool [20]. A general review and summary of the possible risk of bias across all reviewed studies are presented in Fig. 2.

Methodological quality assessment

Quality assessment of the included study was performed using the Cochrane Handbook for Systematic Review interventions [21]. The methodological quality assessment focused on the following criteria: randomization, allocation concealment, blinding, reasonable withdraw and dropout rates, sufficient data reporting and non-selective reporting of outcomes. Two review authors independently scored the relevance of each item on a 2-point Likert scale, ranging from Yes (1) to No (0). Then, studies were categorizing into three classes,

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Amini et al., (2013)	+	?	?	?	-	+	+
Baghiani Moghadam et al., (2014)	-	-	?	?	+	+	-
Ebrahimi et al., (2016)	+	?	+	+	+	+	+
Gavgani et al., (2010)	-	-	?	?	+	+	-
Ghotbi et al., (2014)	-	-	?	?	+	+	-
Goodarzi et al., (2014)	+	?	?	?	-	+	+
Jahromi et al., (2015)	+	?	?	?	+	+	+
Jalilian et al., (2012)	-	-	?	?	+	+	-
Khani Jeihooni et al., (2013)	?	-	?	?	+	+	-
Mamene et al., (2014)	+	?	?	?	-	+	+
Mazlom et al., (2015)	+	?	?	?	-	+	+
Nesari et al., (2015)	+	?	?	?	-	+	-
Razi et al., (2013)	+	?	?	?	?	+	+
Reza et al., (2016)	+	+	?	?	-	+	+
Sadeghi et al., (2013)	+	?	?	?	-	+	+
shahsavari., (2015)	-	-	?	?	+	+	-
Shakibazadeh et al., (2015)	+	+	?	?	-	?	?
Tavakolizadeh et al., (2014)	+	?	+	+	+	+	+
Vatankhah et al., (2009)	-	-	?	?	+	+	-
Zareban et al., (2014)	+	?	?	?	+	+	+
Zendehtalab et al., (2013)	-	-	?	?	+	+	-
Zibaeenezhad et al., (2015)	-	-	?	?	?	+	-
Zinat et al., (2013)	-	-	?	?	-	+	-

Fig. 2 Risk of bias summary: review authors' judgements about each risk of bias item for each included study

according to their reported score, (1) score of >4 indicated high quality, (2) score 3–4 indicated moderate quality, and (3) score of ≤ 2 indicated poor quality. Due to the nature of the intervention, blinding of participants and educators was not feasible. The methodological quality of studies ranged from good to poor, with two studies (8.7%) were classified as being of good quality [22, 23], and nine (39.1%) were of moderate quality [24–32]. The remaining twelve studies (52.2%) were of poor quality.

Evidence –based analysis of the effectiveness

In order to provide a best-estimate of intervention effects, we conducted a Meta-analysis in an attempt to identify factors that might contribute to successful diabetes management. We were primarily interested in the magnitude of the effect size for change in glycemic control over time. To assure a high internal validity of the findings, only randomized control trials were included in our Meta-analysis. The meta-analysis in this study evaluated the effect of the intervention on the primary outcome (HbA1c) using REVMAN 5.2 [33]. Data entered in REVMAN included baseline (pre) and final values (post) for intervention and control groups, the absolute difference between pre and post (final value minuses baseline value), the number of participants for each treatment group in the trial and standard deviations. Unfortunately, the standard deviations for the intragroup differences are often missing. To solve this problem, the standard deviations were pooled using the following formulas [34]:

$$\bullet \quad \text{Pooled SD difference} = SE \times \sqrt{N}$$

Note: SE: standard Error; N= the number of participants for treatment group.

SE calculated using the following formula

$$\bullet \quad SE = \sqrt{\left(\frac{SD \text{ baseline}^2}{N \text{ baseline}} + \frac{SD \text{ follow up}^2}{N \text{ follow up}} \right)}$$

The pooled SD was calculated for each treatment group. The effect size was measured as the standardized mean differences with corresponding 95% confidence intervals. A two-sided p value of less than 0.05 ($P < 0.05$) demonstrated the statistically significant difference in the outcome between groups. The statistical heterogeneity between trials was evaluated by Cochran's χ^2 test and the I^2 statistics [35]. According to the Cochrane handbook for systematic review, the I^2 value of 0–40% represents low heterogeneity, 30–60% moderate heterogeneity, 50–

90% substantial heterogeneity, and 75–100% considerable heterogeneity. Random effect models of analysis were applied if heterogeneity was detected more than 50%. Otherwise, fixed effects (inverse variance) were used in our analysis [35].

Results

Twenty-three studies met the inclusion criteria for this review. All eligible articles had been published between January 2009 and March 2017. Of the twenty-three included studies, eleven (47.8%) were published in English [22–25, 36–42], and the rests were published in Persian. Characteristics of the included studies can be found in Table 1. More than half of the studies included in this review were randomized controlled trial (52.2%) [22, 23, 25–32, 37, 42], and quasi-experimental design accounts for the rest [24, 36, 38, 40, 41, 43–48]. The studies varied in size, duration, and intervention type. The included studies provide the results from 2208 participants with the mean cohort age of 52.3 years (ranging from 41 to 67 years). The sample size in a single study ranged from 30 [36] to 280 [37]. Of the twenty-three studies, only one (5.5%) included female patients [26], and the rests were mixed in the cohort. Totally, 65.2% of the sample being female ($n = 1441$) and the rest being male. All studies described a study population having T2DM. Mean duration of diabetes was 7.5 years ranged from 4.8 years [46] to 10.4 years [29].

Intervention characteristics

- All interventions were embedded in the context of usual care. Thirteen of twenty-three studies (56.5%) reported using behavioral theories/model as the basis for the DSME.
- The interventions had a mean length of 3.5 weeks, ranged from 20 min [38] to 12 weeks [31, 43]
- The intensity of interventions ranged from 20 min over a day [38] to 1500 min over six weeks [37].
- Both individual and group sessions were used to deliver training.
- The duration of follow-up ranged from 4 weeks to 24 weeks.
- Only six studies (26%) used the multidisciplinary care approach to deliver the intervention [23, 28, 36, 37, 41, 42].
- Eleven studies recruited their participants (47.8%) from the outpatient clinics, nine (39.1%) from hospital-based clinics, and the remaining three (13%) from primary care settings.

Study outcomes

Primary outcome (HbA1c)

Thirteen of the twenty-three studies reported HbA1c as an outcome measured. All of these studies reported significant

Table 1 Summary of the 23 included studies in the review

No	Author	Study design	Theory/model used	Intervention			Length of intervention	Length of FU	Results
				Who	How	Where			
1	(Amini et al. [32])	RCT	–	Public health	Group based education + pamphlet	Hospital based	2 weeks	3 months	Significant improvement in practice of self-care (p value = 0.009) Knowledge and attitude were not statistically significant ($P > 0.05$) Significant improvement in knowledge and self-care behavior ($P > 0.05$)
2	(Baghiani Moghadam et al. [44])	QED	HBM	Nurse	SMS	Hospital based	1 month	2 month	Significant improvement in self-care behavior, weight, and HbA1c value ($P < 0.05$)
3	(Gavagani et al. [36])	QED	information-motivation-behavioral skills model	Counselor, Nurse, Medical doctor	Group based education	Hospital based	3 weeks	2 month	Significant improvement in self-care behavior, weight, and HbA1c value ($P < 0.05$)
4	(Ghotbi et al. [45])	QED	Family-centered empowerment model	Nurse	Group education	Outpatient clinic	5 weeks	3 month	Significant improvement in self-care behaviors ($p < 0.05$)
5	(Godarzi et al. [31])	RCT	–	Nurse	SMS	Outpatient clinic	12 weeks	3 month	Significant improvement in Self-efficacy and HbA1c levels ($p < 0.005$)
6	(Jalilian et al., [49])	QED	–	Public health	Group discussion and lecturing	Hospital based	360 min patients + 120 min their families	2 months	Significant improvement was found in knowledge and self-care behavior scores
7	(Khani Jeihooni et al. [41])	QED	BASNEF model	Nurse and diabetes specialists	Group based and lecturing+ family involvement	Outpatient clinic	1 month	3 months	Significant improvement in knowledge, attitude, and HbA1c values ($p < 0.001$)
8	(Mamene et al. [30])	RCT	Collaborative care model	Nurse	Group based education	Hospital based	7 h	3 months	The experimental group reported better performance in compare with control group in items related to using snacks between main meals ($p = 0.05$), liquid fats (0.01), animal fat and butter ($p = 0.04$), fruit ($p < 0.001$), vegetables ($p = 0.03$), fish (0.02), aspect of self-management ($p < 0.001$) Significant improvement in HbA1c Significant improvement in knowledge score and HbA1c value
9	(Mazlom et al. [29])	RCT	–	Consoling and Nurse	Group education	Outpatient clinic	7.5 h in 3 days	2 months	Significant improvement in HbA1c and knowledge score ($P < 0.05$) Significant improvement in self-care behaviors and HbA1c level (p value > 0.001) No significant improvement in Depression (p value > 0.05) No significant improvement in smoking status (p value > 0.05) Significant improvement in Diabetes knowledge, self-care behaviors, health beliefs, attitudes toward diabetes, stigma, self-efficacy, patient satisfaction and HbA1c value (p value < 0.05) Significant improvement in self-regulation, blood sugar, nutrition, and physical activity (p value < 0.001)
10	(Razi et al. [28])	RCT	Family-centered empowerment model	Nurse, Nutritionist, Medical doctor	Group education	Outpatient clinic	1 months	3 month	Significant improvement in HbA1c and knowledge score ($P < 0.05$) Significant improvement in self-care behaviors and HbA1c level (p value > 0.001) No significant improvement in Depression (p value > 0.05) No significant improvement in smoking status (p value > 0.05) Significant improvement in Diabetes knowledge, self-care behaviors, health beliefs, attitudes toward diabetes, stigma, self-efficacy, patient satisfaction and HbA1c value (p value < 0.05) Significant improvement in self-regulation, blood sugar, nutrition, and physical activity (p value < 0.001)
11	(Sadeghi et al. [27])	RCT	Family-centered empowerment model	Nurse	Group based education	Hospital based	1 month	3 months	Significant improvement in HbA1c and knowledge score ($P < 0.05$) Significant improvement in self-care behaviors and HbA1c level (p value > 0.001) No significant improvement in Depression (p value > 0.05) No significant improvement in smoking status (p value > 0.05) Significant improvement in Diabetes knowledge, self-care behaviors, health beliefs, attitudes toward diabetes, stigma, self-efficacy, patient satisfaction and HbA1c value (p value < 0.05) Significant improvement in self-regulation, blood sugar, nutrition, and physical activity (p value < 0.001)
12	(Shahsavari. [43])	QED	–	Nurse	Telephone calls	Outpatient clinic	12 weeks	3 month	Significant improvement in self-care behaviors and HbA1c level (p value > 0.001) No significant improvement in Depression (p value > 0.05) No significant improvement in smoking status (p value > 0.05) Significant improvement in Diabetes knowledge, self-care behaviors, health beliefs, attitudes toward diabetes, stigma, self-efficacy, patient satisfaction and HbA1c value (p value < 0.05) Significant improvement in self-regulation, blood sugar, nutrition, and physical activity (p value < 0.001)
13	(Shakibazadeh et al. [37])	RCT	Adult learning theory, HBM, and social cognitive theory	Nurse Nutritionist Counselor	Group based education	Outpatient clinic	6 weeks	21 weeks	Significant improvement in self-regulation, blood sugar, nutrition, and physical activity (p value < 0.001)
14	(Tavakolizadeh et al. [22])	RCT	Social cognitive theory of self-regulation	Psychologist	Group based	Hospital based	1 month	6 month	Significant improvement in self-regulation, blood sugar, nutrition, and physical activity (p value < 0.001)

Table 1 (continued)

No	Author	Study design	Theory/model used	Intervention			Length of intervention	Length of FU	Results
				Who	How	Where			
15	(Vatankhah et al. [38])	QED	–	Medical doctor	Face to face	Outpatient clinic	20 min	6 months	Significant improvement in knowledge and practice about diabetic foot care ($P < 0.0001$ and $P = 0.01$ respectively)
16	(Zareban et al. [26])	RCT	self-care theory of Orem	Public health and Nurse	Lecturing, group based, CD view	Hospital based	1 month	3 months	Significant improvement in awareness, attitude, self-care behavior, and HbA1c value ($p < 0.001$)
17	Zendehlab et al. [47]	QED	BASNEF model	Nurse	Face to face	Hospital based	135 min	1 month	Significant improvement in quality of life ($p < 0.001$)
18	(Zibaenezhad et al. [40])	QED	–	Cardiologist, Sport medicine, Nutritionist	Face to face	Primary care	5 weeks	3 months	Significant improvement in HbA1c ($P < 0.001$)
19	(Zinat et al. [48])	QED	HBM	Public health	Lecturing + group education	Outpatient clinic	4 h patient+2 h their families	3 months	Significant improvement in mean knowledge scores, perceived severity, perceived susceptibility, perceived benefits and perceived self-efficacy and decreased perceived barriers ($P < 0.05$)
20	(Nesari et al. [42])	RCT	–	Nurse, Nutritionist	Face to face lecturing+ telephone follow up	Primary care	9 h+320 min telephone follow up	3 months	Significant improvement in • HbA1c • Diet • Exercise • Foot care • Medication adherences ($p < 0.001$)
21	(Jahromi et al. [25])	RCT	–	Nurse	Group-based education	Primary care	8 group session	3 months	Significant improvement in quality of life ($p < 0.001$)
22	(Reza et al. [24])	RCT	–	Nurse	Individual + group based education	Outpatient clinic	2 weeks	9 weeks	Significant improvement in HbA1c value and fasting blood sugar ($p < 0.001$)
23	(Ebrahimi et al. [23])	RCT	HBM, Bandura's Learning theory, Cognitive theory	Nurse, Nutritionist, Endocrinologist	Group based	Outpatient clinic	6 week	3 months	Significant improvement in: • HbA1c • FBS • BS • HDL • Cholesterol • Triglyceride No significant improvement in LDL

FU, Follow Up; HBM, Health Belief Model; RCT, Randomized Controlled trial; QED, Quasi Experimental Design; LDL, Low density lipoprotein; HDL, High density lipoprotein

improvement in HbA1c values for experimental groups [23, 24, 26–29, 31, 36, 37, 40–43]. Only randomized controlled trials were included in our Meta-analysis.

Effect size (standardized mean difference) for HbA1c are illustrated in Fig. 3; Analysis 1. A random effect model was used because of significant heterogeneity. There has been a considerable decline in HbA1c levels in the intervention

group compared to the control group. The pooled effect size was -0.61 (95% CI -0.88 to -0.41 ; 1102 participants, eleven trials), which was statistically significant ($p < 0.001$).

To provide more credible and detailed results we conducted stratified analysis for HbA1c values to explore the potential source of heterogeneity between trials. The likelihood of publication bias was evaluated by using funnel plot [50]; Fig. 3;

Fig. 3 **Analysis 1:** Forest plot for HbA1c results. **Analysis 2:** Funnel plot for HbA1c results. **Analysis 3:** Difference in change-from-baseline HbA1c values between behavioral interventions and usual care control sub-grouped by Baseline value of HbA1c. **Analysis 4:** Difference in change-from-baseline HbA1c values between behavioral interventions and usual care control sub-grouped by length of interventions. **Analysis 5:** Difference in change-from-baseline HbA1c values between behavioral

interventions and usual care control sub-grouped by intervention intensity. **Analysis 6:** Difference in change-from-baseline HbA1c values between behavioral interventions and usual care control sub-grouped by delivery of interventions. **Analysis 7:** Difference in change-from-baseline HbA1c values between behavioral interventions and usual care control sub-grouped by interventionists

Fig. 3 (continued)

Fig. 3 (continued)

Analysis 2. A funnel plot is a scatter plot of effect size against study size. When no publication bias is suspected, the

observed studies are distributed symmetrically around the pooled effect size. The funnel plot showed that there might

Fig. 3 (continued)

be some publication bias, with studies with positive or favorable results are more likely to be submitted for peer-review and published. Visual inspection of the funnel plot indicates a gap in the middle and bottom of the funnel plot. It is possible that some smaller studies with large effects will be underrepresented.

i. Stratified analysis for the pooled effect size of HbA1c

Stratified analysis was performed based on the key study characteristics including baseline HbA1c value, the length of intervention, intervention intensity, mode of intervention delivery, and interventionist (see Fig. 3; Analysis 3–7).

a. Stratified analysis based on the baseline HbA1c values

It has been hypothesis that mean HbA1c baseline values of less than 9 are associated with improvement in glycemic control following intervention [17, 18]. To test this hypothesis, we divided baseline HbA1c values into $HbA1c < 9$ and $HbA1c \geq 9$. Standardized pooled effect size revealed that larger effect size was in studies with higher baseline $HbA1c \geq 9$ (-0.87 , $P < 0.001$). Random effect analysis was applied because the overall heterogeneity was substantial ($I^2 = 61\%$). (Refer to Fig. 3, Analysis 3).

b. Stratified analysis based on the length of interventions

It has been hypothesis that studies with longer duration and higher intensity of intervention are more effective in controlling HbA1c values [51]. We performed a subgroup analysis to see if this hypothesis might also be true for behavioral interventions. The stratified analysis suggested that the largest effect size was in studies with the duration of intervention ≥ 3 months (-0.68 , $P < 0.001$). Random effect analysis was used as there was evidence of heterogeneity among studies ($I^2 = 60\%$) (Refer to Fig. 3; Analysis 4).

c. Stratified analysis based on the intervention intensity

As we mentioned earlier Charvala et al., (2016) concluded that studies with higher intensity are more effective in improving HbA1c values [51]. To test this hypothesis, we divided studies into two categories on the bases of intervention intensity. The stratified analysis suggests that interventions with higher intensities produce greater effects in term of improving glycemic control (-0.63 , $P < 0.001$). Random effect analysis was used as there was evidence of heterogeneity among studies ($I^2 = 61\%$) (Refer to Fig. 3; Analysis 5).

d. Stratified analysis based on the mode of intervention delivery

Group-based education was reported to have a greater effect in controlling HbA1c [52]. In our analysis, group-based diabetes education showed larger effects size (-0.60 , $P < 0.001$) in comparison with individual-based education. Random effect analysis was used because there was heterogeneity among studies ($I^2 = 59\%$). (Refer to Fig. 3; Analysis 6).

e. Stratified analysis based on the interventionist

There is evidence that a team care approach can improve diabetes management [53]. As a result, we conducted a stratified analysis to identify if this hypothesis might be true for behavioral interventions. Studies were divided into two categories: ≥ 2 disciplinarians and < 2 disciplinarians. Studies used multidisciplinary team care approach (≥ 2 disciplinarians) had the largest effect size (-0.65 , $p < 0.001$) than studies that delivered by < 2 disciplinarians. Random effect analysis was used because the overall heterogeneity was 61%. (Refer to Fig. 3; Analysis 7).

Discussion

The main purpose of the current study was to review studies using behavioral interventions to improve diabetes self-management. Twenty-three experimental studies with 2208 participants were included in this review. Included studies used a wide range of behavioral change technique and strategies. Glycemic control is the most important aspect in the management of diabetes. The primary outcome of this review was therefore to assess the effects of behavioral interventions on glycemic control. Changes in the blood pressure, Lipid profiles (LDL, HDL, Cholesterol level, Triglyceride), BMI, Self-efficacy, knowledge, attitude, practice, Self-care behaviors, social support, anxiety, and depression were the secondary outcomes.

In order to provide a best-estimate of intervention effects, we conducted a Meta-analysis and try to identify factors that might contribute to effective diabetes management. We were primarily interested in the magnitude of the effect size for change in glycemic control over time. To assure a high internal validity of the findings, only randomized control trials were included in our Meta-analysis. Eleven studies provided sufficient data to be included in our Meta-analysis. The pooled effect sizes indicate that there was a moderate but statistically significant difference in the levels of HbA1c between intervention and control groups of -0.61 mmol/mol (95% CI -0.80 , -0.41). The analysis was associated with substantial heterogeneity ($I^2 = 61\%$) suggesting inconsistency between the types of effect seen in different studies. The findings of

this study have significant implications for current research and clinical practices. Glycemic control is considered as the main therapeutic goal for prevention of diabetes-related complications [54]. We observed that the behavioral interventions were accompanied by a significant reduction in HbA1c levels. According to the United Kingdom Prospective Diabetes Study, for each 1% reduction in the mean HbA1c, there is a relative risk reduction of 21% for any diabetes-related complication or death [55]. Our findings also consistent with the previous meta-analysis and systematic reviews found that behavioral interventions produced a statistically significant reduction in HbA1c levels in patients with diabetes [15–18].

To explore the effects of the study intervention (regarding what aspects of the intervention are most effective), we then conducted a stratified analysis for HbA1c. Larger effects were found in interventions with a longer duration and higher intensity, delivered in the group format, interventions offered to individuals with higher baseline HbA1c, and interventions delivered by a multidisciplinary team.

Our study indicates that behavioral interventions benefited all patients disregarding baseline HbA1c value. However, subgroup analysis revealed that studies enrolled patients with higher baseline HbA1c (> 9 mmol/mol) reported greater reduction (effect size $= -0.87$) following the intervention. The results of previous systematic reviews and Meta-analysis are consistent with our finding [15, 18, 52].

Our study indicates that behavioral interventions benefited all patients disregarding baseline HbA1c value. However, Intervention practices with the highest baseline HbA1c experienced the largest decrease with the effect size of -0.87 (95% CI -1.31 , -0.42 , $P < 0.001$). Our results are consistent with the previous studies [15, 18, 52].

The effect size for longer interventions (duration ≥ 3 -month) was higher than the overall effect size for shorter interventions (duration < 3 -month). There was evidence to suggest that longer duration of interventions was more often associated with the statistically significant reduction [56–58]. The majority of the included interventions had short duration (≤ 3 -month). Few studies included in this review outlined interventions beyond 4 months, limiting the available knowledge about the long-term effect of behavioral interventions. It was hardly possible to identify the key factors responsible for useful results. This issue demonstrates areas for additional research.

Today, the efficacy of care is understood to be a critical part of medical care for diabetes. The maximum contact time per patient during the intervention was established for all studies. We assessed the efficacy of care in studies in which engaged patients in educational programs involving > 5 h compared with those studies involving ≤ 5 h. Similar to our finding, the previous Meta-analysis suggested that more contact hours were often associated with the additional statistically significant reduction in HbA1c values [51]. There seems to be a general need for further research to better establish parameters

for the optimal number of contact hours for different providers' type and different model of delivery. The findings in this review are an initial step in providing some advice and guidance.

The included studies were divided into two subgroups with the respect to the benefits of group versus individual educational activities. In our review, both types of delivery ascertained significant results, but the intervention effects were greater for group-based education. Evidence also suggested that group education is better than individual education at improving diabetes-related health outcomes [52, 59]. Group education is thought to be less costly and will lead to greater treatment satisfaction. Moreover, group-based approaches are more useful in supporting lifestyle changes [60].

There is evidence that a multidisciplinary team approach can improve the care of patients with diabetes. The utilization of diabetes care plans with a multidisciplinary team approach can be effective in improving glycemic control, reducing the risk of developing complications, lowering hospitalization, reducing healthcare costs, enhancing effective patient education, and increasing patient satisfaction [53]. This review emphasizes the importance of a multidisciplinary team approach in improving glycemic control. Additional evaluation of the role of multidisciplinary team care approach in diabetes care and its effects on patients' outcomes is warranted.

None of the included studies in the review reported follow-up period longer than 6 months. Therefore, our study lacked adequate power to detect significant differences in short- or long-term follow-ups. More long-term follow-up studies need to be conducted in order to ascertain factors contributing to better diabetes management.

Our review indicated that behavioral interventions are effective in improving patients' knowledge, attitude, and practice towards diabetes self-care. All of the included studies were of short duration with short follow-up period. Behavioral interventions with short follow-up tended to show significant improvement in diet, physical activity, and medication adherence. No studies measured the effect of education on weight, BMI, waist circumference and their health risk assessment issues. This will lead to insufficient credibility to draw conclusions on the benefit of the intervention of interest. Thus, the effectiveness of behavioral interventions in Iranian clinical practice and implementing research studies are currently being questioned.

We found significant improvement in the psychological outcomes such as self-efficacy and quality of life [61, 62]. There is lack of evidence on the effectiveness of behavioral interventions for depression. It might be attributed to fewer numbers of studies targeting this outcome. Brief interventions with short follow-up duration may also explain the lack of effectiveness because changes in this outcome are slow. Longer interventions with longer follow-up periods are needed to explain their impact on depression.

There was a relative lack of evidence on how behavioral interventions affect heart-disease risk factors. Previous prospective studies have demonstrated a strong association between T2DM and increased the risk of both micro- and macrovascular complications [55, 63]. Each 1% absolute reduction in the mean A1c was associated with a 37% decline the risk of microvascular complications, and a 21% decrease for death related to disease [55]. Therefore, any improvement in glycemic control is likely to prevent deaths from complications of diabetes as cardiovascular and cerebrovascular disease account for a significant proportion (50–60%) of all mortality in a diabetic population [55].

Strengths and limitations

This review has several strengths. We used rigorous reviewing methods including a comprehensive search strategy, explicit and reproducible eligibility criteria, and selecting studies by two independent reviewers. We used a broad search strategy to capture all relevant information. To the best of our knowledge, this is the first empirical review to explore the effectiveness of behavioral interventions in diabetes management. We used stratified analysis that would allow answering clinically relevant and important questions that have not previously been addressed.

Our review also has several limitations. Our findings might be vulnerable to selective reporting of the outcome. We did not search all available medical journals, and therefore, our results may not be applicable to journals outside our sample. Our review, however, includes core and highly affects clinical journals that cover all clinical and public health areas. Methodological biases in the design and execution of the clinical trials was frequent. Only two studies were rated as good quality. The quality of the included studies in this review was treated by absence of blinding of participants and/or outcome assessors, contamination especially in the control group, inadequate description of randomization method, unclear or inadequate concealment of allocation, deficits in the validity and reliability of the screening instruments, insufficient description of sample size estimation, selection-maturation interaction, unintended co-interventions, and lack of Intention-To-Treat analysis. There was an inadequate description of the intervention and participants. As the consequence, other researchers cannot replicate or build on research findings, and healthcare professionals and patients cannot reliably implement behavioral interventions that displayed to be effective [64]. Generalizability of the findings is also frequently limited by the selective publication of studies because of the magnitude and direction of their findings (publication bias). Another confounding variable is the possible difference between study groups in medications. Medications and drug prescription information were not reported in any of included studies. We could not evaluate the effect of the behavioral intervention on

death and adverse events attributed to cardiovascular disorders. Thus it is not clear how the changes we observe in cardiovascular disease associated risk factors reflect these clinical outcomes [65].

Conclusion

When conducting this review we discovered that there are very few well-designed and sufficiently powered randomized controlled trials of behavioral interventions. Although growing body of evidence suggests that behavioral interventions increase adherence and improve success in diabetes self-management, most have been underpowered, the interventions are poorly described, and follow-up duration is relatively short. Clearly, more research is needed into the effectiveness of such interventions with adequate methodological quality, large sample size, extended follow-up period, and accurate statistical analysis. In this review, we found out that high-intensity intervention with frequent debriefing sessions was more effective in improving patient outcomes. We also found out that the group-based interventions might be more effective than the individual intervention. Moreover, we identified several gaps in the existing literature that need to be addressed. First, very few studies have targeted cardiovascular risk factors such as blood pressure and lipid profiles. Second, very few studies explicitly mentioned the behavioral change techniques applied. Third, few studies provide a detailed description of the intervention program and its theoretical background. Efforts to encourage standardization and critically review the theoretical background should be made.

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Compliance with ethical standards

Competing interest None.

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