Assessing the Effectiveness of Diabetes Intervention Methods on Type 2 Diabetes Patient Outcomes: A Systematic Review

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Abstract

Background: Type 2 diabetes remains a serious global public health concern. Despite the number of diabetes education efforts designed to improve diabetes-related outcomes, the number of individuals living with type 2 diabetes continues to increase. The purpose of this study was to examine the various diabetes interventions used with individuals living with type 2 diabetes and assess their impact on HbA1c levels, improving glycemic control, and overall quality of long-term diabetes-related success.

Methods: A systematic review of the literature was conducted using one major database. Inclusion criteria included: participants with type 2 diabetes, adults (18 years or older), randomized control study design, HbA1c must be at least one evaluation measure, and published between 2008-2018. Data was organized using Covidence computer software.

Results: Seven articles meeting the inclusion criteria were included in this systematic review. Four studies utilized individualized, structured diabetes education regarding lifestyle changes, blood glucose monitoring, and diabetes knowledge resulting in significantly improved HbA1c levels as compared to control groups.

Conclusion: Implementing diabetes education that is structured and individualized may improve HbA1c levels and produce long-term success to improve overall diabetes-related outcomes in adults with type 2 diabetes.

Keywords: Systematic review, type 2 diabetes, diabetes education, intervention methods, HbA1c, glycemic control

INTRODUCTION

Type 2 diabetes remains a public health problem and is the leading cause of morbidity and mortality worldwide; mortality rates can be as high as 30 deaths per 100,000 people living with diabetes per year (Strajtenberger-Trbovic, Turk-Strajtenberger, & Sekerija, 2011; Moreno, Perez, Vrotsou, Carlos, Ortiz, del Campo Pena, de Retana Garcia, A.R. Portu, Elorriaga, Pikatza, Bengoa, Echave, Sampedro, A.O. Portu, Fano, Sorondo, & Del Campo, 2013; Iyer, Joshi, & Dhruv, 2010; J. Lee, Chan, Chua, Ng, Paraidathathu, K. Lee, & S. Lee, 2016). Currently, 29.1 million adult Americans are living with type 2 diabetes which equates to roughly 9% of the population (Marincic, Hardin, Salazar, Scott, Fan, & Gaillard, 2017; National Institute of Diabetes and Digestive and Kidney Diseases, 2017). Type 2 diabetes accounts for 90-95% of all diabetes cases (Ziba, Mereshi, Seyedfatemi, & Haghani, 2017). The number of type 2 diabetes cases is rapidly increasing at a rate of 1.5 million new cases among adult Americans each year, and still remains the seventh leading cause of death in the United States (National Institute of Diabetes and Digestive and Kidney Diseases, 2017; American Diabetes Association, 2018). The number of individuals being diagnosed and living with diabetes can be attributed to the increase in population growth, aging, urbanization, and increasing prevalence of obesity and physical inactivity (Iyer et al., 2010).

By definition, type 2 diabetes is a chronic disease characterized by high blood glucose values, which results from an increase in resistance to insulin. Insulin is a hormone produced by beta-cells in the pancreas and facilitates the entry of glucose into the body's cells (Dasgupta, Jarvandi, De Civita, Pillay, Hajna, Gougeon, Bader, & De Costa, 2014; Al-Hassan, Al-Akour, & Aburas, 2015). However, when an individual becomes insulin resistant (i.e. type 2 diabetes), glucose cannot gain efficient entry and causes an accumulation of glucose in the blood. This causes hyperglycemia, or high blood glucose, and also exacerbates the insulin resistance

(Dasgupta et al., 2014). Individuals who are overweight or obese, are older than 45 years of age, have a family history of diabetes, are of certain races or ethnicities, have high blood pressure, live sedentary lifestyles, or have a history of heart disease or stroke are at increased risk of developing type 2 diabetes (National Institute of Diabetes and Digestive and Kidney Diseases, 2016).

In order to diagnose type 2 diabetes, an individual will undergo a few different tests. These tests include the A1c, fasting plasma glucose (FPG), and the oral glucose tolerance test (OGTT) (American Diabetes Association, 2016). The A1c test measures the average blood glucose for the past three months; diabetes is diagnosed when an A1c is equal to or greater than 6.5% (American Diabetes Association, 2016). When measuring FPG, the individual is requested to fast for at least eight hours and the test is done first thing in the morning. A reading of 126 mg/dL or higher indicates type 2 diabetes. Lastly, the OGTT is a two-hour test where blood glucose readings are taken before and two hours after a special sweet drink is consumed; a reading of 200 mg/dL or higher indicates type 2 diabetes (American Diabetes Association, 2016).

Once diagnosed, proper glycemic control of type 2 diabetes is crucial. Controlled diabetes is when individuals have achieved a HbA1c of <7%, and 50% of individuals with type 2 diabetes are currently not meeting and/or sustaining this recommended target (Almalki & Albalawi, 2017; Chrvala, Sherr, & Lipman, 2015). Controlled HbA1c values are associated with decreased incidence of microvascular and macrovascular complications associated with diabetes (Almalki & Albalawi, 2017; Chrvala et al., 2015; Rasekaba, Graco, Risteski, Jasper, Berlowitz, Hawthorne, & Hutchinson, 2012). Regular blood glucose checking and monitoring is associated with increased glycemic control, therefore reducing risk of diabetes-related complications and

results in better diabetes management and improved quality of life (Ezenwaka, Okoye, Esonwune, Dioka, Onuoha, Oguejiofor, & Meludu, 2014; Shabbidar, Fathi, & Shirazifard, 2006).

Failing to meet target HbA1c can result in prolonged hyperglycemia, or uncontrolled diabetes, and eventually lead to serious microvascular and macrovascular complications (Essien, Out, Umoh, Enang, Hicks, & Walley, 2017). Complications include renal failure, retinopathy, neuropathy, foot ulcers, and amputation, all of which can be a result of poor glycemic control (Al-Hassan et al., 2015; Sharifirad, Najimi, & Hassanzadeh, 2011; American Diabetes Association, n.d.). Additionally, type 2 diabetes can result in cardiovascular events, peripheral arterial disease, issues in the nervous systems, poor oral function, and insufficiency in the blood stream as well if poorly managed. All of these complications and health concerns can be life-threatening (Peterson, Beeson, Shulz, Firek, De Leon, Balcazar, Tonstad, & Cordero-Maclntyre, 2010; Ziba et al., 2017; Essien et al., 2017). Even a 1% reduction in HbA1c values can lead to a 15-21% reduction in diabetes-related deaths and a 33-41% reduction in microvascular complications (Rasekaba et al., 2012). Therefore, tightly controlling blood sugar levels to ensure that patients reach target HbA1c through use of medications and adopting a healthier lifestyle, such as diet and physical activity, reduces the risk of serious complications (Essien et al., 2017).

Type 2 diabetes requires a multitude of lifestyle modifications that are necessary to normalize blood glucose levels and avoid potential complications; these changes include following a healthy diet, achieving modest weight loss, and participating in regular physical activity all which aid in successfully managing diabetes to achieve a HbA1c of <7% (Chong, Ding, Byun, Comino, Bauman, & Jalaludin, 2017; Almalki & Albalawi, 2017). Individualized nutrition therapy is at the root of diabetes treatment and has proven effective in improving the prognosis and reducing risk of potential complications (Shabbidar et al., 2006; Li, Jin, Chen,

Sun, Jing, Zhao, Zhu, & Guo, 2017). Nutrition interventions promote lifestyle adherence by evoking behavior change, and are seen to have positive effects on glycemic control and diabetes-related complications (Sharifirad et al., 2011).

Nutrition education plays a prominent role in diabetes interventions as patients need to be educated on carbohydrate intake and counting, portion sizes, eating a well-balanced diet, and overall healthier lifestyle modifications (Muchiri, Gericke, & Rheeder, 2016). Individuals should be taught how to build a healthy plate at every meal including whole-grains as they are rich in many vitamins and fiber, lean or plant-based proteins, low-fat or fat-free dairy products, consume mono- and polyunsaturated fats, and should consume water over sugar-sweetened beverages such as soda, fruit drinks, or sports drinks (American Diabetes Association, 2017). Once patients have a good understanding of diet recommendations, carbohydrate counting and low glycemic index foods are typically incorporated into their diabetes education. Carbohydrate counting is a meal planning tool for individuals living with type 2 diabetes and it helps patients keep track of their carbohydrate intake on a daily basis. Patients should be able to identify healthy carbohydrates such as, whole-grains, fruits, and vegetables versus unhealthy carbohydrates like food and drinks with added sugars as these provide little to no nutritional value (National Institute of Diabetes and Digestive and Kidney Diseases, 2014). Low glycemic index (GI) foods are another component of nutrition education that is incorporated into diabetes education; glycemic index is a measure of how carbohydrate-containing foods raise blood glucose (American Diabetes Association, 2014). Therefore, educating patients on low-GI foods such as oatmeal, barley, sweet potatoes, non-starchy vegetables, and most fruits is crucial and fosters success as low GI foods have a lower, more sustained impact on blood glucose levels. Additionally, it's important to educate patients on both carbohydrate counting and glycemic

index as the quality and quantity of carbohydrates consumed are equally important (American Diabetes Association, 2014).

Diabetes education is a crucial component to successfully managing diabetes and customarily includes topics like clinical care, health promotion, diabetes-related knowledge, proper food choices, psychosocial needs, and working to improve confidence and self-efficacy in managing their diabetes (Banerjee, MacDougal, & Lakhdar, 2012; Smith et al., 2016; Shao, Liang, Shi, Wan, & Yu, 2017). Patient-centered care is being incorporated more frequently in diabetes interventions as the number of type 2 diabetes diagnoses continues to rise.

At the foundation of all diabetes education is diabetes-related knowledge and skills; this is an area that can continuously be improved upon, as 50-80% of the individuals with diabetes lack the relevant knowledge necessary to successfully manage their disease (Hakimian, Sadrpoushan, & Shahreza, 2015; Strajtenberger-Trbovic et al., 2011). The continuous nature of diabetes education promotes self-efficacy among patients, empowering them with the confidence to take control of their disease to improve their health outcomes by adhering to their management practices (Hakimian et al., 2015; Shao et al., 2017). In most cases, the motivation to change is present but the patient lacks the knowledge to implement the necessary changes. Research shows that individualized and structured diabetes education improves patients' knowledge and understanding of their condition, thus leading to improved habits (Mash, Levitt, Steyn, Zwarenstein, & Rollnick. 2012; Vos, Eikelenboom, Klomp, Stellato, & Rutten, 2016; Sturt, Taylor, Docherty, Dale, & Louise, 2006; Chong et al., 2017).

Type 2 diabetes is increasing in incidence and affecting individuals younger and younger, therefore the need for effective prevention and intervention methods is as crucial as ever to reduce the number of uncontrolled diabetes cases and risk for diabetes-related complications

(Jaworski, Panczyk, Cedro, & Kucharska, 2018). Utilizing evidenced-based, individualized, patient-based care, as there is no one-size-fits-all approach when working with type 2 diabetics, is essential in order to manage blood glucose and HbA1c levels as these lead to improved quality of life (Steinsbekk, Rygg, Lisulo, Rise, & Fretheim, 2012; Huffman, DuBois, Millstein, Celano, & Wexler, 2015; Yuan, Lai, Chan, Chow, Law, & Ying, 2014; Smith, McNaughton, & Meyer, 2013). Similarly, using a collaborative and integrative team approach can help optimize glycemic control among type 2 diabetes patients (Yoder, Dixon, Barnette, & Beardsley, 2012). However, despite these findings there is still a great need for feasible, effective and wide reach approaches to support the growing number of type 2 diabetes cases in order to achieve and maintain glycemic control as 50% of individuals do not meet the target HbA1c value (Eakin, Reeves, Winkler, Healy, Dunstan, Owen, Marshal, & Wilkie, 2013; Chrvala et al., 2015).

The purpose of this systematic review is to examine the various diabetes interventions used with individuals living with type 2 diabetes and assess their impact on HbA1c levels, improving glycemic control, and overall quality of long-term diabetes-related success.

METHODOLOGY

Review Search Strategy

The review was conducted by one independent reviewer from Eastern Illinois University. A three-step process was used to identify studies, including (1) search, (2) distillation, and (3) independent review. Once studies were found, the researcher used Covidence computer software to organize and identify studies to be used in the systematic review.

During the first phase, search, the researcher used one major database: EbscoHost Academic Search Complete which searched all University databases for relevant articles. Keywords used to identify these articles included: “type 2 diabetes education AND HbA1c,”

"type 2 diabetes interventions AND HbA1c," "effects of diabetes education AND blood glucose levels," "diabetes education AND improved self-management," "type 2 diabetes AND nutrition education," "diabetes lifestyle education AND glycemic control," "diabetes interventions AND adherence." No language restriction was applied to the search. A time restriction was applied for literature published between January 1, 2008 to February 28, 2018. Literature found during phase one was then entered into Covidence software to aid in screening, eliminating duplicates, and selecting final articles.

Study Selection

Distillation was the second phase of the systematic review process. All titles and abstracts were read to identify any articles that met the following six inclusion criteria: (1) included participants that have type 2 diabetes, (2) participants were adults, 18 years or older, (3) used a randomized control research design, (4) studies measured changes in HbA1c levels, (5) were published in peer-reviewed journals, and (6) were issued during 2008-2018.

Studies were excluded if (1) participants had type 1 diabetes, (2) participants had gestational diabetes, (3) participants had eating disorders, (4) participants had other chronic conditions or pre-existing conditions (i.e. metabolic syndrome, cardiovascular disease, etc.), (5) changes in HbA1c levels were not measured, and (6) were published prior to 2008.

The researcher then conducted phase three of the systematic review process, the independent review. During this phase, the researcher read all remaining articles to identify which articles met the inclusion criteria and would be included in the systematic review.

Data Collection and Abstraction

Data from each article found during the final phase was extracted and organized into a standardized form (Table 1) to highlight key content. Data extracted included the first author's last name, publication year, participants' age, number of participants, study design and duration, intervention methods, evaluation measures, and intervention outcomes, including means, clinical measurement changes, specifically changes in HbA1c.

RESULTS

A total of 658 articles were identified during the search phase. Once duplicate articles were eliminated (n=31), 627 articles remained. After the second phase, distillation, another 520 articles were eliminated. During this phase, articles were removed if the studies included children (n=7), participants had type 1 diabetes (n=16), participants had gestational diabetes (n=3), were published prior to 2008 (n=21), study design was not a randomized control (n=102), participants had a pre-existing condition (n=26), or the intervention methods did not address overall diabetes management (n=345). After the distillation phase, there were 107 articles remaining for further review. These 107 articles were examined by the researcher during the third phase, the independent review. Articles were eliminated if they discussed both type 1 and type 2 diabetes (n=4), included participants with pre-existing conditions (n=17), studies had a design other than a randomized control (n=7), or outcomes did not include HbA1c or glycemic control (n=72). A total of 7 articles remained after the three-phase process for critical appraisal (Figure 1).

Table 1 illustrates characteristics of the studies included in this systematic review. The seven studies had a total of 2,276 participants that were adults 18 years or older. Participants were between 40 and 67 years old. The individual study sample sizes ranged from 62 to 1,289 participants. The studies were conducted both internationally and domestically. All seven studies

were randomized control trials. The duration of the studies ranged from 9 weeks to 18 months, including the intervention and follow-up telephone calls, interviews, or appointments (Abaza & Marschollek, 2017; Selea, Sumarac-Dumanovic, Pesic, Suluburic, Stamenkovic-Pejkovic, Cvijovic, & Micic, 2011; Guo, Ji, Lu, J. Liu, Lou, J. Liu, Shen, Zhang, Feng, & Gu, 2013; Miller & Gutschall, 2009; Aliha, Asgari, Khayeri, Ramazani, Farajzadegan, & Javaheri, 2012; Adachi, Yamaoka, Watanabe, Nishikawa, Kobayashi, Hida, & Tango, 2013; Fan, Huang, Tang, Han, Dong, & Wang, 2016).

All seven studies had a common purpose which was to determine the effectiveness of their intervention methods on diabetes control indicators including fasting plasma glucose, post-prandial blood glucose, but specifically HbA1c. Table 1 highlights the various intervention outcome measures in the selected studies including: HbA1c, weight, BMI, blood pressure, lipid profiles, waist circumference, FPG, as well as qualitative measures such as empowerment, self-efficacy, knowledge, and outcome expectations (Abaza & Marschollek, 2017; Selea et al., 2011; Guo et al., 2013; Miller & Gutschall, 2009; Aliha et al., 2012; Adachi et al., 2013; Fan et al., 2016). Common components of the interventions included nutrition education addressing lifestyle changes, glycemic control, dietary intake, physical activity, carbohydrate counting, potential complications, and self-monitoring of blood glucose levels. Being randomized control trials, the studies all had an intervention group and a control group. Intervention groups received diabetes education in various modalities including SMS text messages, individualized education, structured education, or printed materials (Abaza & Marschollek, 2017; Selea et al., 2011; Guo et al., 2013; Miller & Gutschall, 2009; Aliha et al., 2012; Adachi et al., 2013; Fan et al., 2016). The control groups either did not receive education at all, did not receive the same intervention method or simply received more traditional education. Additionally, four of the studies included

family members as an extra level of support; they were encouraged to attend all education sessions and received the same educational materials as participants (Fan et al., 2016; Selea et al., 2011; Miller & Gutschall, 2009; Abaza & Marschollek, 2017). Five studies included structured education and provided specific diabetes management information to all participants in the intervention group (Adachi et al., 2013; Aliha et al., 2012; Fan et al., 2016; Guo et al., 2013; Miller et al., 2009). One study utilized technology by sending daily SMS text messages with diabetes-related texts (Abaza & Marschollek, 2017). The last study incorporated printed educational materials to assess their effects on glycemic control (Selea et al., 2011). All studies selected for this systematic review utilized various intervention methods to determine their effects on HbA1c and overall glycemic control.

DISCUSSION

A total of seven studies were included in this systematic review examining the intervention methods used regarding diabetes education to promote behavior change among adults with type 2 diabetes that resulted in improvements in diabetes-related outcomes, specifically HbA1c. All the studies included in this systematic review produced favorable outcomes such as lowered HbA1c, and while results were short-term (i.e. 6 months or less), the findings reiterated the importance of continuous diabetes education. While all seven studies saw significant decreases in HbA1c levels, specific, individualized diabetes education that encouraged adopting healthy practices to stimulate independent self-management practices appeared to be more successful in lowering HbA1c levels as opposed to the more self-guided interventions, such as printed education materials or SMS text messages.

While the study utilizing printed educational materials saw significant improvement in HbA1c levels, it was only short-term; there was more of an improvement in overall diabetes

knowledge (Selea et alk. 2011). This study had an initial appointment where participants received the education materials, and HbA1c and fasting plasma glucose (FPG) values were obtained. Participants had follow-up appointments to test HbA1c, FPG levels as well as their knowledge base at three, six, and eighteen months (Selea et al., 2011). Participants were being treated with different therapeutic modalities: insulin, oral hypoglycemic drugs, or lifestyle modifications. Those being treated with just lifestyle modifications saw the least significant changes in HbA1c levels. However, the greatest HbA1c improvement was seen at three and six months across three modalities, indicating that continuous education and support is imperative to see long-term success (Selea et al., 2011).

SMS messages proved to be an effective and feasible tool for diabetes management with great potential for future interventions to improve clinical outcomes. Intervention group participants received daily text messages regarding diet, physical activity, complications, etc. for twelve weeks; blood glucose values were self-recorded but also recorded by healthcare professionals, while the control group simply received a diabetes booklet (Abaza & Marschollek, 2017). While participants saw a significant drop in mean HbA1c values compared to their control group counterparts, researchers concluded the messaging system was only as effective as participants were engaged, therefore indicating that self-direction and motivation are needed in order to be successful long-term (Abaza & Marschollek, 2017). Similar results to this systematic review were found in a different study that examined the effects of a web-based dietary intervention (Ramadas, Chan, Oldenburg, Hussien, & Quek, 2013). Researchers from this web-based intervention as well as another text messaging based intervention, stated that while technology can be an effective platform for diabetes education, patient's success is only as strong

as their involvement in the self-paced and self-directed intervention (Ramadas et al., 2013; Nelson, Mulvaney, Gebretsadik, Johnson, & Osborn, 2016).

Additionally, Miller & Gutschall (2009) incorporated the social cognitive theory (SCT) at the foundation of their nine-weekly group diabetes sessions addressing self-monitoring, goal setting, portion control, carbohydrate counting, the GI and factors that influence the postprandial glucose response, and how to maintain these changes. Participants set weekly goals at the end of each session to motivate them and hold them accountable (Miller & Gutschall, 2009). Researchers did not see direct improvements in HbA1c, but rather an increase in behavior change and a greater adoption of a diet lower in glycemic index therefore leading to a reduction in HbA1c levels. While this study was the first of its kind to utilize a theory-based diabetes intervention to promote behavior change, elicit HbA1c reductions, and improve overall diabetes-knowledge, the results, again, were only short-term. Utilization of the SCT has demonstrated being effective in evoking behavior change, however, this study could have been strengthened by incorporating follow-up support and ensuring that changes are being sustained (Miller & Gustchall, 2009). Similar methods were used in a different article not included in this review. Cooking classes were designed on key components of the social cognitive theory, i.e. self-efficacy, cognitive restructuring, and social support; while glycemic control was not measured, the social cognitive theory proved to benefit participants as they adopted healthy eating recommendations such as decreased fat and calories and increased healthy carbohydrates. Researchers concluded that the social cognitive theory can promote long-term success by instilling positive health behaviors in individuals (Archuleta, VanLeeuwen, Halderson, Jackson, Bock, Eastman, Poweel, Titone, Marr, & Wells, 2012).

Structured, individualized interventions identified during this systematic review proved to be the most effective method in improving HbA1c levels among adults with type 2 diabetes (Adachi et al., 2013; Guo et al., 2013; Fan et al., 2016; Aliha et al., 2012). One study used structured individual-based lifestyle education in the intervention group. Participants were encouraged to reduce energy intake, increase vegetable intake as well as practice self-management of glycemic control by diet, exercise, and stress management (Adachi et al., 2013). The control group only received information regarding dietary intake and general advice about glycemic control. There was a significantly greater mean change in HbA1c in the intervention group compared to the control group from baseline (Adachi et al., 2013). The structured education contributed to significant improvements in BMI and other clinical outcome measures such as blood pressure and lipid panels as well. Structured interventions based on medical nutrition therapy continue to prove clinically effective in diabetes management (Adachi et al., 2013). Additionally, utilizing an individualized approach is necessary in order to modify behaviors with regard to dietary intake. Future studies would need to be done with longer follow-up time to ensure that long-term glycemic control was being achieved (Adachi et al., 2013).

A similar study utilized structured education in adult participants with type 2 diabetes. The intervention group received a program called OPENING and were educated on medications, self-monitoring practices, healthy diet, increased physical activity, and the prevention of hypoglycemia and other potential complications, while the control group received general education about self-monitoring of blood glucose practices, hypoglycemia, and self-management practices (Guo et al., 2013). Favorable outcomes were produced and researchers saw a significant reduction in HbA1c levels in the intervention group as compared to baseline. Authors concluded that continuous reminder messages, goal-setting discussions, and encouragement to

communicate may have heavily contributed to the intervention group's maintenance of healthy habits and management and ultimately leading to prolonged glycemic control further demonstrating the importance of continuous education and/or support (Guo et al., 2013; Selea et al., 2011). Furthermore, the OPENING program demonstrated that structured education is an integral component to effective diabetes self-management as it established good self-management behaviors which predict better glycemic control (Guo et al., 2013).

Similarly, another study incorporated individualized diabetes in-person counseling based on a personality assessment given, so all education interventions were tailored to the participants' personality traits (Fan et al., 2016). Participants received individualized, tailored education provided face-to-face after their knowledge on diabetes and self-care was assessed. Interventions covered medications, self-monitoring of blood glucose and blood pressure, and psychological counseling (Fan et al., 2016). Those in the control group received group education regarding general diabetes and dietary modifications. Modifying interventions based on personality traits, proved to be effective and produce strong outcomes; HbA1c was significantly lower compared to the control and baseline levels. Additional clinical measures such as BMI, waist circumference, and fasting blood glucose saw significant improvements as well. Authors concluded that diabetes education tailored to patients' personality was associated with greater diabetes control and could be beneficial in future research (Fan et al., 2016).

Another study that delivered structured diabetes education including lectures, movies, booklets, and face-to-face counseling and following-up via telephone once a month for three months saw significant improvements in their HbA1c and compliance as opposed to individuals in the control group who received conventional treatment (Aliha et al., 2012). Researchers found this particular study to be successful due to the intervention methods. Its structured nature proved

to be beneficial, however, specifically the follow-up phone calls that each participant received. Due to the frequent follow-ups participants saw greater improvement in blood sugar control and adherence to treatment recommendations (diet, exercise, drugs, etc.) as they allowed participants to stay motivated, on track, and accountable to their choices (Aliha et al., 2012).

Studies in this review showed a variety of education methods, however, only a few showed to be successful in maintaining HbA1c reductions or for potential maintenance in the future. Successful diabetes self-management requires a great deal of knowledge and support to evoke behavior change when it comes to healthy eating and physical activity practices, but also self-monitoring of blood glucose in order to sustain these changes and maintain glycemic control (Rise, Pellerud, Rygg, & Steinsbekk, 2013).

Limitations

A limitation of this study was the inability to compare long-term outcomes due to study lengths and methodologies. The research provided in the systematic review had relatively short study durations, therefore, the discussion highlighted statistically significant reductions in HbA1c levels short-term. A second limitation would be including only randomized control trials in this review; while this research design is seen as a gold standard, other research designs could have been beneficial to identify effective intervention methods that produce long-term success and glycemic control.

Strengths

Even with the limitations, this systematic review included studies that demonstrated the positive effects of diabetes education on individuals with type 2 diabetes on clinical outcomes specifically HbA1c levels, at least in the short-term. Results showed that by making interventions individualized and structured based on patient needs and education level,

participants improved their overall glycemic control. Additionally, results indicated that continuous follow-up appointments encouraged patients to sustain their success. Therefore, implementing individualized, tailored education interventions along with follow-ups may be the best course of action for producing long-term diabetes control and maintenance.

CONCLUSION

Type 2 diabetes continues to remain a prominent global issue; despite preventative measures and diabetes education, there remains a strong need for effective interventions to delay the onset or progression of the disease to improve diabetes-related outcomes and overall quality of life. Implementing specific, individualized, and structured diabetes education is an ideal intervention style as it produces favorable outcomes of lowered HbA1c levels. This review concluded that there are numerous intervention methods available that produce short-term success, however, the need for long-term, sustained methods remains. This review demonstrates that individualized education and continuous follow-ups from healthcare providers are both essential in holding patients accountable and keeping them on track with their self-management ultimately leading to long-term success. The level of support that comes with individualized, one-on-one diabetes education improves self-efficacy and thus improving diabetes-related outcomes among adults with type 2 diabetes.

IMPLICATIONS FOR FUTURE RESEARCH

Diabetes is a complicated disease that requires a great deal of education and support. There is limited research regarding the long-term effects of diabetes education interventions on HbA1c levels among adults with type 2 diabetes. Future research should be conducted to examine the effects of diabetes education interventions and their ability to maintain improvements in HbA1c levels over a longer period of time, including long-term follow-ups with

participants. Incorporating follow-up consultations with participants can be beneficial in holding them accountable and allowing them to ask real-time questions or address concerns that may arise while they are independently managing their disease. These questions or concerns going unacknowledged could demotivate them and hinder their success.

IMPLICATIONS FOR HEALTH PROFESSIONALS

Due to the need for extensive education for successful diabetes management, an initial visit with a registered dietitian is simply not enough to not only motivate patients to change but to maintain those changes as well so they see improvements in their overall health. It is important, as healthcare professionals, to follow the course with them to ensure that healthy practices are being adopted and success is being seen. Diabetes is an overwhelming disease due to the mass amounts of information, knowledge, and care it takes to manage it, and establishing a strong relationship built on trust and empathy with patients is crucial in order to motivate them and encourage them to incorporate these new lifestyle changes. High levels of support will energize patients and increase the chances of them attending follow-up appointments.

Health professionals must provide patients with the necessary resources like printed materials, group education sessions, individualized one-on-one counseling, or even technology interventions, all of which have been proven to be effective. However, it is incredibly important to tailor these methods to the individual patient needs, for example, making sure that printed materials are at an appropriate literacy level including health literacy. Additionally, when working with patients one-on-one, motivational interviewing plays a key role in the success of the session. Identifying what the patient specifically needs and wants to work on will keep them engaged and will allow them to feel more confident in making various changes. As a dietetics professional, making sure that patients are receiving the individualized diabetes education is

crucial in their success and self-efficacy in improving diabetes-related outcomes and ensuring glycemic control.

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Table 1. Summary of Results of Systematic Analysis (n=7)

Author (Year)	Age & Number of Participants	Study Design & Duration	Intervention Methods	Evaluation Measures	Intervention Outcomes
Abaza et al. (2017)	52 ± 9 years N= 73	RCT 3 months (12 weeks)	-Intervention: received daily diabetes educational SMS messages & reminder prompts to rake tests and record readings -Control: received no SMS messages -Both groups received a introductory booklet of diabetes care instructions and a monitoring table to record blood glucose readings	Weight, blood glucose level, HbA1c	-Decrease in body weight by 1.3 kg in intervention (0.5 kg in control) -Decrease in blood glucose levels by 61 mg/dl in intervention (decrease of 19 mg/dl in control) -Mean drop of -1.05% in HbA1c in intervention group (-0.69% in control)
Adachi et al. (2013)	Intervention: 60 ± 11 years Control: 62 ± 10 years N=193	Prospective RCT 6 months	-Intervention: structured, individual-based lifestyle education all centered around glycemic control -Control: received information on dietary intake estimated using FFQW82 and general advice on glycemic control	HbA1c, BMI, blood pressure, FPG, lipid profiles (LDL, HDL, and TG)	-Greater mean change in HbA1c from baseline in intervention (95% confidence interval) compared to control (-0.7% vs. -0.2%). -No statistically significant changes in BMI, FPG, blood pressure, LDL, HDL, and TG. -Larger energy and fat intake at dinner associated with an increased in HbA1c -Larger vegetable intake at breakfast and whole day associated in HbA1c reduction
Aliha et al. (2012)	Intervention: 51 ± 7 years Control: 55 ± 10 years N=62	RCT 12 weeks	-Intervention: self-care group education to intervention(case) group including lectures, face-to-face, use of films, booklets, etc.; follow-up calls from a nurse -Control: received conventional management and usual education for diabetes	FBG, 2-hour post-prandial blood glucose, HbA1c, patient adherence to treatment	-Reduction in FBG in both groups -Significant reduction in 2-hour post prandial blood glucose and HbA1c (66 mg/dl, 1.4% decline respectively)
Fan et al. (2016)	63 ± 10 years N= 280	RCT 6 months	-Intervention: 1-hour individualized face-to-face diabetes education tailored to personality traits (based on personality assessment); follow-up phone call every month for 6 months; 10 min phone call once a month to address any issues. -Control: 1-hour face-to-face group diabetes education; no personality assessment conducted; follow-up and monthly telephone interviews still conducted.	BMI, waist circumference, blood pressure, FPG and post-prandial blood glucose, blood lipid panel, and HbA1c	-Decreased BMI, waist circumference, FPG, post-prandial blood glucose, blood pressure ($p<0.01$) in both groups -decreased total cholesterol, TGs, LDL ($p<0.01$) in both groups -Greater decrease in BMI, waist circumference, FPG, post-prandial blood glucose and HbA1c in intervention group ($p<0.05$)
Guo et al. (2013)	Intervention: 57 ± 11 years Control: 57 years ± 10 years N= 1,289	RCT 16 weeks	-Intervention: received structured educational program (OPENING program) regarding 7 different modules, and additional individualized complication education; received telephone follow-up calls -Control: received education according to study center's own practices (i.e. insulin injections, SMBG); no telephone follow-up calls	HbA1c, proportion of patients achieving HbA1c levels, changes in FBG, incidence of hypoglycemia	-Significant decrease in HbA1c in intervention (9.38±1.98% to 7.22±1.04%) and control (from 9.46±1.90% to 7.38±1.12%) -Proportion of patients achieving target HbA1c in intervention vs. control 43.81% and 36.86% respectively -Lower final FBG in control group -Hypoglycemic events in intervention and control groups were 2.28 and 1.75 episodes per-person-year respectively
Miller et al. (2009)	Intervention: 56 ± 8 years Control: 60 ± 7 years N= 103	RCT (pre-post test) 9 weeks	-Intervention (immediate group): 9 weekly group sessions (each 1.5-2 hours) addressing self-monitoring, goal setting, portion sizes, CHO counting, GI and factors that influence post-prandial blood glucose -Control(delayed): received same intervention methods just 9 weeks later and served as a control condition	Empowerment, self-efficacy, knowledge, outcome expectations, glucose monitoring, glucose control	-Significant improvement in all knowledge areas, self-efficacy, empowerment and dietary GI values for immediate group -Significant improvement in dietary barrier, family support, and glycemic control -Delayed group saw similar improvements in knowledge, self-efficacy, empowerment and dietary measures -Greater glycemic control improvement in delayed group
Selea et al. (2011)	40-65 years old N= 276	RCT 18 months	-Intervention: received printed education materials "healthy lifestyle with diabetes type 2" -Control: did not receive education materials -Both received a diabetes questionnaire regarding empowerment and patient attitudes -3 modalities: insulin, oral hypoglycemic drug and lifestyle intervention	FPG and HbA1c Required correct answers (RCAs) on questionnaire	-Significantly improved HbA1c (glycemic control) at 3 (8.00 ± 1.66% vs. 9.06% ±2.23% and 6 (7.67 ± 1.75% vs. 9.06 ± 2.23%) months compared to baseline -RCAs significantly improved after 3 months of the study (64.5 ± 33.7% vs 55.6 ± 33.2%)

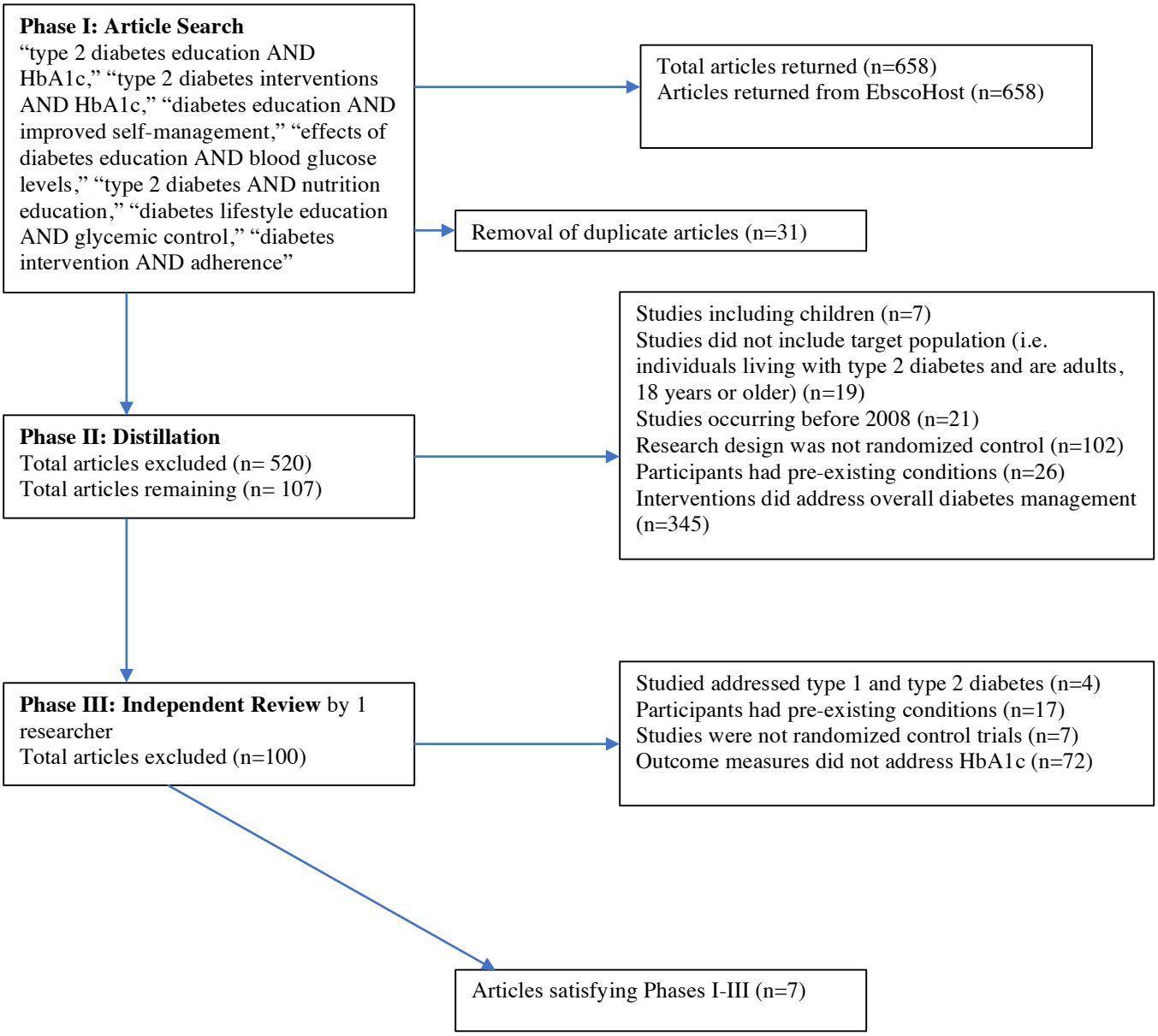

Figure 1. Article Extraction