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Physical Activity Behavioral Intervention for type 2 DM Patients: A Literature Review

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ABSTRACT

Various chronic and acute conditions as comorbid diseases are highly influential to the everyday life of type 2 diabetes mellitus patients, including in physical, psychological, economic, family burden, and quality of life aspects. The protocol and evaluation of this literature review used the PRISMA checklist. Using four databases; Pubmed, Science-direct, Scopus/Web of Science, and ProQuest. Five main physical activity behavioral intervention models for diabetes mellitus patients were discovered: 1. empowerment (individual and familial); 2. diabetes self-management education; 3. web-based digital health intervention; 4. motivational interviewing; and 5. SMS-based education. The five models focused on strengthening the importance of physical activity in diabetes mellitus patients' self-management.

Keywords:

Physical activity, Behavioral, DMT2, Self-management, Intervention Model

1. INTRODUCTION

Numerous epidemiologic studies have demonstrated upward trends in the incidence and prevalence of type 2 diabetes mellitus all over the world. The global number of cases has multiplied from 153 million in 1980 to 425 million in 2017 [1]. It is estimated that 415 million people worldwide are living with diabetes, and the number of adults living with DM globally is projected to rise to 642 million by 2040 [2] The prevalence of diabetes mellitus in 2019 was estimated to reach 9.3% (463 million people), up to 10.2% (578 million) by 2030 and 10.9% (700 million) by 2045. The prevalence of type 2 DM in Asia per se is constantly on the rise, projected to increase from 78 million in 2015 to 140 million by 2040 [3]. DM may occur as a result of the inability to control blood sugar consistently, leading to severe diseases that affect the heart and blood vessels, eyes, kidneys, nerves, and teeth and may lead to lower-limb amputation [4]–[6]. In addition, diabetes patients are at higher risk of getting infections [7], [8].

The global prevalence of glucose intolerance disorder (hyperglycemia) was an estimated 7.5% (374 million) in 2019 and was projected to reach 8.0% (454 million) and 8.6% (548 million) by 2030 and 2045, respectively [3]. As many as 1,785 DM patients suffered from various complications, including macrovascular complications (16%), microvascular complications (27.6%), neuropathy (63.5%), diabetic retinopathy (42%), and nephropathy (7.3%) [9], [10]. Diabetic sensorimotor polyneuropathy occurred in 10–54% of type 2 DM patients, retinopathy in 26.5% of type 2 DM patients, and nephropathy in 32% of type 2 DM patients [11]. As a result, morbidity and mortality are all affected.

Chronic and acute conditions such as comorbid diseases are highly impactful and can be problematic to patients. They may affect the economic, psychological, and quality of life aspects as well as result in family burden [12]. It is essential to pay attention to the economic factor as an effect of type 2 DM patients' inability to control their blood sugar [13]. DM morbidity and complications from hyperglycemia as a result of the inability to control blood sugar levels had a considerable effect on treatment costs [14]. The financial burden is higher in individuals

with both diabetes and related comorbid conditions than in those with only diabetes [2], [15]. It is significantly higher in the case of patients with comorbidities or complications [12], [13]. Therefore, preventive and treatment efforts, such as performing self-management in terms of physical activity, dietary and medical compliance, and self-care ability, are critical.

Various self-management (SM) activities for glycemic level control are interconnected with one another. Physical activity, diet, and medication are considered to be the three foundations of diabetes therapy. Increased physical activity and improved nutritional habits with hypocaloric diets (with varied macronutrient composition) are important to slow down type 2 DM manifestation. Regular physical activity is recommended for patients with type 2 DM as it has a beneficial effect on metabolic risk factors for diabetes complication progression blood [16]–[18]. A previous systematic review aimed to see how effective SM (physical activity, healthy diet, medical compliance, blood glucose monitoring, and problem-solving related to self-care in diabetes) is at controlling glycemic levels in type 2 DM and discovered that self-management activities were interrelated with one another in controlling glycemic levels [19]. Another systematic review showed that 75% of research articles found that physical activity decreased blood sugar levels more significantly than other self-management activities [20].

Physical activity in DM patients holds a central role in the control of blood sugar; when a person conducts a physical activity, there is an increase in the use of glucose by active muscles, hence directly leading to a decrease in blood glucose [16], [18]. The physical activity recommended by the American College of Sports Medicine and the American Diabetes Association lasts for 150 minutes per week, added with endurance exercise at least 2–3 days per week, which is in parallel with pharmacological medication [21]. In light of the variety of problems and causing factors, whether they be individual, time, or motivational, which discourage a patient with type 2 DM from performing a physical activity, and keeping in mind that not all ages of diabetes patients are influential to the behavioral change of the diabetes patients, a behavioral intervention to improve health and attain the recommended level of physical activity needs to be implemented to type 2 DM patients. Some studies [22]–[24] showed that a modified diet and physical activity were able to lower blood sugar and HbA1c levels in patients with diabetes mellitus.

Therefore, it is deemed necessary to encourage DM patients to perform physical activity through behavioral interventions. Behavioral interventions for type 2 DM patients can be implemented as the first step to type 2 DM control, to improve patients' knowledge and skills and generate a preventive lifestyle against type 2 DM complications. To have a closer look at some physical activity intervention models in the treatment and prevention of DM from progressing, this review aimed to further review forms of behavioral interventions for increased physical activity in type 2 DM patients.

2. METHOD

Literature Search Strategy

A thorough summary in the form of a literature review on physical activity behavioral intervention for type 2 DM patients was made. The protocol and evaluation of the literature review in choosing studies matching the aim of this literature review were based on the PRISMA checklist. The data employed in this research were secondary data from the research works of previous researchers rather than from direct observations. The secondary data sources were articles from international journals under a predetermined theme. The literature search was performed on four databases of high and moderate quality, namely PubMed, ScienceDirect, Scopus/Web of Science, and ProQuest. The MeSH terms and keywords used were *DM type 2 "AND" Intervention*, *DM Type 2 "Behavior Intervention*, and *DM Type 2 "AND" Physical Intervention AND Cognitive Behavior Intervention*. The determination of the inclusion and exclusion criteria followed the PICOS Flow (Table 1).

Table 1. CriteriaThe PICOS Flow

	Inclusion	Exclusion
Population	DMT2	DMT1, Gestational
Intervention	Education, empowerment, and technology use	No intervention, descriptive
Comparators	Standard procedures	No comparators
Outcome	Physical activity is the primary outcome and HbA1c is the	The primary and secondary outcomes were not explained
Study Design	RCT	The quasi-experimental study, systematic review, qualitative research, and cross-sectional study
Publication year/Language	Last six years (2014–2021)/English	Non-English

DMT2= Diabetes Mellitus Type 2 DMT1 = Diabetes Mellitus Type 1 RCT= Randomized Controlled Trial
HbA1c= Hemoglobin A1c

Based on the results of a literature search through the publication of two databases and using keywords that have been adapted to MeSH, 1058 articles were found that matched the keywords. Then, a duplication check found the same 948 articles were removed and the remaining 445 articles. The next step was screening based on the title (n = 208), abstract (n = 52), and articles on physical activity and diet interventions (n = 8) which were adjusted to the theme of the literature review. The assessment was carried out based on the feasibility of the inclusion and exclusion criteria, it was found that eight articles met the criteria for review. The results of the selection of study articles can be depicted in a PRISMA Flow-Chart (Fig. 1).

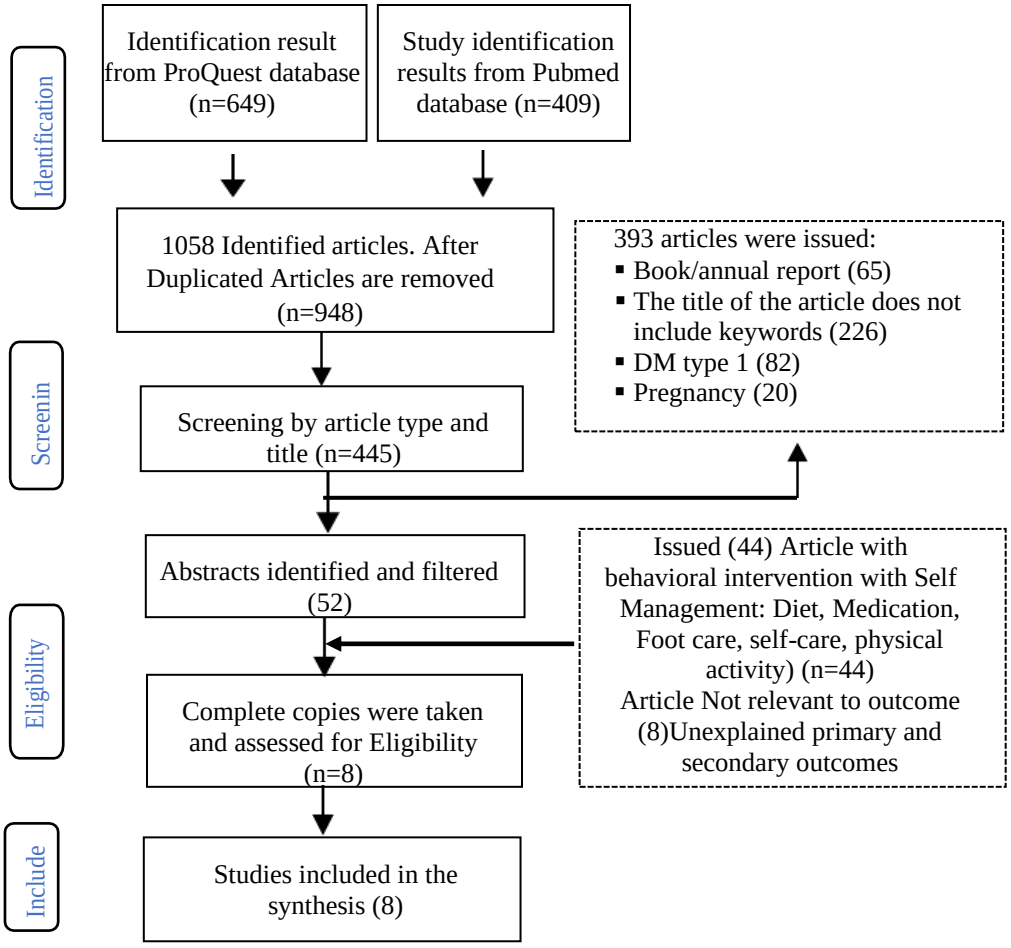

Figure 1 PRISMA Flow-Chart

Study design, model, and intervention media

The eight articles used the Randomized Controlled Trial (RCT) study design with two groups: the intervention group which received a physical activity treatment and the control group as a benchmark which received a standard care procedure treatment. Five main physical activity behavioral intervention models for DM patients were discovered: 1) empowerment (individual and familial); 2) education through DSME; 3) web-based digital health intervention; 4) motivation (motivation interviewing), and 5) SMS-based education. The results of the Grid Synthesis Analysis (Table. 2)

Table 2. Analisis Sintesis Grid

No	Article Title, Author, Year, Journal Name,	Population	Intervention	Control	Outcome		DS
					Primary Outcome	Secondary Outcome	
1	The Effect of a Community- Based Self-Help Intervention: Korean-Americans with type 2 Diabetes (Kim et al., 2015). Maryland, Baltimore, the United States of America (USA)	Type 2 DM ≥ 35 years	• Individual empowerment: Education + Counseling • Education with WCS officials, by empowering patients through health education : Knowledge, self-efficacy change	Comparing empowerment against short education brochure media	Physical activity and diet	HbA1c, total cholesterol, and lipoprotein psychosocial and behavioral: quality of life, self-efficacy, compliance, health knowledge	RCT
2	Effects of a Family-Based Diabetes Intervention on Behavioral and Biological Outcomes for Mexican- American Adults (McEwen et al., 2017).Arizona (USA)	Type 2 DM 35–75 years	• Family empowerment • Providing family members with information on the disease and possible medication options, validating their experience as support providers, teaching them various stress management skills, and assisting them in making future plans	Comparing against a waiting list after intervention The application duration in control being 2 hours/week over the course of 3 weeks	Physical activity and diet	HbA1c Knowledge, psychosocial aspect, and self-efficacy	RCT
3	Outcomes at 18 Months from a Community Health Worker and Peer Leader Diabetes Self-Management Program for Latino Adults (Spencer et al., 2018b).	Type 2 DM ≥ 35 years	• DSME • Education based on curriculum and FGDs • FGD: (Knowledge, self-efficacy	Control intervention by comparing with standard diabetes treatment (control group)	Physical activity and diet	HbA1c, total cholesterol, LDL [LDLc], and HDL, knowledge, social support, psychological aspect	RCT
4	Michigan (USA) Effect of a Nurse-Led Diabetes Self-Management Education Program on Glycosylated Hemoglobin among Adults with Type 2 Diabetes (Azami et al., 2018). Selangor (Malaysia)	Type 2 DM ≥ 18 years	• DSME with diabetes self-management led by the nurse • Media: booklets, film clips, FGDs • Follow-up: phone calls	Control intervention by comparing standard diabetes treatment (control group)	Physical activity and diet	Glycosylated hemoglobin (HbA1c values), blood pressure, body weight, lipid profile, self-efficacy (self-management behavior, quality of life, social support, and anxiety	RCT
5	Randomized Trial of a Lifestyle Intervention for Urban Low-Income African Americans with Type 2 Diabetes (Lynch et al., 2019), Illinois (USA)	Type 2 DM ≥ 18–70 years	• DSME intervention based on LIFE • Media: Curriculum	Comparing against the control group with standard treatment	Physical activity and diet	HbA1c, knowledge, skills	RCT
6	Effect of novel technology- enabled multidimensional physical activity feedback in primary care patients at risk of chronic disease – the MIPACT study: a randomised controlled trial (Peacock et al., 2020). South-West of United Kingdom (UK)	Type 2 DM ≥ 35 years	• E-Health based on the web • Digital Health: by measuring effectiveness against PAL change	Comparing against the control group with web treatment but receiving additional sessions from the team	PAL	Mass index, waist circumference, fat mass, systolic and diastolic blood pressure, glucose control (glucose and insulin), lipid (total cholesterol, HDL, LDL, triglyceride), and C-reactive protein	RCT

No	Article Title, Author, Year, Journal Name,	Population	Intervention	Control	Outcome		DS
					Primary Outcome	Secondary Outcome	
7	Impact of Motivational Interviewing on Self-Management in Patients with Type 2 Diabetes (Wong et al., 2020). Hongkong - China	Type 2 DM ≥ 18 years	• Intervention: Motivation Interviewing (MI) • MI by providing education • Logbook dan FGD: (knowledge and experience with problem-solving) • 5 sessions, 30–45 minutes/session every 2 weeks	The control group only getting standard treatment	Physical activity and diet	HbA1c, blood pressure, BMI, waist-to-hip ratio, fasting blood, psychosocial measure, and self-care	RCT
8	The Role of Text Messaging Intervention in Inner Mongolia among Patients with Type 2 DM: A Randomized Controlled Trial (Wang et al., 2020). Mongolia	Type 2 DM ≥ 18 years	• Text message intervention • Sending structured SMS using the text messaging feature in non-smartphones	The control group receiving regular education from standard texts	Diet control, physical activity	Plasma glucose, blood glucose control, body weight control, and lifestyle (smoking cigarettes)	RCT

SD - Design Study RCT= Randomized Controlled Trial FGDs= Focus Group Discussion HbA1c= Hemoglobin A1c LDL= Low Density Lipopprotein HDL= High Density Lipoprotein PAL (Physical Activity Level) LIFE (lifestyle improvement through food and exercise) DSME = Diabetes Self Management Education BMI Body Mass Index

The five models were focused on strengthening the understanding of the importance of physical activity in self-management. There were two types of media used in the eight articles reviewed, namely conventional and electronic media. The former included leaflets, modules, curriculum books, film clips, log books, and short messages, whereas the latter included web-based digital media and short message services (SMS) via non-smartphones. Six of the eight articles reviewed used conventional media, and one of the six used a combination of booklets (conventional) and video/film clips (electronic). The two other articles used digital-based electronic media.

Primary and secondary outputs

The primary output of the eight articles reviewed was increased physical activity. Meanwhile, the secondary outputs included HbA1c level, total cholesterol (LDL, HDL, VLDL, and VHDL), C-reactive protein, self-efficacy, blood pressure, plasma glucose, psychological and psychosocial aspects, quality of life, anxiety, and social support.

3. RESULTS AND DISCUSSION

Population

Based on the diagram (Figure 2), the eight studies were focused on the age range of 35–70 years. The population of type 2 DM patients varied in racial characteristics, including African-Americans, Korean Americans, Mongolian, and Latin Americans.

Critical appraisal

From the results, it is concluded that type 2 DM as a problem or the populations on which type 2 DM-induced physical activity interventions were applied were attributed to faulty insulin use. The insulin in the body transfers glucose into body cells for storage and usage in the form of energy. However, due to insulin resistance, the insulin fails to function maximally, preventing glucose from entering muscular cells for storage as energy; consequently, the glucose is accumulated in the blood circulation and causes hyperglycemia. Therefore, to overcome insulin resistance and prevent glucose accumulation in the blood circulation, which must be secreted to maintain the glucose level at the normal level, one must perform physical activity.

Type 2 diabetes mellitus is a problem that must be addressed by type 2 DM patients through physical activity by ADA. Therefore, some research works conducted some approaches empirically through behavioral interventions, including education based on individual and familial empowerment, DSME, and motivation and education interventions via websites and SMS, to provide education or promote health about the importance of physical activity as recommended for each level for type 2 DM [20], [25], [26].

Type 2 DM begins as prediabetes; hence, it is necessary to conduct preventive efforts and pay special attention to prediabetes. Prediabetes may manifest as a condition of an increased risk for type 2 DM with impaired fasting glucose tolerance and impaired glucose tolerance. Prediabetes may suddenly manifest into type 2 DM. A prospective cohort study states that within 3–5 years, prediabetes would manifest into type 2 DM in 25% of observed subjects, and in 70% of the population, prediabetes would turn into type 2 diabetes in a lifetime observation [27]. A meta-analysis study showed that a decrease of 1 kilogram of body weight through physical activity would reduce the risk of diabetes progression by 7% [28].

Study results indicated that the physical activity interventions for DM patients were applied under various methods and using various media. In addition, they also revealed the effective times for interventions and the effectiveness of the interventions regarding primary and secondary outcomes.

Some of the physical activity behavioral interventions applied took the following forms

Empowerment

A variety of empowerment-based interventions aiming to change the physical activity behavior of type 2 DM patients were able to alter outcomes as desired [29], [30]. A health education intervention for empowerment with the counseling support of trained community nurses that was focused on individual DM patients was able to improve the self-management skills and self-efficacy of DM patients [29]. Another study focused on patient and family involvement in the education provision. The empowerment education covered skills, DM knowledge, physical activity behavior, and complication prevention [30]. Family empowerment was considered important to do by providing family members with information on the disease and possible medication options, validating their experience as support providers, teaching them various stress management skills, and assisting them in making plans.

The two studies developed brochures and booklets as media with follow-ups in the form of home visits and phone calls to observe the respondents' physical activity progression. The sessions involved in the education were the same: there were education sessions for 2 hours/weak over a course of 6 weeks with a follow-up in the form of home visits (3 x 2 hours/week) over the course of 3 weeks during the intervention and phone calls for 20 minutes/week over the course of 3 weeks [29], [30].

One of the eight articles reviewed found no significant improvement in a healthy diet or physical activity as the respondents reported numerous hindrances to perform physical activity routinely, including family responsibilities, irregular working hours, a lack of walking area, and a lack of exercise facilities [30]. Therefore, a consistent intervention was deemed necessary to reach effectiveness during the observation.

The studies by Kim et al (2015) and McEwen et al (2017) about empowerment can be used as references for modifying physical activity behavior through both individual and family empowerment. Empowerment for family members as the closest ones to patients who are with emotional attachment to the patients may be carried out by providing them with facilitation about the disease the patients were suffering from, validating their experience as support providers, teaching them various stress management skills, and assisting them in making plans [29], [30]. In the study by McEwen et al (2017) however, the family empowerment conducted is still unclear [30]. Diabetes requires diabetes patients to make significant modifications to their behavior, which may affect their family members. A systematic review of 29 studies on the effect of type 2 DM on family members (2000–2011, 16 quantitative, 10 qualitative) by Rintala, Jaatinen, Paavilainen, & Åstedt-Kurki (2013) reported that it is important to pay attention to the effect of diabetes on family members [31]. The study by Fisher, Chesla, Skaff, Mullan, & Kanter (2002) found that emotional pressure was greater in the partners than in the patients [32]. It is, therefore, necessary to conduct an in-depth study on family members, particularly on spouse.

Diabetes self-management education (DSME)

Several studies developed an educational intervention through DSME [22], [23], [33]. The three studies aforementioned differed in the implementation of the DSME intervention; they used focus group discussions (FGDs), booklets, film clips, and curriculum books covering the education to be provided. DSME is a continuous process that is intended to facilitate DM patients' improvement of knowledge, skills, and abilities related to self-care [34]. One of the articles reviewed had similarities in the actors involved, namely the health personnel, as well as the variety of media used, with a combination of FGDs and the strategy used as a follow-up of the intervention applied, i.e., phone calls [22]. FGDs were implemented in 4 discussion sessions, covering materials on knowledge, self-efficacy, skills, and problem-solving. These FGDs were aimed at gaining depth of data with a focus on problem-solving related to various social experiences and interactions of DM patients in discussions.

The intervention performed was more complete with the use of FGDs, booklets, and film clips of recovered patients. The booklets presented covered educational messages on DM knowledge, complication, and the benefits of physical activity for minimizing complications [22]. This study is more about developing an emotional approach to the content with subjects and interventions following the self-efficacy theory. The film clips that were used as media were able to result in behavioral changes; the contents were educational and used verbal-persuasive language. These clips contained information from recovered DM informants regarding their experiences as DM patients, life hacks for DM patients, how to maintain self-management, long- and short-term complications, physical activities, and healthy lifestyles for diabetes patients. Another study was focused on the ability to build knowledge, self-efficacy, and skills, problem-solving action plans, and peer support. This study also directly involved family members as social support providers to encourage patients to attend education sessions, demonstrate dietary compliance, conduct Physical activity, and improve their quality of life [35], [36].

The two studies developed FGDs to implement the intervention to have a look at the problem, be it from the self-efficacy, attitude, intention, knowledge, or problem-solving point of view. The two studies deviated in the

duration used. The first study used FGDs in four sessions weakly intervals with the involvement of 10 people over the course of four weeks, 120 minutes/session [22]. The second study conducted FGDs in 11 sessions, lasting 2 hours (120 minutes) per session, every two weeks [35]. The former was weak about the latter in terms of the intervention duration used, which was too short for evaluating the long-term effect of the self-management intervention, such as one on self-efficacy, and in terms to the primary outcome parameter of HbA1c. However, it can still be used as a reference for behavioral interventions in 12 weeks, revealing the glycemic control level based on HbA1c ($p < 0.001$) in week 12 and behavioral changes as secondary outcomes.

Differently, the studies by Lynch et al. (2019) and Spencer et al. (2018a) focused the intervention used on evaluating the effect of the intervention in longer terms (12 months and 18 months, respectively). The two studies developed culture-based curricular media. Using curricular media, the group-based DSME intervention in the long term resulted in a greater decrease in HbA1c in month 12 in the respondents, which was significant to their knowledge and self-efficacy. It was a long-term study with the HbA1c being measured in the sixth month. It reports a significant decrease in HbA1c in month 6, which mostly endured even into month 12 and month 18 [23], [35].

The DSME intervention was varied in the media used for a changed physical activity behavior, including booklets, curriculum books, FGDs, and film clips, which were effective for delivering education to see the physical activity outcome as well as secondary outcomes of HbA1c and other components (e.g., knowledge, intention, self-efficacy, skills, quality of life, and social support).

It must be noted that in behavioral research there is one thing known as the Hawthorne effect. The Hawthorne effect can influence the respondents' behavior, potentially strengthening or altering their behavior as a response to the fact that they are aware of being observed. Given this effect, a strict design is therefore required.

Web-based intervention

The research by Peacock et al. (2020) developed a website to change physical activity behavior. This research stated that low physical activity is the main problem and an important independent risk factor to be addressed, and it suggested increasing physical activity. It aimed at figuring out the effectiveness of a web-based intervention, with nurses serving as assistants, comparing only with applications [37].

Some other studies used digital health technologies. A systematic review by Fanning, Mullen, & Mcauley (2012) on increasing physical activity with cellular devices concluded that it is an effective way to affect physical activity behavior and is recommended for patients with chronic diseases, such as heart disease, hypertension, and cancer. A study on the use of digital health technology by patients with chronic diseases found that there was a change in resting diastolic blood pressure and compliance with hypertension protocols [38].

The study by Shariful Islam et al. (2019) found that an SMS-based digital health intervention was able to change compliance in terms of physical activity in heart disease patients [39]. Additionally, Navin, Vadivu, Maharaj, Thomas, & Lavanya (2018) revealed that a smartphone-based intervention was able to educate and motivate tuberculosis patients to be medication-compliant [40]. A study by Schwinn, Schinke, Keller, & Hopkins (2019) reported a web-based drug abuse prevention program, which was effective at reducing drug use and related risk factors by improving teens' cognitive skills and behavior. This intervention was proven to enable adolescents to refuse alcohol, cigarettes, and marijuana. These studies proved that web-based interventions have been widely used to modify behavior, but an educational intervention with a greater degree of integration is needed [41].

Motivational Intervention

Wong et al. (2020) stated that the motivational intervention (MI) led directly by a nurse could improve primary (physical activity) and secondary outcomes (psychosocial and self-care aspects for individuals with type 2 DM) [24]. A review on motivational intervention by Martins & McNeil (2009) showed betterment in health behavior such as diet and exercise in diabetes patients [42].

In motivational intervention, communication skills are required to influence this behavior. The clinical outcomes of DM are more complete with a combination of diet, physical activity, and measured secondary outcomes such as glycemic control (measured using HbA1c), blood pressure, BMI, waist-to-hip ratio, fasting blood measures, psychosocial measures, and self-care.

The 12-month-long study by Wong et al. (2020) implemented an intervention by changing psychosocial behavior and clinical outcomes. The intervention used a logbook and FGDs to provide education in 5 sessions, which lasted for 30–45 minutes/per session, in a two-week interval [24].

SMS Gateway

A recent study implemented an educational intervention via SMS, considering that it is a feature available for all kinds of mobile phones to receive information, being economical, comfortable, real-time, and easy to operate, whether or not the phones are in 4G network or connected to Wi-Fi, highly suitable for economically underdeveloped regions. The weaknesses of this research are that it only looked at secondary parameters of knowledge, self-efficacy, and body weight control, the clinical (primary) outcome of HbA1c had yet to be measured, and it targeted only type 2 DM patients visiting the service clinic rather than being community-based. The limitations and recommendations offered by this research can be used as considerations to conduct the

intervention in areas with limited Internet networks and for low-economy communities. Therefore, the researchers attempted to use this research as a benchmark for the present study by developing a community-based intervention using a web-based SMS Gateway application for both rural and urban people, with the parameter of a change in compliance behavior to reach the recommended physical activity level. With this application, patients can choose the best exercise mode and ensure the best exercise time and frequency to reach the recommended physical activity level for type 2 DM patients.

4. CONCLUSION

From the explanation above, it is concluded that all the interventions given were in the form of health education. Therefore, attainment of the recommended physical activity level through behavioral health education interventions is an urgent issue. Prediabetes and DM patients need an educational approach with a greater degree of integration using digital technologies for prevention efforts that target various DM behavior contexts.

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