Review Paper

# Investigating Education as the Key to Success in Non-pharmacological Interventions in the Control and Treatment of Type 2 Diabetes: A Systematic Review

**Fatemeh Ghardashi[1], Roya Akbarzadeh[2], Roghayeh Zardosht[3*], Mohammad Hossein Zadeh Hesari[4]**

*1. Non-communicable Diseases Research Center, School of Paramedical, Sabzevar University of Medical Sciences, Sabzevar, Iran.*
*2. Department of Anesthesiology, School of Allied Medical Sciences, Sabzevar University of Medical Sciences, Sabzevar, Iran.*
*3. Department of Operating Room, Iranian Healthy Aging Research Center, School of Paramedical, Sabzevar University of Medical Sciences, Sabzevar, Iran.*
*4. School of Allied Medical Sciences, Sabzevar University of Medical Sciences, Sabzevar, Iran.*

Use your device to scan and read the article online

**Citation** Ghardashi F, Akbarzadeh R, Zardosht R, Hossein Zadeh Hesari M. Investigating Education as the Key to Success in Non-pharmacological Interventions in the Control and Treatment of Type 2 Diabetes: A Systematic Review. Journal of Research & Health. 2023; 13(6):391-406. http://dx.doi.org/10.32598/JRH.13.6.2219

http://dx.doi.org/10.32598/JRH.13.6.2219



## ABSTRACT

**Background:** The prevalence of type 2 diabetes is a global health challenge that requires continuous care. Non-pharmaceutical interventions in controlling and treating type 2 diabetes can be less costly and have fewer complications. Accordingly, this study identifies non-pharmaceutical interventions in controlling and treating type 2 diabetes through systematic review.

**Methods:** This study is a systematic review of the papers published in non-pharmaceutical interventions to control and treat type 2 diabetes. The authors have used the standard guideline of systematic review (PRISMA). A total of 41 papers were selected from 529 full-text articles published between 2014 and 2020. The search included the electronic data banks, including Medline, Science Direct, Embase, Scopus, Cochrane Library, and the Google Scholar search engine.

**Results:** Non-pharmaceutical interventions were classified into four categories: Lifestyle, treatment devices, traditional treatment, and education. The results showed that lifestyle modification is the most effective non-pharmaceutical intervention for treating type 2 diabetes.

**Conclusion:** Study findings show that applying non-pharmaceutical interventions effectively controls and prevents type-2 diabetes complications. Education is a part that needs to be given more attention.

**Keywords:** Type 2 diabetes, Education, Lifestyle, Health

**Article info:**
**Received:** 31 Jan 2023
**Accepted:** 03 Jun 223
**Publish:** 01 Nov 2023

*** Corresponding Author:**
*Roghayeh Zardosht, Assistant Professor.*
***Address:*** *Department of Operating Room, Iranian Healthy Aging Research Center, School of Paramedical, Sabzevar University of Medical Sciences, Sabzevar, Iran.*
***Phone:*** *+98 (915) 5002398*
***E-mail:*** *Rozardosht@yahoo.com*

## 1. Introduction

Diabetes is one of the most critical health challenges worldwide. During the past three decades, the number of diabetic cases has increased more than twofold [1, 2]. The prevalence of vulnerability to diabetes is growing rapidly and will reach approximately 625 million people in all quarters of the globe by 2045 [3]. According to the estimations by the international diabetes federation in the year 2015, about 75% of adult diabetics are living in low-income countries [4]. Some risk factors of vulnerability to type 2 diabetes are unchanging, such as age and family background; however, other risk factors, such as weight gain, blood sugar, and triglyceride, change dramatically with lifestyle correction [5]. Monitoring the metabolic indicators, such as blood pressure, body weight, blood sugar, HbA1c, and lipid, is imperative for managing diabetics [6]. Studies have shown that pharmaceutical interventions and lifestyle modification can effectively control Hyperglycemia [7]. Correcting the lifestyle and mood factors, self-confidence, and social support can save pre-diabetics from the risk of vulnerability to this illness [8, 9]. About 50% to 80% of the people with diabetes have no adequate skills and knowledge of self-care and illness management [10]. Numerous studies have demonstrated that healthcare strategies engaging the diabetics' family members cause higher awareness and self-efficacy concerning self-care in patients with diabetes [11]. In recent years, the US and UK diabetes associations have confirmed the effect of a low carbohydrate diet in lowering weight and improving blood glucose and lipid regulation in mellitus diabetics [12, 13]. Combinatorial diet programs and physical activity promotion plans may hinder and delay the progress of type 2 diabetes [14-17]. Disease management programs have introduced particular instructions as the best strategy for diabetes prevention in which the increase in physical activity [18, 19], decrease of consumable calories, and training of patients together with the support by peer groups are among the most crucial disease management programs [20-26]. Despite the variety and frequency of the interventions to control and treat type 2 diabetes in different countries, the knowledge and awareness of the methods and the relevant consequences are crucial for the science community. They can be counted as a decisive step toward promoting this science. A systematic review is a comprehensive study based on a predetermined and accurate protocol. Many studies do not have good interpretive power for various reasons; however, the systematic review and meta-analysis that often follows will combine studies to reach a larger sample size; therefore, they can be examined with greater power and ultimately provide better conclusions. Accordingly, this study aims to determine effective non-pharmacological interventions in controlling and treating type 2 diabetes by systematic review method. This study has been conducted to find answers to the following questions:

1) What are the types of non-pharmacological interventions used in intervention studies to control or treat type 2 diabetes?

2) Which non-pharmacological intervention is primarily recommended in controlling or treating type 2 diabetes in intervention studies?

3) What have been the outcomes of non-pharmacological interventions in controlling or treating type 2 diabetes?

## 2. Methods

This study is a systematic review of the papers published on the non-pharmaceutical intervention arrangements in controlling and treating patients with type 2 diabetes. The authors have used the standard systematic review guideline (PRISMA), including 27 items [27].

The search included the electronic data banks, including Medline, Science Direct, Embase, Scopus, Cochrane Library, and the Google Scholar search engine. The main selected keywords were as follows: “Clinical trial,” “treatment,” “type-2 diabetes,” and “control.” Their equivalents were also searched in MeSH: “NIDDM” and “diabetes mellitus.” The words “AND” and “OR” were used to combine the keywords. Searching was restricted to all relevant English papers published and indexed from June 2014 to the end of 2020.

### Inclusion criteria

The inclusion criteria of selected papers were from scientific research journals, the language of the paper was in English, and the documents were full-text papers. The criteria for selecting articles were as follows: Type of participants=type 2 diabetes, type of interventions=non-pharmaceutical interventions, type of comparator=intervention performed, type of outcome=control or treatment, study type=clinical trial or empirical.

### Exclusion criteria

The exclusion criteria of papers were inaccessibility to the full text, letters to the editors, and exclusively descriptive and review papers.

### Data extraction, variables, and data analysis

A researcher-made data extraction form based on the study objective was used to analyze the papers. This form included parts of the article details, including the authors' names, publication year, paper's objective, study design, study methodology, information relevant to type 2 diabetes, and final results and outputs. Two researchers were involved in the selection work and data extraction activities. The main features of the studies and their results have been summarized considering the following variables:

Type of study: The papers from clinical trials or empirical studies were selected.

Target population: The patients with type 2 diabetes and gestational diabetes (GDM).

### Types of interventions

Types of interventions in this study were classified into four categories, namely "lifestyle," "education," "traditional treatment," and "Treatment devices," based on the World Health Organization (WHO) interventions category guidelines [28], and the study objectives that embraced only the non-pharmaceutical interventions.

Two reviewers worked independently to determine whether a study met the inclusion criteria. They collected information to assess each study's methodological validity (degree of protection against confounding and bias). They also extracted data from the included studies using structured and standardized data extraction forms. The reviewers resolved discrepancies by jointly reviewing any study in question. A third reviewer would enter as an external peer reviewer if no consensus were reached. The third author was unaware of the other reviewers' determinations and functioned as an arbitrator.

## 3. Results

Searching of the data sources was performed for two months based on the keywords and searching strategies, and a total of 41 papers were selected from 529 articles after three selection steps. The authors systematically considered the title and abstract of all papers in the indices in the first step based on the relevancy to the study subject in addition to the inclusion and exclusion criteria. Accordingly, a total of 198 articles were entered into the study. Meanwhile, 35 articles were excluded from the study due to inaccessibility to the full text or duplication (indexed in different sites). An expert panel thoroughly analyzed the remaining articles (n=163) with two expert reviewers (after a full-text reading of the articles). Eventually, 68 articles with more comprehensive and relevant information were selected. The full text of the above 68 papers was then handed to two independent expert authors, and finally, 36 articles were selected. Then, 5 articles were added from among the articles' references, and 41 papers were selected. The flow chart of article selection is presented in Figure 1.

Table 1 represents the main features of the selected articles in addition to their aims and results.

The result indicated that the above 41 selected articles were from the outcome of studies performed in 21 different countries. Most of the randomized controlled trial (RCT) studies (82.9%) and interventions were related to lifestyle (61%). Meanwhile, most studies (53.7%) represented an improvement in the patient's status and a decrease in HbA1c, while the reduction of HbA1c accompanied the outcome of most diet intervention studies (88.9%). The percentage and frequency of the understudy variables in terms of the type of study, type of intervention, the comparison group, and the interventions' outcomes are shown in Table 2. In response to the first question of the study:

1) What are the types of non-pharmacological interventions used in intervention studies to control or treat type 2 diabetes?

In the present study, it was determined that the researchers had used the interventions, such as "changing the lifestyle (diet, physical activity, and social support)," "treatment devices," "treatment-other," "traditional treatment," and other interventions (education).

In response to the second and third questions of the study:

2) In intervention studies, which non-pharmacological intervention is most recommended in controlling or treating type 2 diabetes?

3) What have been the outcomes of non-pharmacological interventions in controlling or treating type 2 diabetes?

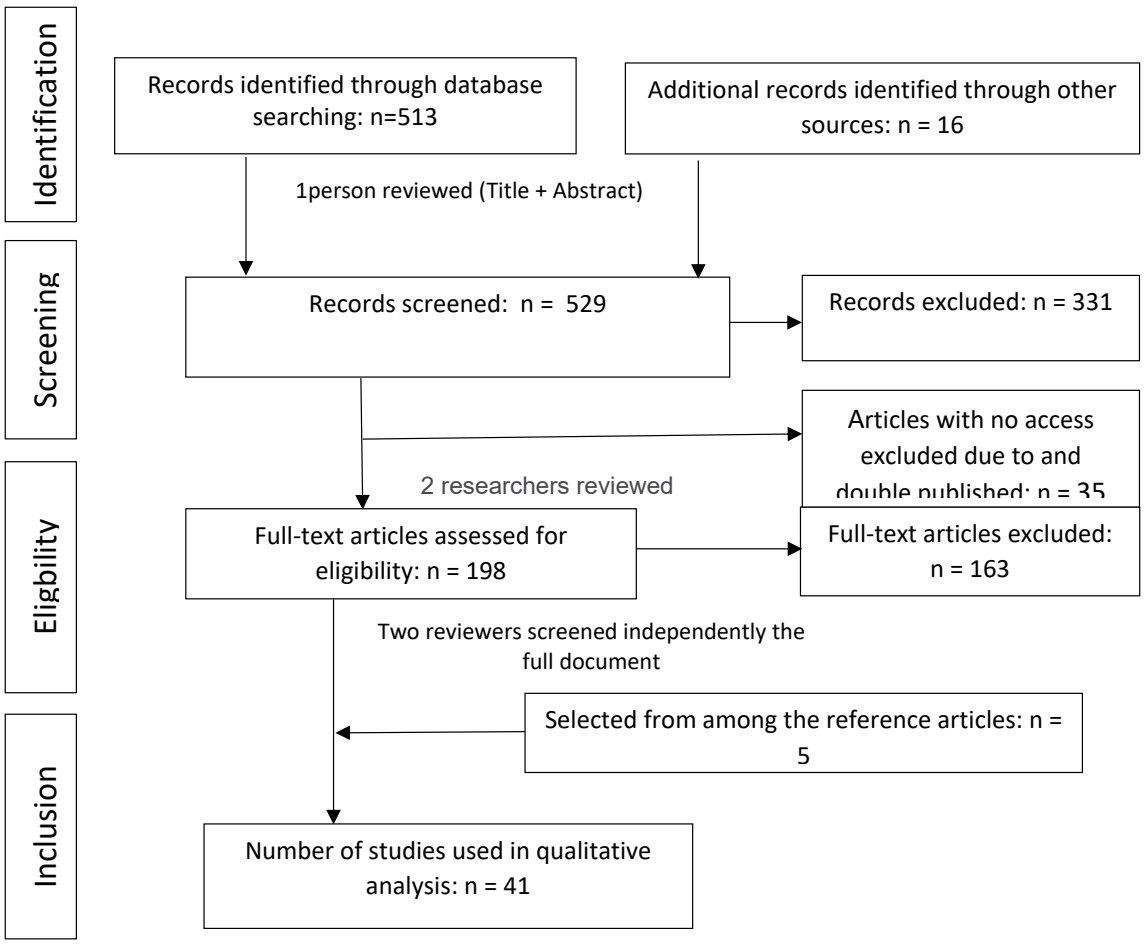


**Figure 1.** PRISMA flow diagram for the literature review and study selection

Most non-pharmacological intervention to control and improve type 2 diabetes was related to lifestyle (60.9%), although only 4.9% of the studies had investigated all lifestyle elements. Among the lifestyle variables, the highest frequency was diet and nutritional supplements (19.5%). Subsequently, physical activity (26.8%) and social support (7.3%) had the highest frequencies, respectively.

About 65.9% of interventions resulted in controlling and improving blood sugar and decreasing HbA1c. Meanwhile, 7.3% of the studies represented satisfaction and increased patients' quality of life; only 26.8% showed no significant statistical result. The study's results also demonstrated that all diet-related interventions produced the outcome of better control and improvement of blood sugar and decreased HbA1c, which indicates the importance of diet as an essential factor in controlling and preventing type 2 diabetes.

## 4. Discussion

Articles related to diabetes have dramatically increased worldwide in recent years. The Medline website contains more than 60 thousand papers published in the past seven years on this subject, hence confirming the importance of the issue and the concerns felt by all countries regarding the prevalence of diabetes and their serious attempt to find ways to prevent and control this disease. Using non-pharmaceutical interventions to treat and control diabetes while avoiding expenses for the patient and society prevents drug side effects. Hence, the use of non-pharmaceutical interventions is preferable to pharmaceutical ones.

WHO has classified the intervention types into 12 classes as follows: Behavior, diagnosis, early detection, lifestyle, placebo, prevention, rehabilitation, treatment devices, treatment-drugs, treatment-surgery, and treatment-other and other. The results of this study were classified into four categories: 1) Lifestyle, 2) Treatment-devices, 3) Treatment-other (traditional treatment), and 4) Other (education).

**Table 1.** Characteristics of selected articles

| Row | Study Details (Authors/ Date) | Study, Location, Number of Subject, Duration | Study Objectives | Interventions Category | Results/Conclusions |
|---|---|---|---|---|---|
| 1 | Sato et al. 2017 [37] | RCT, Japan, (n=66), 6 m | Comparing the effectiveness and safety of a low-carbohydrate diet with calorie-restricted diet | Lifestyle/diet | Low-carbohydrate diet is a potentially helpful nutrition therapy for Japanese patients who cannot adhere to a calorie-restricted diet. |
| 2 | Kitalong et al. 2017 [39] | RCT, Palau, (n=68), 12 w | Effects of traditional drink as adjuvant therapy when diabetes control is insufficient | Lifestyle/diet | Poorly controlled diabetic patients improved the control of diabetes within 12 weeks when drinking traditional drinks for at least 6 weeks. |
| 3 | Gomes et al. 2017 [63] | RCT, Brazil, (n=164), 2 y | Evaluating the contribution of family social support to the clinical/metabolic control of people with type 2 diabetes mellitus | Lifestyle/social support | The results showed a greater reduction in blood pressure and glycated hemoglobin in the intervention group than in the control group. |
| 4 | Nakayama et al. 2017 [40] | RCT, Tokyo, Japan, (n=18), 8 w | Evaluating the effect of glutinous brown rice intake for 8 weeks on glycemic control in outpatients with diabetes mellitus | Lifestyle/diet | Glutinous brown rice was well tolerated for 8 weeks and improved glycemic control in patients with type 2. |
| 5 | Sato et al. 2016 [38] | RCT, Tokyo, Japan, (n=34), 8 m | Assessing the effects of treatment guidance based on data from a continuous glucose monitoring device on glycemic control and patient satisfaction in patients with type 2 diabetes mellitus | Treatment-devices | The study did not demonstrate that treatment guidance using retrospective continuous glucose monitoring data effectively improved glycemic control and therapeutic satisfaction in Japanese patients with type 2 diabetes mellitus. |
| 6 | Sönnichsen et al. 2010 [26] | RCT, Austria, (n=337), 24 m | Testing the effectiveness of peer support in additionally to disease management programs for type 2 diabetes patients | Lifestyle/social support | Peer support intervention as an additional disease management programmed component showed no significant impact on HbA1c and secondary outcome measures. |
| 7 | Asemi et al. 2016 [41] | RCT. Iran, (n=102), 6 w | Determining the beneficial effects of β-carotene fortified symbiotic food intake on metabolic status in patients with type 2 diabetes mellitus | Lifestyle/diet | B-carotene fortified symbiotic food intake in patients with type 2 diabetes mellitus for 6 weeks had favorable effects on insulin. |
| 8 | Fountoulakis et al. 2015 [49] | RCT, Greece, (n=115), 1 y | Comparing the effects of telemonitoring on HbA1c, body mass index, frequency of hyper- and hypoglycemia, and cost of insufficiently controlled insulin-treated diabetes mellitus patients versus usual outpatient care alone | Treatment-devices | Telemonitoring can result in the reduction of HbA1c and frequency of hypo-and hyperglycemia. |
| 9 | Sato et al. 2016 [38] | RCT, Japan, (n=24), 1 y | Comparing HbA1c and body mass index between the low- low-carbohydrate diet and calorie-restricted diet groups at 1 year after the end of the 6-month RCT | Lifestyle/diet | Well-constructed nutrition therapy programs, both a restricted diet and low-carbohydrate diet, were equally effective in improving HbA1c for at least 1 year. |
| 10 | Li et al. 2014 [42] | RCT, China, (n=71),12 w | Examining the effect of a low glycemic index multi-nutrient supplement, consumed in place of breakfast, on glycemic control in patients with type 2 diabetes mellitus | Lifestyle/diet/ nutritional supplements | Breakfast replacement with a low glycemic index multi-nutrient supplement can improve glycemic and weight control in type 2 diabetes mellitus. |
| 11 | Yuan et al. 2014 [81] | Experimental, Hong Kong, (n=76), 3 m | Evaluating the effect of a short-term diabetes self-management education on metabolic markers and atherosclerotic parameters in patients with type 2 diabetes | Education | Diabetes self-management education can improve HbA1c and body weight in patients with type 2 diabetes. |
| 12 | Kirilmaz et al. 2015 [29] | Experimental, Turkey, (n=83), 3 m | Evaluating the effect of lifestyle modifications and glycemic control on the efficiency of sildenafil citrate in patients with type-2 diabetes and erectile dysfunction | Lifestyle | Glycemic control and lifestyle changes are not solely adequate for better sexual function in erectile dysfunction due to diabetes, and sildenafil citrate should be used additionally. |

| Row | Study Details (Authors/ Date) | Study, Location, Number of Subject, Duration | Study Objectives | Interventions Category | Results/Conclusions |
|---|---|---|---|---|---|
| 13 | Wang et al. 2018 [43] | RCT, China, (n=56), 3 m | Evaluating low-fat diet to improve blood glucose levels in patients with type 2 diabetes mellitus | Lifestyle/Diet | A low-carbohydrate diet can improve blood glucose more than a low-fat diet in Chinese patients with type 2 diabetes mellitus. |
| 14 | Huhmann et al. 2018 [44] | RCT, USA, (n=12), 2 m | Evaluating an enteral nutrition formula containing a very high concentration of protein and low concentration of carbohydrate provides better control of postprandial blood glucose relative to a high-protein/higher carbohydrate formula | Lifestyle/Diet | An enteral nutrition formula containing high-protein and low-carbohydrate loads can significantly improve glucose control in subjects with type 2 diabetes. |
| 15 | Rasekaba et al. 2018 [70] | RCT, Australia, (n=95), 10 w | Exploring the effects of telemedicine-supported gestational diabetes mellitus care on a range of health service utilization and maternal and fetal outcomes | Treatment-devices | Telemedicine was a significant predictor of better glycemic control. |
| 16 | Gholaman et al. 2018 [49] | RCT, Iran, (n=40), 8 w | Investigating the effects of training along with fenugreek seed supplement on lipid profile, body composition, insulin resistance, and $VO_2$ max in obese women with type 2 diabetes | Traditional treatment | Fenugreek consumption increases the endurance training-induced adaptations in obese women with type 2 diabetes. |
| 17 | Sajatovic et al. 2017 [79] | RCT, Japan, (n=200), 60 w | Assessing the effects of targeted training in illness management vs usual treatment | Lifestyle/ Physical activity | Targeted training in illness management was associated with improved psychiatric symptoms, functioning, and diabetes knowledge compared with treatment as usual. |
| 18 | O'Dea et al. 2015 [30] | RCT, Ireland, (n=50), 12 w | Evaluating a group-based lifestyle intervention program for women with prediabetes following gestational diabetes | Lifestyle | Prevention programmers must tackle the barriers to participation faced by this population; home-based interventions should be investigated. |
| 19 | Sklempe Kokic et al. 2018 [51] | RCT, Croatia, (n=38), 6 weeks | Investigating the impact of a structured exercise program on the parameters of glycemic control and other health-related outcomes in pregnant women diagnosed with gestational diabetes mellitus | Lifestyle/ Physical activity | The structured exercise program had a beneficial effect on postprandial glucose levels at the end of pregnancy. |
| 20 | Draffin et al. 2017 [83] | RCT, UK, (n=150), 1 y | Evaluating the impact of an innovative patient-centered educational DVD on anxiety and glycemic control in women newly diagnosed with gestational diabetes mellitus | Education | The results did not highlight differences between the intervention and those who received usual care. |
| 21 | Davoudi et al. 2016 [48] | Quasi-experimental, Iran, (n=10) | Investigating the effect of different intensities of acute aerobic exercise on plasma resistance levels in men with type 2 diabetes | Lifestyle/ Physical activity | Acute exercise with different intensities does not affect resistance action in individuals with diabetes. |
| 22 | Ghoreishi et al. 2016 [78] | RTC, Iran, (n=60), 2 m | Evaluating the effect of consuming sesame seeds on some biochemical factors in type 2 diabetic patients | Traditional treatment | The sesame seeds suggested that this plant is probably useful as a complementary therapy for treating and preventing diabetes disorders. |
| 23 | Mirfeizi et al. 2014 [76] | RCT, Iran, n=75), 2 y | Evaluating the effect of oral supplementation of cinnamon on glucose control index and lipid profile in type 2 diabetic patients | Traditional treatment | The oral supplementation of cinnamon to adjust the weight of diabetic patients with conventional therapy is recommended. |
| 24 | Samadi et al. 2017 [77] | RCT, Iran, (n=57), 12 w | Assessing bee propolis supplementation on insulin resistance Indices in patients with type 2 diabetes | Traditional treatment | The daily intake of 900 mg of bee propolis supplement for 12 weeks improves glycemic and some serum lipid levels in patients with type 2 diabetes. |

| Row | Study Details (Authors/ Date) | Study, Location, Number of Subject, Duration | Study Objectives | Interventions Category | Results/Conclusions |
|---|---|---|---|---|---|
| 25 | Ji et al. 2019 [90] | Pilot study, RCT, China, (n=100), 3 & 6 m | Investigate whether simulation education and case management had any effect on glycemic control in type 2 diabetes patients | Education | After 6 months, HbA1c, fasting plasma glucose, and postprandial blood glucose level improvements were superior in the experimental group compared with the control group. |
| 26 | Madsen et al. 2015 [58] | RCT, Denmark, (n=33), 8 w | Investigating glycemic control, pancreatic function, and total fat mass before and after 8 weeks of low volume high-intensity interval training on a cycle ergometer in type 2 diabetes patients and matched healthy control individuals | Lifestyle/ Physical activity | These results demonstrate that high-intensity interval training improves overall glycemic control and pancreatic β cell function in type 2 diabetes patients. |
| 27 | Gupta et al. 2020 [84] | RCT, (n=81), 3 m | Investigating the effectiveness of a video-based lifestyle education program in improving glycemic control in people with type 2 diabetes mellitus compared with usual care | Education | A significant reduction ([0.6%-95% CI) (0.1, 1.1)], P=0.013) in HbA1c was seen in the video-based lifestyle education program group compared to usual care was observed. |
| 28 | Yuan et al, 2014 [81] | RCT, Hong Kong, (n=76), 3 m | Comprehensively evaluating the effect of short-term diabetes self-management education on metabolic markers and atherosclerotic parameters in patients with type 2 diabetes | Education | Diabetes self-management education can improve HbA1c and body weight in patients with type 2 diabetes. |
| 29 | Xu et al. 2018 [89] | RCT, China, (n=300) | Evaluating the intervention effects of peer support education mode for type 2 diabetes control in rural residents | Education | Peer support for education intervention seemed beneficial for diabetic control. The combination of education and effect evaluation was important for assessing diabetes prevention and control. |
| 30 | Abdulah et al. 2018 [82] | Iraq, double-arm post-test interventional clinical trial, (n=87), 15-69 y | Investigating the impact of 3 months of diabetes self-management intervention on glycemic control in patients with non-complicated type 2 diabetes | Education | The current study showed a substantial statistically higher participation of patients in the experimental arm in walking, higher consumption of some healthy foods, and a statistically considerably lower consumption of some unhealthy foods following a three-month self-management intervention. |
| 31 | Zaidi et al. 2018 [59] | RCT, Norway, (n=137), 41-81 years, 12 months | Investigating whether exercise training would reduce the levels of circulating IL-18, as well as gene expression of IL-18, Caspase-1, and NLRP3 in circulating leukocytes and AT in patients with coronary artery diseases and type 2 diabetes mellitus | Lifestyle/ Physical activity | Long-term exercise training had no significant effects on the inflammasome-related mediators in our patients with combined coronary artery disease and type 2 diabetes mellitus. |
| 32 | Gaffney et al. 2018 [45] | RCT, New Zealand; (n=24 men), 10 weeks, 40-65 years, | Determining if pretraining whey protein supplementation combined with mixed-mode interval training can improve glycemic control | Lifestyle/Diet/ Nutritional supplements | Consumption of 20 g of whey protein before and after high-intensity mixed-mode interval training for 10 weeks, compared with iso caloric non–protein control, did not clearly enhance glycemic control in middle-aged men with type 2 diabetes. |
| 33 | Tokmakidis et al. 2014 [50] | Clinical trials, Greece, n=13 (postmenopausal women), 21 m | Investigating the effects of training, detraining, and retraining, using a combined strength and aerobic exercise program on glycemic control in women with type 2 diabetes | Lifestyle/ Physical activity | The cessation of exercise brings about negative alterations while retraining restores all beneficial adaptations and improves them even more. |
| 34 | Hermanns et al. 2017 [86] | RCT, Germany, (n=182), 6 m | Comparing the effects of MEDIAS 2 BSC with an established education program acted as a control group in a randomized, multi-center trial | Education | MEDIAS 2 BSC was more effective in lowering HbA1c than the control condition. |

| Row | Study Details (Authors/ Date) | Study, Location, Number of Subject, Duration | Study Objectives | Interventions Category | Results/Conclusions |
|---|---|---|---|---|---|
| 35 | Andersen et al. 2014 [62] | RCT, Germany; (n=21) middle-aged men, 24 w | Evaluating the effects of 24 weeks of recreational football training on glycemic control, muscular adaptations, body composition, and maximal oxygen uptake in middle-aged male subjects with type 2 diabetes mellitus | Lifestyle/ Physical activity | 24 weeks of recreational football training improved $VO_2$ peak and lowered total body and android fat mass in middle-aged men with type 2 diabetes mellitus. |
| 36 | Kuniss et al. 2018 [80] | RCT (prospective, longitudinal trial), Germany, (n=33), 12 m | Assessing the efficacy of a patient education programs for the optimization of conventional insulin therapy in patients with type 2 diabetes in an in- and outpatient setting | Education | Participation in an out- or inpatient DTTP improved substantially HbA1c levels in people with type 2 diabetes on conventional insulin treatment. |
| 37 | Deng et al. 2016 [64] | RCT, China, (n=200), 40-70 y , 7 m | Observing the effects of a peer support program on the outcomes of patients with type 2 diabetes who received community-based insulin therapy in rural communities of central China | Lifestyle/Social support | This study indicates that 4-month peer support training achieved a satisfactory effect on diabetic behavior, knowledge related to diabetes, and self-management of patients with diabetes in rural communities of central China. |
| 38 | Park et al. 2014 [61] | RCT, Korea, (n=37), 12 w | Investigating the effect of circuit exercise training and detraining in type 2 diabetic patients | Lifestyle/ Physical activity | Neither group had a significant improvement in BMI and blood lipid profile. |
| 39 | Karstoft et al. 2017 [60] | RCT, Denmark, (n=14), 8 w | Evaluating the effects of oxygen consumption-matched short-term interval walking training vs continuous walking training on glycemic control, including glycemic variability in individuals with type 2 diabetes | Lifestyle/ Physical activity | In contrast to continuous walking training, short-term interval walking training improves CGM-derived measures of glycemic control independent of changes in physical fitness and body composition in individuals with type 2 diabetes. |
| 40 | Karstoft et al. 2014 [57] | RCT, Japan, (n=20), 4 m | Elucidating the underlying mechanisms behind the advantageous effects of interval training compared with continuous training on glycemic control in individuals with type 2 diabetes | Lifestyle/ Physical activity | These results suggest that training with alternating intensity, not just training volume and mean intensity, is a key determinant of changes in whole body glucose disposal in individuals with type 2 diabetes. |
| 41 | Delevatti et al. 2015 [51] | RCT, Brazil, (n=34), 12 w | Comparing the effects of two aerobic training methods in water and on dry-land on glycemic, lipid, inflammatory, hormonal, cardiorespiratory, and functional outcomes in patients with type 2 diabetes | Lifestyle/ physical activity | Aerobic training in an aquatic environment provides effects similar to aerobic training in a dry-land environment in patients with type 2 diabetes. |

RCT: Randomized controlled trial.

## Lifestyle

US Diabetes Association considers lifestyle management a principal aspect of preventing and controlling type 2 diabetes [29]. Although lifestyle interventions are the major element of care in type 2 diabetes cases [30] and lifestyle can prevent the micro- and macro-vascular complications accompanied by type 2 diabetes [31], due to the complexity and time-consuming nature of complete intervention in lifestyle, a minimal number of studies are often conducted. Most studies consider only one of the elements involved in the lifestyle as an individual variable. This is while numerous factors, including smoking, alcohol consumption, physical activities, diet, social support and spiritual dimensions, and stress in lifestyle are also involved [32-34]. Based on the findings of this study, among the lifestyle components, most of the components, including physical activity, nutrition, and social support, have been studied.

## Diet

Most of the articles reviewed in this study have investigated the diet component as an essential factor in lifestyle. Low carbohydrates, low-calorie diet [35-36], traditional beverages [37], brown rice [38], β carotene-enriched foods [39], nutritional supplements containing several low-glucose nutrients with breakfast [40], low-

**Table 2.** Percentage and frequency of studied variables by the type of intervention (n=41)

| Variables | | Intervention Categories | | | | | | | No. (%) |
|---|---|---|---|---|---|---|---|---|---|
| | | Education | Treatment-devices | Traditional Treatment | Lifestyle | | | | |
| | | | | | Lifestyle | Social Support | Physical Activity | Diet | |
| Study design | RCT | 8 | 4 | 4 | 0 | 2 | 8 | 9 | 34(82.9) |
| | Experimental | 1 | 0 | 0 | 2 | 1 | 3 | 0 | 7(17.1) |
| Comparison | Placebo | 0 | 0 | 4 | 0 | 0 | 0 | 1 | 5(12.2) |
| | Other interventions | 1 | 1 | 0 | 0 | 1 | 3 | 4 | 10(24.4) |
| | Crossover | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2(4.9) |
| | Usual care | 8 | 2 | 0 | 2 | 2 | 8 | 2 | 24(58.5) |
| Outcome | Satisfaction | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 3(7.3) |
| | Control | 1 | 0 | 1 | 0 | 1 | 2 | 0 | 5(12.2) |
| | Improve | 5 | 1 | 2 | 0 | 1 | 5 | 8 | 22(53.7) |
| | None | 2 | 1 | 1 | 1 | 1 | 4 | 1 | 11(26.8) |

RCT: Randomized controlled trial.

fat diet [41], and prepared food with high protein and low glucose concentration in enteral nutrition [42] have been effective in better blood sugar control and reduction of HbA1c level in type 2 diabetes patients. However, whey protein supplementation was not effective [43]. Vitamin D supplementation did not affect type 2 diabetes incidence or insulin resistance [44].

Accordingly, the results of this study are indicative of the essential role of diet in controlling the blood sugar of people with type 2 diabetes; therefore, it is recommended that considering the native and local nutritional cultures of each country and ease of access to foodstuffs, the necessary education is given to this type of diabetics. The latest guidelines for type 2 diabetes in China also introduce medical nutrition therapy as an essential component of the control and treatment of these patients [45].

## Physical activity

In this study, it was confirmed that acute exercise with various intensities is ineffective in controlling the blood sugar of type 2 diabetes patients [46]; however, the use of vegetable supplements, such as fenugreek seed with physical activity, in addition to the reduction of blood sugar, would significantly decrease the body fat percentage [47]. The results of studies also indicate the effect of following a regular and uninterrupted exercise program throughout life on controlling glucose metabolism [48] and programmed structured exercise on the blood sugar level after delivery in the GDM [49].

Physical activity affects lipids, blood sugar, cardiovascular incidents, and life quality and is additionally considered an essential element in predicting and controlling type 2 diabetes. Physical activity with moderate weight loss can decrease the vulnerability risk of type 2 diabetes by up to 58% in high-risk populations [50]. Aerobic exercise, on land and in water, may improve blood sugar and nerve function in type 2 diabetes [51, 52]. Ghanbarzadeh (2017) also demonstrated that a balanced and low-fat diet maintained with (aerobic or anaerobic) exercise can be effective in decreasing the blood sugar of diabetics [53]. In some studies, the intensity of physical exercise is known as the main determinant of metabolic improvement and is also effective on blood sugar [54, 55].

According to the contradictory results of studies [56-60], the effective role of physical activity in decreasing weight and physical health is not unknown. Still, due to a lack of knowledge on the type of activity, intensity, and frequency of exercises that could be effective on the blood sugar of type 2 diabetes patients, the whole issue needs further investigation.

### Social support

This study determined that the family's social support, especially with their participation in the health care program of type 2 diabetes patients, results in blood sugar control [61]. Peer social support had a satisfactory effect on diabetic behavior, diabetes-related knowledge, and self-management of diabetic patients in rural China [ ]; however, peer-supportive interventions were ineffective in controlling blood sugar and side effects [56].

The results of other studies are in line with the results of this study that community-based social support will be associated with better health [63] and is effective on the HbA1c level and lifestyle as well as self-efficacy [64-66].

### Lifestyle

The study results indicate the effects of the lifestyle interventions on better sexual performance of the patients and their satisfaction [67]. Also, better stress control has been accompanied by diet self-efficacy and higher life quality, although with no evident changes in the biochemical variables [68].

### Treatment-devices

Continuous glucose monitor (CGM) devices were effective in the patients' blood sugar control and satisfaction [38]. Although telemonitoring was effective in controlling the blood sugar and improving the HbA1c level of type 2 diabetes patients, this effectiveness was weakened six months after the termination of such monitoring [69]. In GDM, telemedicine can be associated with better diabetes control and maternal and neonatal outcomes [70].

The diabetes monitoring device may include sensors to supervise one or more of the following items: Blood sugar level, physical activity, energy consumption, and insulin dose [71]. Although numerous interventions have reported the significance and effect of telemedicine and telemonitoring interventions on controlling and preventing diabetes complications [72-74], telemedicine services must facilitate infrastructure, including continuous support services and service guideline training, to be effective. Therefore, the capacity of telemedicine providers will be far more critical than the competence of their recipients in the success of telemedicine services [75].

### Traditional treatment

Although the result of this study is indicative of the ineffectiveness of using cinnamon nutritional supplements [76] in reducing the blood sugar of type 2 diabetes patients, the consumption of bee propolis [77] and sesame seeds [78] achieved the fetal bovine serum reduction outcome besides reducing the HbA1c level.

### Education

Targeted training in diabetes management (TTIM) improved psychiatric symptoms and heightened the knowledge level of diabetes [79, 80]. Diabetes self-management and education can, in addition to decreasing body weight, improve the HbA1c level [81, 82]. Although the training DVD was not effective in controlling blood sugar in type 2 diabetics, the video-based lifestyle education program was effective in improving glycemic control in patients with type 2 diabetes [83, 84].

Diabetes self-management and education support facilitate the knowledge, skill, and ability required for self-care in diabetics [85, 86]. Based on the results reported by numerous studies, education currently represents one of the most essential elements in preventing and controlling diabetes [87, 88]. Peer support for educational intervention and simulation education in diabetes control will be useful [89, 90]. However, assessing educational needs is necessary for the success of every educational program [91]. The self-management education must be appropriate to the specific population considering the ethnic, social, cognitive, literacy, and cultural factors. There is a need to improve access to and absorption of diabetes self-management programs across the globe [92], and comprehensive research should be conducted on the manner, period, and method of interaction with the trainer. It is recommended that in every educational group, first, the preliminary educational needs assessment is performed. Then, based on the literacy level, cultural and ethnic factors, and the groups' educational needs, the content and tools suitable to the training are selected, and the educational planning is executed.

## 5. Conclusion

Study findings show that applying non-pharmaceutical interventions effectively controls and prevents type 2 diabetes complications. The interventions, such as lifestyle correction, suitable diet, social support, application of treatment devices, traditional treatment, and education, all have a role in treating type-2 diabetes. However, depending on the patient’s condition, these interventions

may need to be accompanied by medication. Most studies are in line with a low-carbohydrate diet. Still, this study demonstrated that in addition to the low glucose and high protein diet, consuming some foodstuffs, including brown rice, DAK beverages, β-carotene contained foods, and low-fat diets could decrease HbA1c levels. Structured physical activity, family support through their participation in the care programs, application of telemonitoring devices, and diabetes self-management education are all effective methods in controlling diabetes and preventing its complications. However, some of these components need further investigation to confirm a rigorous and consistent program. In addition, it seems that the most important issue is education because using all of the above methods requires patient education, so proper patient education should not be neglected.

### Study limitations

We attempted to minimize the limitations of this study. We used several strategies to identify studies to limit publication bias's possible effect. The Inclusion criteria were chosen to increase the possibility that high-quality studies would be selected. However, there are many limitations. Firstly, a literature search was conducted in major electronic databases, Medline, Science Direct, Embase, Scopus, Cochrane Library, and the Google Scholar search engine. Still, no other databases were searched (gray literature). Therefore, some relevant studies are probably missing. Secondly, based on the search strategy in the study, we included all studies with available full text in English and Persian languages that investigated the non-pharmacological interventions in the control and treatment of type 2 diabetes with "clinical trial," "treatment," "type-2 diabetes," 'control," and its equivalents in MeSH, namely "NIDDM" and "diabetes mellitus." However, other interventions for treating this disease can be investigated in other studies, but due to the small number of them, they were not included in this study, and only the main interventions were used. Third, we excluded articles published in preprint databases due to a lack of peer review.

## Ethical Considerations

### Compliance with ethical guidelines

This study was approved by the Ethics Committee of Sabzevar University of Medical Sciences (Code: IR.MEDSAB.REC.1399.145) and informed consent was obtained from every participant.

### Funding

This research did not receive any grant from funding agencies in the public, commercial, or non-profit sectors.

### Authors' contributions

Writing–review and editing: Fatemeh Ghardashi and Roghayeh Zardosht; Data collection and writing–original draft: All authors.

### Conflict of interest

The authors declared no conflict of interest.

### Acknowledgments

The authors would like to thank Sabzevar University of Medical Sciences for their support.

### References

[1] Chen L, Magliano DJ, Zimmet PZ. The worldwide epidemiology of type 2 diabetes mellitus--present and future perspectives. Nature Reviews. Endocrinology. 2011; 8(4):228-36. [DOI:10.1038/nrendo.2011.183] [PMID]

[2] Zimmet PZ, Magliano DJ, Herman WH, Shaw JE. Diabetes: A 21st century challenge. The Lancet. Diabetes & Endocrinology. 2014; 2(1):56-64. [DOI:10.1016/S2213-8587(13)70112-8] [PMID]

[3] Duarte AA, Mohsin S, Golubnitschaja O. Diabetes care in figures: Current pitfalls and future scenario. The EPMA Journal. 2018; 9(2):125-31. [DOI:10.1007/s13167-018-0133-y] [PMID] [PMCID]

[4] International Diabetes Federation. Diabetes atlas. Belgium: International Diabetes Federation; 2015. [Link]

[5] Balducci S, Zanuso S, Nicolucci A, De Feo P, Cavallo S, Cardelli P, et al. Effect of an intensive exercise intervention strategy on modifiable cardiovascular risk factors in subjects with type 2 diabetes mellitus: A randomized controlled trial: The Italian diabetes and exercise study (IDES). Archives of Internal Medicine. 2010; 170(20):1794-803. [DOI:10.1001/archinternmed.2010.380] [PMID]

[6] Tripathi BK, Srivastava AK. Diabetes mellitus: Complications and therapeutics. Medical Science Monitor. 2006; 12(7):RA130-47. [PMID]

[7] Georgoulis M, Kontogianni MD, Yiannakouris N. Mediterranean diet and diabetes: Prevention and treatment. Nutrients. 2014; 6(4):1406-23. [DOI:10.3390/nu6041406] [PMID] [PMCID]

[8] Goldney RD, Phillips PJ, Fisher LJ, Wilson DH. Diabetes, depression, and quality of life: A population study. Diabetes Care. 2004; 27(5):1066-70. [DOI:10.2337/diacare.27.5.1066] [PMID]

[9] Stenlöf K, Cefalu WT, Kim KA, Alba M, Usiskin K, Tong C, Canovatchel W, Meininger G. Efficacy and safety of canagliflozin monotherapy in subjects with type 2 diabetes mellitus inadequately controlled with diet and exercise. Diabetes, Obesity & Metabolism. 2013; 15(4):372-82. [DOI:10.1111/dom.12054] [PMID] [PMCID]

[10] Clement S. Diabetes self-management education. Diabetes Care. 1995; 18(8):1204-14. [DOI:10.2337/diacare.18.8.1204] [PMID]

[11] Baig AA, Benitez A, Quinn MT, Burnet DL. Family interventions to improve diabetes outcomes for adults. Annals of the New York Academy of Sciences. 2015; 1353(1):89-112. [DOI:10.1111/nyas.12844] [PMID] [PMCID]

[12] Dyson PA, Kelly T, Deakin T, Duncan A, Frost G, Harrison Z, et al. Diabetes UK evidence-based nutrition guidelines for the prevention and management of diabetes. Diabetic Medicine. 2011; 28(11):1282-8. [DOI:10.1111/j.1464-5491.2011.03371.x] [PMID]

[13] Wheeler ML, Dunbar SA, Jaacks LM, Karmally W, Mayer-Davis EJ, Wylie-Rosett J, et al. Macronutrients, food groups, and eating patterns in the management of diabetes: A systematic review of the literature, 2010. Diabetes Care. 2012; 35(2):434-45. [DOI:10.2337/dc11-2216] [PMID] [PMCID]

[14] Knowler WC, Barrett-Connor E, Fowler SE, Hamman RF, Lachin JM, Walker EA, et al. Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. The New England Journal of Medicine. 2002; 346(6):393-403. [DOI:10.1056/NEJMoa012512] [PMID] [PMCID]

[15] Lindström J, Louheranta A, Mannelin M, Rastas M, Salminen V, Eriksson J, et al. The Finnish diabetes prevention study (DPS): Lifestyle intervention and 3-year results on diet and physical activity. Diabetes Care. 2003; 26(12):3230-6. [DOI:10.2337/diacare.26.12.3230] [PMID]

[16] Pan XR, Li GW, Hu YH, Wang JX, Yang WY, An ZX, et al. Effects of diet and exercise in preventing NIDDM in people with impaired glucose tolerance. The Da Qing IGT and Diabetes Study. Diabetes Care. 1997; 20(4):537-44. [DOI:10.2337/diacare.20.4.537] [PMID]

[17] Ramachandran A, Snehalatha C, Mary S, Mukesh B, Bhaskar AD, Vijay V; Indian Diabetes Prevention Programme (IDPP). The Indian diabetes prevention programme shows that lifestyle modification and metformin prevent type 2 diabetes in Asian Indian subjects with impaired glucose tolerance (IDPP-1). Diabetologia. 2006; 49(2):289-97. [DOI:10.1007/s00125-005-0097-z] [PMID]

[18] Ofman JJ, Badamgarav E, Henning JM, Knight K, Gano AD Jr, Levan RK, et al. Does disease management improve clinical and economic outcomes in patients with chronic diseases? A systematic review. The American Journal of Medicine. 2004; 117(3):182-92. [DOI:10.1016/j.amjmed.2004.03.018] [PMID]

[19] Pimouguet C, Le Goff M, Thiébaut R, Dartigues JF, Helmer C. Effectiveness of disease-management programs for improving diabetes care: A meta-analysis. CMAJ. 2011; 183(2):E115-27. [DOI:10.1503/cmaj.091786] [PMID] [PMCID]

[20] Esposito K, Giugliano D. Mediterranean diet and type 2 diabetes. Diabetes/Metabolism Research and Reviews. 2014; 30(Suppl 1):34-40. [DOI:10.1002/dmrr.2516] [PMID]

[21] Glasgow RE, Boles SM, McKay HG, Feil EG, Barrera M Jr. The D-Net diabetes self-management program: Long-term implementation, outcomes, and generalization results. Preventive Medicine. 2003; 36(4):410-9. [DOI:10.1016/S0091-7435(02)00056-7] [PMID]

[22] Anderson-Loftin W, Barnett S, Bunn P, Sullivan P, Hussey J, Tavakoli A. Soul food light: Culturally competent diabetes education. The Diabetes Educator. 2005; 31(4):555-63. [DOI:10.1177/0145721705278948] [PMID]

[23] Lorig K, Ritter PL, Villa F, Piette JD. Spanish diabetes self-management with and without automated telephone reinforcement: Two randomized trials. Diabetes Care. 2008; 31(3):408-14. [DOI:10.2337/dc07-1313] [PMID]

[24] Lorig K, Ritter PL, Villa FJ, Armas J. Community-based peer-led diabetes self-management: A randomized trial. The Diabetes Educator. 2009; 35(4):641-51. [DOI:10.1177/0145721709335006] [PMID]

[25] Murrock CJ, Higgins PA, Killion C. Dance and peer support to improve diabetes outcomes in African American women. The Diabetes Educator. 2009; 35(6):995-1003. [DOI:10.1177/0145721709343322] [PMID]

[26] Sönnichsen AC, Winkler H, Flamm M, Panisch S, Kowatsch P, Klima G, et al. The effectiveness of the Austrian disease management programme for type 2 diabetes: A cluster-randomised controlled trial. BMc Family Practice. 2010; 11:86. [DOI:10.1186/1471-2296-11-86] [PMID] [PMCID]

[27] Liberati A, Altman DG, Tetzlaff J, Mulrow C, Gøtzsche PC, Ioannidis JP, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: Explanation and elaboration. Plos Medicine. 2009; 6(7):e1000100. [DOI:10.1371/journal.pmed.1000100] [PMID] [PMCID]

[28] WHO. Diabetes. Geneva: World Health Organization; 2023. [Link]

[29] Kirilmaz U, Guzel O, Aslan Y, Balci M, Tuncel A, Atan A. The effect of lifestyle modification and glycemic control on the efficiency of sildenafil citrate in patients with erectile dysfunction due to type-2 diabetes mellitus. The Aging Male. 2015; 18(4):244-8. [DOI:10.3109/13685538.2015.1072154] [PMID]

[30] O'Dea A, Tierney M, McGuire BE, Newell J, Glynn LG, Gibson I, et al. Can the onset of type 2 diabetes be delayed by a group-based lifestyle intervention in women with prediabetes following gestational diabetes mellitus (GDM)? Findings from a randomized control mixed methods trial. Journal of Diabetes Research. 2015; 2015:798460. [DOI:10.1155/2015/798460] [PMID] [PMCID]

[31] Paulweber B, Valensi P, Lindström J, Lalic NM, Greaves CJ, McKee M, et al. A European evidence-based guideline for the prevention of type 2 diabetes. Horm Metab Res. 2010; 42(Suppl 1):S3-36. [DOI:10.1055/s-0029-1240928] [PMID]

[32] American Diabetes Association. Lifestyle management: Standards of medical care in diabetes-2018. Diabetes Care. 2018; 41(Suppl 1):S38-50. [DOI:10.2337/dc18-S004] [PMID]

[33] Chen L, Pei JH, Kuang J, Chen HM, Chen Z, Li ZW, et al. Effect of lifestyle intervention in patients with type 2 diabetes: A meta-analysis. Metabolism. 2015; 64(2):338-47. [DOI:10.1016/j.metabol.2014.10.018] [PMID]

[34] LAR G. Long term effects of a lifestyle intervention on weight and cardiovascular risk factors in individuals with type 2 diabetes: Four year results of the Look AHEAD trial. Archives of Internal Medicine. 2010; 170(17):1566-75. [DOI:10.1001/archinternmed.2010.334]

[35] Bouchard DR, Langlois MF, Domingue MÈ, Brown C, LeBrun V, Baillargeon JP. Age differences in expectations and readiness regarding lifestyle modifications in individuals at high risk of diabetes. Archives of Physical Medicine and Rehabilitation. 2012; 93(6):1059-64. [DOI:10.1016/j.apmr.2011.12.028] [PMID]

[36] Adler A. Understanding human nature: Psychology revivals. London: Routledge; 2014. [DOI:10.4324/9780203438831]

[37] Sato J, Kanazawa A, Makita S, Hatae C, Komiya K, Shimizu T, et al. A randomized controlled trial of 130 g/day low-carbohydrate diet in type 2 diabetes with poor glycemic control. Clinical Nutrition. 2017; 36(4):992-1000. [DOI:10.1016/j.clnu.2016.07.003] [PMID]

[38] Sato J, Kanazawa A, Ikeda F, Shigihara N, Kawaguchi M, Komiya K, et al. Effect of treatment guidance using a retrospective continuous glucose monitoring system on glycaemic control in outpatients with type 2 diabetes mellitus: A randomized controlled trial. The Journal of International Medical Research. 2016; 44(1):109-21. [DOI:10.1177/0300060515600190] [PMID] [PMCID]

[39] Kitalong C, Nogueira RC, Benichou J, Yano V, Espangel V, Houriet J, et al. "DAK", a traditional decoction in Palau, as adjuvant for patients with insufficient control of diabetes mellitus type II. Journal of Ethnopharmacology. 2017; 205:116-22. [DOI:10.1016/j.jep.2017.05.003] [PMID]

[40] Nakayama T, Nagai Y, Uehara Y, Nakamura Y, Ishii S, Kato H, et al. Eating glutinous brown rice twice a day for 8 weeks improves glycemic control in Japanese patients with diabetes mellitus. Nutrition & Diabetes. 2017; 7(5):e273.[DOI:10.1038/nutd.2017.26] [PMID] [PMCID]

[41] Asemi Z, Alizadeh SA, Ahmad K, Goli M, Esmaillzadeh A. Effects of beta-carotene fortified synbiotic food on metabolic control of patients with type 2 diabetes mellitus: A double-blind randomized cross-over controlled clinical trial. Clinical Nutrition. 2016; 35(4):819-25. [DOI:10.1016/j.clnu.2015.07.009] [PMID]

[42] Li D, Zhang P, Guo H, Ling W. Taking a low glycemic index multi-nutrient supplement as breakfast improves glycemic control in patients with type 2 diabetes mellitus: A randomized controlled trial. Nutrients. 2014; 6(12):5740-55. [DOI:10.3390/nu6125740] [PMID] [PMCID]

[43] Wang LL, Wang Q, Hong Y, Ojo O, Jiang Q, Hou YY, et al. The effect of low-carbohydrate diet on glycemic control in patients with type 2 diabetes mellitus. Nutrients. 2018; 10(6):661. [DOI:10.3390/nu10060661] [PMID] [PMCID]

[44] Huhmann MB, Yamamoto S, Neutel JM, Cohen SS, Ochoa Gautier JB. Very high-protein and low-carbohydrate enteral nutrition formula and plasma glucose control in adults with type 2 diabetes mellitus: A randomized crossover trial. Nutrition & Diabetes. 2018 8(1):45. [DOI:10.1038/s41387-018-0053-x] [PMID] [PMCID]

[45] Gaffney KA, Lucero A, Stoner L, Faulkner J, Whitfield P, Krebs J, et al. Nil whey protein effect on glycemic control after intense mixed-mode training in type 2 diabetes. Medicine and Science in Sports and Exercise. 2018; 50(1):11-7. [DOI:10.1249/MSS.0000000000001404] [PMID]

[46] Wallace IR, Wallace HJ, McKinley MC, Bell PM, Hunter SJ. Vitamin D and insulin resistance. Clinical Endocrinology. 2016; 84(2):159-71. [DOI:10.1111/cen.12760] [PMID]

[47] Orlando G, Sacchetti M, D'Errico V, Haxhi J, Rapisarda G, Pugliese G, et al. Muscle fatigability in patients with type 2 diabetes: Relation with long-term complications. Diabetes/Metabolism Research and Reviews. 2020; 36(2):e3231. [DOI:10.1002/dmrr.3231] [PMID]

[48] Davoudi Z, Ghanbarzadeh M, Shakeriyan S, Habbibi A. [The effect of different intensities of acute aerobic exercise on plasma resistin concentration and insulin resistance index in type 2 diabetic males (Persian)]. Journal of Advanced Biomedical Sciences. 2016; 6(1):79-86. [Link]

[49] Gholaman M, Gholami M. [Effect of eight weeks' endurance training along with fenugreek ingestion on lipid profile, body composition, insulin resistance and VO2max in obese women's with type2 diabetes (Persian)]. Journal of Medicinal Plants. 2018; 17(65):83-92. [Link]

[50] Tokmakidis SP, Touvra AM, Douda HT, Smilios I, Kotsa K, Volaklis KA. Training, detraining, and retraining effects on glycemic control and physical fitness in women with type 2 diabetes. Hormone and Metabolic Research. 2014; 46(13):974-9.[DOI:10.1055/s-0034-1390483] [PMID]

[51] Sklempe Kokic I, Ivanisevic M, Biolo G, Simunic B, Kokic T, Pisot R. Combination of a structured aerobic and resistance exercise improves glycaemic control in pregnant women diagnosed with gestational diabetes mellitus. A randomised controlled trial. Women & Birth. 2018; 31(4):e232-8. [DOI:10.1016/j.wombi.2017.10.004] [PMID]

[52] Colberg SR, Sigal RJ, Fernhall B, Regensteiner JG, Blissmer BJ, Rubin RR, et al. Exercise and type 2 diabetes: The American college of sports medicine and the American diabetes association: Joint position statement. Diabetes Care. 2010; 33(12):e147-67. [DOI:10.2337/dc10-9990] [PMID] [PMCID]

[53] Ghanbarzadeh M, Omidi M. The effects of physical activity on serum visfatin level: A literature review. International Journal of Basic Science in Medicine. 2017; 2(2):83-9. [DOI:10.15171/ijbsm.2017.16]

[54] Gu Y, Dennis SM, Kiernan MC, Harmer AR. Aerobic exercise training may improve nerve function in type 2 diabetes and pre-diabetes: A systematic review. Diabetes/Metabolism Research and Reviews. 2019; 35(2):e3099. [DOI:10.1002/dmrr.3099] [PMID]

[55] Delevatti RS, Kanitz AC, Alberton CL, Marson EC, Lisboa SC, Pinho CD, et al. Glucose control can be similarly improved after aquatic or dry-land aerobic training in patients with type 2 diabetes: A randomized clinical trial. Journal of Science and Medicine in Sport. 2016; 19(8):688-93. [DOI:10.1016/j.jsams.2015.10.008] [PMID]

[56] Röhling M, Herder C, Stemper T, Müssig K. Influence of acute and chronic exercise on glucose uptake. Journal of Diabetes Research. 2016; 2016:2868652. [DOI:10.1155/2016/2868652] [PMID] [PMCID]

[57] Karstoft K, Winding K, Knudsen SH, James NG, Scheel MM, Olesen J, et al. Mechanisms behind the superior effects of interval vs continuous training on glycaemic control in individuals with type 2 diabetes: A randomised controlled trial. Diabetologia. 2014; 57(10):2081-93. [DOI:10.1007/s00125-014-3334-5] [PMID]

[58] Madsen SM, Thorup AC, Overgaard K, Jeppesen PB. High intensity interval training improves glycaemic control and pancreatic β cell function of type 2 diabetes patients. Plos One. 2015; 10(8):e0133286. [DOI:10.1371/journal.pone.0133286] [PMID] [PMCID]

[59] Zaidi H, Byrkjeland R, Njerve IU, Åkra S, Solheim S, Arnesen H, et al. Effects of exercise training on inflammasome-related mediators and their associations to glucometabolic variables in patients with combined coronary artery disease and type 2 diabetes mellitus: Sub-study of a randomized control trial. Diabetes & Vascular Disease Research. 2019; 16(4):360-8. [DOI:10.1177/1479164119836922] [PMID]

[60] Karstoft K, Clark MA, Jakobsen I, Müller IA, Pedersen BK, Solomon TP, et al. The effects of 2 weeks of interval vs continuous walking training on glycaemic control and whole-body oxidative stress in individuals with type 2 diabetes: A controlled, randomised, crossover trial. Diabetologia. 2017; 60(3):508-17. [DOI:10.1007/s00125-016-4170-6] [PMID]

[61] Park SY, Lee IH. Effects on training and detraining on physical function, control of diabetes and anthropometrics in type 2 diabetes; a randomized controlled trial. Physiotherapy Theory and Practice. 2015; 31(2):83-8. [DOI:10.3109/09593985.2014.958265] [PMID]

[62] Andersen TR, Schmidt JF, Thomassen M, Hornstrup T, Frandsen U, Randers MB, et al. A preliminary study: Effects of football training on glucose control, body composition, and performance in men with type 2 diabetes. Scandinavian Journal of Medicine & Science in Sports. 2014; 24(Suppl 1):43-56. [DOI:10.1111/sms.12259] [PMID]

[63] Gomes LC, Coelho ACM, Gomides DDS, Foss-Freitas MC, Foss MC, Pace AE. Contribution of family social support to the metabolic control of people with diabetes mellitus: A randomized controlled clinical trial. Applied Nursing Research. 2017; 36:68-76. [DOI:10.1016/j.apnr.2017.05.009] [PMID]

[64] Deng K, Ren Y, Luo Z, Du K, Zhang X, Zhang Q. Peer support training improved the glycemic control, insulin management, and diabetic behaviors of patients with type 2 diabetes in rural communities of central China: A randomized controlled trial. Medical Science Monitor. 2016; 22:267-75. [DOI:10.12659/MSM.895593] [PMID] [PMCID]

[65] Koetsenruijter J, van Lieshout J, Lionis C, Portillo MC, Vassilev I, Todorova E, et al. Social support and health in diabetes patients: an observational study in six European countries in an era of austerity. Plos One. 2015; 10(8):e0135079. [DOI:10.1371/journal.pone.0135079] [PMID] [PMCID]

[66] Rad GS, Bakht LA, Feizi A, Mohebi S. Importance of social support in diabetes care. Journal of Education and Health Promotion. 2013; 2:62. [DOI:10.4103/2277-9531.120864] [PMID] [PMCID]

[67] Shao Y, Liang L, Shi L, Wan C, Yu S. The effect of social support on glycemic control in patients with type 2 diabetes mellitus: The mediating roles of self-efficacy and adherence. Journal of Diabetes Research. 2017; 2017:2804178. [DOI:10.1155/2017/2804178] [PMID] [PMCID]

[68] van Dam HA, van der Horst FG, Knoops L, Ryckman RM, Crebolder HF, van den Borne BH. Social support in diabetes: A systematic review of controlled intervention studies. Patient Education and Counseling. 2005; 59(1):1-12. [DOI:10.1016/j.pec.2004.11.001] [PMID]

[69] Fountoulakis S, Papanastasiou L, Gryparis A, Markou A, Piaditis G. Impact and duration effect of telemonitoring on HbA1c, BMI and cost in insulin-treated diabetes mellitus patients with inadequate glycemic control: A randomized controlled study. Hormones. 2015; 14(4):632-43. [DOI:10.14310/horm.2002.1603]

[70] Rasekaba TM, Furler J, Young D, Liew D, Gray K, Blackberry I, et al. Using technology to support care in gestational diabetes mellitus: Quantitative outcomes of an exploratory randomised control trial of adjunct telemedicine for gestational diabetes mellitus (TeleGDM). Diabetes Research and Clinical Practice. 2018; 142:276-85. [DOI:10.1016/j.diabres.2018.05.049] [PMID]

[71] Yuval G, Uri S. System, device and method for diabetes treatment and monitoring. Shirlington: Patent Application; 2006. [Link]

[72] Istepanian RS, Zitouni K, Harry D, Moutosammy N, Sungoor A, Tang B, et al. Evaluation of a mobile phone telemonitoring system for glycaemic control in patients with diabetes. Journal of Telemedicine and Telecare. 2009; 15(3):125-8. [DOI:10.1258/jtt.2009.003006] [PMID]

[73] Jaana M, Paré G. Home telemonitoring of patients with diabetes: A systematic assessment of observed effects. Journal of Evaluation in Clinical Practice. 2007; 13(2):242-53. [DOI:10.1111/j.1365-2753.2006.00686.x] [PMID]

[74] Shea S, Weinstock RS, Teresi JA, Palmas W, Starren J, Cimino JJ, et al. A randomized trial comparing telemedicine case management with usual care in older, ethnically diverse, medically underserved patients with diabetes mellitus: 5 year results of the IDEATel study. Journal of the American Medical Informatics Association. 2009; 16(4):446-56. [DOI:10.1197/jamia.M3157] [PMID] [PMCID]

[75] Rho MJ, Kim HS, Chung K, Choi IY. Factors influencing the acceptance of telemedicine for diabetes management. Cluster Computing. 2015; 18(1):321-31. [DOI:10.1007/s10586-014-0356-1]

[76] Mirfeizi M, Mehdizadeh Tourzani Z, Mirfeizi SZ, Asghari Jafarabadi M, Rezvani H, Shoghi M. [Effects of cinnamon on controlling blood glucose and lipids in patients with type II diabetes mellitus: A double blind, randomized clinical trial (Persian)]. Medical Journal of Mashhad University of Medical Sciences. 2014; 57(3):533-41. [DOI:10.22038/mjms.2014.3008]

[77] Samadi N, Mozaffari-Khosravi H, Rahmanian M, Askarishahi M. Effects of bee propolis supplementation on glycemic control, lipid profile and insulin resistance indices in patients with type 2 diabetes: A randomized, double-blind clinical trial. Journal of Integrative Medicine. 2017; 15(2):124-34. [DOI:10.1016/S2095-4964(17)60315-7] [PMID]

[78] Ghoreishi AS, Mohammadian Shahrbabaki F, Toghroli N, Sheikh Fathollahi M, Hajizadeh MR, Khoshdel A, et al. [Investigating the effect of sesamum indicum consumption on biochemichal parameters in type 2 diabetic patients (Persian)]. Journal of Advanced Biomedical Sciences. 2016; 6(1):87-95. [Link]

[79] Sajatovic M, Gunzler DD, Kanuch SW, Cassidy KA, Tatsuoka C, McCormick R, et al. A 60-week prospective RCT of a self-management intervention for individuals with serious mental illness and diabetes mellitus. Psychiatric Services. 2017; 68(9):883-90. [DOI:10.1176/appi.ps.201600377] [PMID] [PMCID]

[80] Kuniss N, Müller UA, Kloos C, Müller R, Starrach G, Jörgens V, et al. Substantial improvement in HbA1c following a treatment and teaching programme for people with type 2 diabetes on conventional insulin therapy in an in- and outpatient setting. Acta Diabetologica. 2018; 55(2):131-7. [DOI:10.1007/s00592-017-1070-2] [PMID]

[81] Yuan C, Lai CW, Chan LW, Chow M, Law HK, Ying M. The effect of diabetes self-management education on body weight, glycemic control, and other metabolic markers in patients with type 2 diabetes mellitus. Journal of Diabetes Research. 2014; 2014:789761. [DOI:10.1155/2014/789761] [PMID] [PMCID]

[82] Abdulah DM, Hassan AB, Saadi FS, Mohammed AH. Impacts of self-management education on glycaemic control in patients with type 2 diabetes mellitus. Diabetes & Metabolic Syndrome. 2018; 12(6):969-75. [DOI:10.1016/j.dsx.2018.06.007] [PMID]

[83] Draffin CR, Alderdice FA, McCance DR, Maresh M, Harper R, Patterson CC, et al. Impact of an educational DVD on anxiety and glycaemic control in women diagnosed with gestational diabetes mellitus (GDM): A randomised controlled trial. Diabetes Research and Clinical Practice. 2017; 126:164-71. [DOI:10.1016/j.diabres.2017.02.016] [PMID]

[84] Gupta U, Gupta Y, Jose D, Mani K, Jyotsna VP, Sharma G, et al. Effectiveness of a video-based lifestyle education program compared to usual care in improving HbA1c and other metabolic parameters in individuals with type 2 diabetes: An open-label parallel arm randomized control trial (RCT). Diabetes Therapy. 2020; 11(3):667-79. [DOI:10.1007/s13300-020-00769-2] [PMID] [PMCID]

[85] Beck J, Greenwood DA, Blanton L, Bollinger ST, Butcher MK, Condon JE, et al. 2017 National standards for diabetes self-management education and support. The Diabetes Educator. 2017; 43(5):449-64. [DOI:10.1177/0145721717722968] [PMID]

[86] Hermanns N, Ehrmann D, Schall S, Maier B, Haak T, Kulzer B. The effect of an education programme (MEDIAS 2 BSC) of non-intensive insulin treatment regimens for people with Type 2 diabetes: A randomized, multi-centre trial. Diabetic Medicine. 2017; 34(8):1084-91. [DOI:10.1111/dme.13346] [PMID]

[87] Coppola A, Sasso L, Bagnasco A, Giustina A, Gazzaruso C. The role of patient education in the prevention and management of type 2 diabetes: An overview. Endocrine. 2016; 53(1):18-27. [DOI:10.1007/s12020-015-0775-7] [PMID]

[88] Powers MA, Bardsley J, Cypress M, Duker P, Funnell MM, Fischl AH, et al. Diabetes self-management education and support in type 2 diabetes. The Diabetes Educator. 2017; 43(1):40-53. [DOI:10.1177/0145721716689694] [PMID]

[89] Xu ZX, Geng K, Bai Y, Wang XY, Zhu LX. [Evaluation of peer support education mode for type 2 diabetes control in rural residents (Chinese)]. Zhonghua Liu Xing Bing Xue Za Zhi. 2018; 39(12):1560-4. [DOI:10.3760/cma.j.issn.0254-6450.2018.12.005] [PMID]

[90] Ji H, Chen R, Huang Y, Li W, Shi C, Zhou J. Effect of simulation education and case management on glycemic control in type 2 diabetes. Diabetes/Metabolism Research and Reviews. 2019; 35(3):e3112. [DOI:10.1002/dmrr.3112] [PMID] [PMCID]

[91] Hashemian M, Ghardashi F, Izadi AR, Akbarzadeh R. Prioritizing the health education needs based on community participation: AHP method. Journal of Education and Health Promotion. 2019; 8(1):127. [DOI:10.4103/jehp.jehp_7_19]

[92] Chatterjee S, Davies MJ, Heller S, Speight J, Snoek FJ, Khunti K. Diabetes structured self-management education programmes: A narrative review and current innovations. The Lancet. Diabetes & Endocrinology. 2018; 6(2):130-42. [DOI:10.1016/S2213-8587(17)30239-5] [PMID]

This Page Intentionally Left Blank