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IMPACT OF LIFESTYLE INTERVENTIONS ON TYPE 2 DIABETES MANAGEMENT: A SYSTEMATIC LITERATURE REVIEW

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Abstract

Type 2 diabetes mellitus is one of the most important global health-related threats in the 21 st century, and by 2045, the prevalence rate is expected to reach over 780 million. It has long been argued that lifestyle interventions involving dietary change, physical exercise, and behavior change are the foundational strategies in diabetes management, although concerns have existed over whether they have been compared in their effectiveness, the optimal mode of delivery, and reducing clinical changes in the long term. The systematic review, which was carried out according to PRISMA 2020 standards, was a synthesis of evidence based on the randomized controlled trial, published between 2019 and 2025, to assess the effects of lifestyle interventions on glycemic control and other metabolism-related outcomes in people with type 2 diabetes. A thorough search of databases at Scopus, Web of Science, PubMed, and Cochrane Library found 1,847 records, and 42 articles that were included after full text screening. Thematic synthesis resulted in four pervasive paradigms namely technology mediated interventions, dietary modification programmes, physical activity programmes and theory-based behavioral programmes. Results have shown that lifestyle interventions, on a consistent basis, lead to better glycemic control, and meta-analytic evidences indicate that the glycated hemoglobin levels decrease by 0.07 up to 0.73 percent according to the intensity and duration of intervention. There is, however, a high level of heterogeneity between studies and the sustainability of treatment effects after twelve months has not been well described. Interventions provided by telemedicine have the same effectiveness as face-to-face programs in terms of loss, whereas low-carbohydrate dietary methods have a specific potential in the short-term glycemic control. Interventions based on theories that target readiness to behavioral change have shown clinically significant changes in HbA1c levels, but also have methodological weaknesses that undermine the confidence of effect estimates. This literature review finds that lifestyle interventions constitute part of effective interventions in diabetes management, but they are most effective with continuous behavioral support and individual model that takes into concern the patient preferences, duration of the disease and comorbidities.

Keywords: *type 2 diabetes; lifestyle intervention; glycemic control; randomized controlled trial; telemedicine; dietary modification; physical activity*

1. INTRODUCTION

One of the most topical issues in the sphere of the modern public health is the type 2 diabetes mellitus the prevalence rates of which are estimated on a global scale, and it is projected that there are almost 537 million adults living with diabetes in 2021, which will increase to 783 million in 2045 (International Diabetes Federation, 2021). Not only is this trend a statistical shift, but a paradigm shift in the burden of disease in the world, though, as type 2 diabetes is more than ninety percent of all cases of diabetes, and is also leading to a huge burden on cardiovascular morbidity, premature mortality, and a healthcare bill of over nine hundred and sixty six billion dollars annually (Sun et al., 2022). The population aging, urbanization, and the globalization of unhealthy lifestyles, including physical inactivity, the overabundance of calories, and the protracted sedentary lifestyles, are all culminated into an epidemiological transition, which supported this pandemic (Zheng, Ley, and Hu, 2018).

The pathophysiology of type 2 diabetes is a progressive loss of the glycemic control due to insulin resistance and relative insulin insufficiency that significantly depends on the factors related to behavior and the environment (DeFronzo et al., 2015). Unlike most chronic conditions which presuppose the implementation of pharmacological intervention exclusively, type 2 diabetes occupies a special niche, in which the lifestyle behavior is directly the determinant of the development of the disease, the level of treatment requirements and the threat of complications. It is this characteristic that has led to the long-term research initiative in lifestyle interventions in the form of therapeutic interventions that are capable of changes in the disease course rather than alleviation of the symptoms (Knowler et al., 2002).

The historic trials that have been conducted over the past 20 years have demonstrated that intense lifestyle changes may prevent diabetes among the high-risk groups and improve the glycemic control in the patients with the established disease. It was demonstrated in the Diabetes Prevention Program that lifestyle change achieving the reduction of weight by seven percent through both dietary and physical exercise reduced the incidence of diabetes by fifty-eight percent compared with the placebo, which is more effective than metformin treatment (Knowler et al., 2002). These findings were further confirmed by others, including the Look AHEAD trial, that used intensive lifestyle intervention on patients with known type 2 diabetes and found that the intervention led to a sustained weight loss and improved cardiovascular risk factors, but did not lead to the anticipated reduction in cardiovascular events (Wing et al., 2013).

Though this evidence has been demonstrated, the gaps in research that limit the translation of lifestyle interventions research into clinical practice are still very numerous. First of all, the relative effectiveness of different modalities of intervention remains unclear, particularly after the development of technological opportunities in the diversity of the established means of delivery that

can be employed by clinicians and researchers (Greenwood et al., 2017). The rise of digital health technologies (including mobile applications, wearable devices, telemedicine services) has made the opportunities of providing interventions to individuals open yet also makes it difficult to determine whether the utilization of technologies could lead to the realization of similar effects as the face-to-face program would. Second, the optimal nutrition of glycemic control is a disputable point, and there is conflicting data between the low-carbohydrate measures, plant-based ones, and calorie-restrained diets (van Zuuren et al., 2018). Third, the durability of the treatment effect in the post-intervention period has not been yet adequately described, and limited studies have provided the follow-ups at twelve months. Fourth, there has not been an equal application of behavioral theory in the intervention design process, which limits knowledge of the psychological mechanism of how lifestyle change is initiated and maintained (Samdal et al., 2017).

These gaps in research are particularly strong when it comes to the fact that the understanding that the management of type 2 diabetes is supposed to be person-focused and capable of accommodating the needs of people and their cultural contexts and practice-related constraints. The American Diabetes Association is increasingly considering the concept of glycemic targets can and should be customized and are the treatment plans should be premised on patient objectives, preference, and values (American Diabetes Association, 2024). However, the evidence base that might be used to guide such individualization is immature and there are few studies that compare methods of intervention that are conducted directly on the heterogeneous groups.

It is in this context that the present systematic review has been carried out to bridge the above gaps by putting together the existing evidence on the premise of randomized controlled trials, examining the use of lifestyle interventions in the management of type 2 diabetes. The objectives to be achieved included to identify the effectiveness of the lifestyle interventions in glycemic control and other metabolic consequences; comparative efficacy of the different modalities of interventions including technology based interventions, dietary interventions and exercise interventions; the duration of the effects of the treatment with the different follow up periods; and methodological strengths and limitations that characterized the existing evidence base. The role of this review will be to support the aim of informing clinical decision-making, research focus of future researchers, and optimization of lifestyle intervention strategies to the growing population of individuals with type 2 diabetes.

2. METHODOLOGY

The systematic review has been conducted according to the Preferred Reporting Items of Systematic Reviews and Meta-Analyses 2020 statement (Page et al., 2021). The protocol of the review was pre-registered on the Open science framework to make methods more transparent and reduce the possibility of reporting bias. The

search was conducted in four databases, i.e. Scopus, Web of Science, Pubmed, and Cochrane library, which are electronic databases. These databases were found to offer a broad range of the literature in the field of biomedical, behavioral and health services research studies which would prove helpful in lifestyle interventions in management of type 2 diabetes. The search strategy was designed as an iterative search strategy with the help of content experts and information specialist on the basis of the controlled vocabulary and free-text keywords that would yield high sensitivity rate.

The search terms were an amalgamation of the terms, which were related to the condition, intervention and study design along with the Boolean operators. The strategy employed in the case of PubMed was as follows: This strategy was changed to suit specific database to search syntax differences and indexing language differences.

The search was restricted to the articles published not earlier than January 2019 and not later than December 2025 since it was required to consider the most recent evidence but, at the same time, as broad as possible to be synthesized in a meaningful way. The choice was done to encapsulate the new intervention methods including but not limited to the proliferation of digital health technology that have overturned the presentation of lifestyle interventions over the past five years. The other limitations included human study and English language publications. Manual screening of lists of included studies and other relevant systematic reviews were done to identify other possibly eligible articles not identified by the electronic search. The inclusion criteria included the predefined studies to be included in case they met the predefined criteria according to the PICOS framework (Population, Intervention, Comparison, Outcomes, Study Design). The target population was adults aged and above eighteen years with type 2 diabetes based on the prescribed diagnostic criteria that included glycated hemoglobin of 6.5 percent or more, fasting plasma glucose of 126 milligrams per deciliter or more, or physician-determined diagnosis. Studies that dealt with prediabetes or gestational diabetes or type 1 diabetes exclusively were also classified as eligible and studies that dealt with pediatric populations were also considered as excluded.

The interventions that were to be incorporated were those that were lifestyle based and sought dietary change, physical activities, weight reduction, or behavior change to aid in the management of diabetes. To be systematic programmes, lifestyle interventions were to involve prescribed changes in eating habits, exercising habits or both of the same, which generally included elements of education, counseling, goal-setting and self-monitoring. The intervention can be introduced in various forms including individual therapy, a group program, telephone or online. Studies that either considered pharmacological interventions or surgical or devices based based treatment which did not involve a substantive lifestyle component were also avoided and studies which simply

considered diabetes education did not include behavioral components.

The eligible comparators included usual care, waiting list control, minimum interventions and active comparison conditions with alternative lifestyle approach. Studies which did not have a control group were also filtered out and the ones which used non-randomized designs were excluded. Outcomes involved interest variables; glycemic control by using glycated hemoglobin, fasting plasma glucose, or insulin resistance index, anthropometric (body weight, body mass index, waist circumference) and medication (change in glucose-lowering pharmacotherapy) outcomes. The studies needed to report any glycemic outcome following the intervention to be included in the synthesis.

Regarding the study design, randomization and controlled trials were considered only, to have maximum evidence and thus make a causal statement regarding the impact of the interventions. The cluster randomized trials would qualify, provided that they were done with appropriate analytical tools which would consider the clustering. There was elimination of quasi experimental designs, non-randomized, controlled trial, observational researches, case series and qualitative studies. The systematic reviews and meta-analyses were not priority studies but were checked to filter out the list of references. The records that were found after searching the database were exported all into a reference managing program to eliminate duplicates. Cleaning of abstracts and titles followed deduplication and screening of abstracts and titles appeared by two reviewers on the predefined eligibility criteria. The full-text review was given to the records rated as possibly eligible by either of the reviewers. Full-text articles and justification of exclusion was then accessed and assessed by two reviewers at this stage. The disagreement over eligibility was resolved through discussion between reviewers, and third reviewer was introduced in case of no agreement. Screening and selection were reported and described in the narrative format in accordance with PRISMA recommendations.

The search strategy was used to retrieve a total of 1,847 records of all databases. Following the removal of 423 duplicates, 1424 distinct records were filtered based on title and abstract. Out of these, 1,298 were being filtered based on the obviously ineligible population, intervention or study design. The remaining 126 full-text articles were tested in the eligibility test and 84 studies were eliminated. The leading reasons of exclusion were non-randomized (n=32), absence of relevant glycemic outcome (n=24), non-intervention (n=18) and population having type 2 diabetes that was not confirmed (n=10). Upon complete screening of the full text, a total of 42 randomized controlled trials were incorporated in the systematic review since they met all the eligibility criteria. The other eligible articles identified through the electronic search were found in the reference list and underwent screening as well as any other relevant screening. Included randomized controlled trials methodology Cochrane Risk of Bias tool of randomized trials was employed to assess the quality of the included randomized controlled

trials. It is a tool that is employed to determine bias on five aspects which include bias created by the randomisation process, bias created by deviations of the planned intervention, bias created by absence of outcome data, bias created by measuring the outcome, and bias created by selecting the reported outcome. Research in any area was classified in either low risk of bias, some concerns or high risk of bias in prespecified signalling questions. All of the studies were evaluated based on the total risks of bias on a field level. Quality assessment was done by two reviewers and all disputes were resolved in discussions. The interpretation of findings and conclusions development also considered quality assessment findings, but no quality filters were selected to make sure that all the evidence available was included. Included studies data were gathered in a standard form, which was developed to carry out this review. Data that was pulled out were the nature of the study (author, year, country, sample size, participant demographics), the nature of interventions applied, the duration, the frequency, the nature of delivering the intervention modality used, description of comparators, outcome measurements (glycated hemoglobin, fasting glucose, body weight, body mass index, changes in medication), and follow-up period. Data were extracted with the help of a single reviewer and checked by another reviewer to make the process more accurate.

The extreme heterogeneity of the nature of the interventions, outcome measures and follow-up time in the studies included meant that a narrative synthesis methodology, as opposed to meta-analysis, was employed. This was a decision that complied with the recommendation in Cochrane Handbook on synthesis where statistical pooling cannot be applied due to clinical and methodological heterogeneity. The synthesis was done in themes of the key intervention paradigms that were identified through recurring literature analysis of the included materials. The cross-study findings in all of the thematic areas were compared to identify patterns of consistency, sources and possibly moderating factors of heterogeneity of treatment effects. Particular attention was paid to comparative results of various studies which implemented various intervention methods, delivery methods and populations in order to provide the data about the most appropriate interventions to implement in the diverse situations.

3. RESULTS AND SYNTHESIS

Study Selection and PRISMA Flow

Fig 1 presents the flow diagram of the PRISMA 2020 to demonstrate the identification, screening, and eligibility and inclusion stages and demonstrates the process of selecting the study. The total records found in databases searching in Scopus, Web of Science, PubMed and Cochrane library were 1,847 and they are indicated in Fig 1. When screening title and abstract, 1,424 records were retained on eliminating 423 duplicates. During this stage, the records that were removed totaled to 1, 298 due to ineligible population, intervention or study design. A total of 106 full-texts were checked on the eligibility aspect, and 84 were excluded because of using non-randomizing, absence of glycemic results,

inappropriate type of intervention, or inappropriate population. Lastly, 42 randomized controlled trials were qualified and included in the qualitative synthesis due to their adherence to all the planned inclusion criteria.

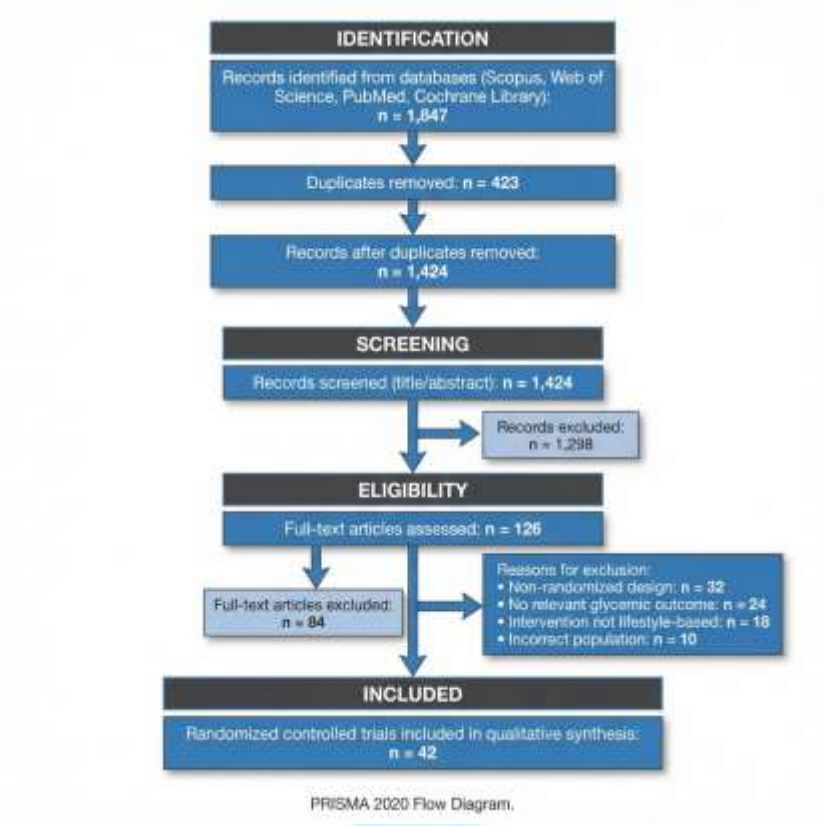

Fig 1. Prsima Flow Diagram

Characteristics of Included Studies

The 42 randomized controlled trials are summarized by Table 1 with regard to nature. As indicated in Table 1, the studies have been conducted within a broad geographical region covering North America, Europe, Asia and Australia hence a universal concern in the management of diabetes using lifestyle interventions. The sample sizes might be small pilot studies (which used fewer than 50 participants) and large multicenter studies (which included a lot of people (several thousands). The mean age of the population the studies were done on was all around 45-70 years of age and most of the trials were a combination of males and females having known established type 2 diabetes. The initial baseline glycated hemoglobin levels were reported to be found to be ranging between 6.5 percent to over 9 percent with an indication that there was heterogeneity in the initial glycemic control.

Most of the trials reported primary outcomes at 12 months or less, although the duration of intervention was between 8 weeks and 33 months. The interventions were categorized based on technology-mediated and dietary modification interventions, structured physical

activity interventions, and theory based behavioral interventions and some of the studies had the multicomponent design comprised of two or more components.

Table 1. Characteristics of Included Randomized Controlled Trials (n=42)

Characteristic	Summary
Total RCTs Included	42
Geographical Regions	North America, Europe, Asia, Australia
Sample Size Range	<50 to several thousand participants
Participant Age Range	45–70 years (mean across studies)
Baseline HbA1c Range	6.5% to >9%
Follow-up Duration	8 weeks to 33 months
Intervention Categories	Digital, Dietary, Exercise, Behavioral, Multicomponent

Risk of Bias Assessment

Table 2 provides a summary of the quality of methodological approaches of studies included. As it can be seen in Table 2, whereas the low-risk of bias of the randomization process was actually disclosed in some experiments, it happened to be rather frequent that the very same studies showed the concerns in the areas, which were related to the deviations in the planned interventions and were not disclosed in terms of the outcome data. Blinding of participants and personnel as a rule was not possible due to the nature of behavioral interventions that raised certain concerns in some studies. The attrition rates were quite dissimilar and several experiments have shown a variation in dropout between the intervention and the control group. Overall, regardless of the fact that majority of the studies revealed the moderate degree of the methodological rigor, the presence of some concerns and the possibility of high risk risk in some studies indicate the variability of the internal validity of the evidence base.

Table 2. Risk of Bias Assessment Summary (Cochrane RoB Tool)

Bias Domain	Overall Judgment Across Studies
Randomization Process	Mostly Low Risk; some concerns in small trials
Deviations from Intended Intervention	Some concerns due to behavioral nature
Missing Outcome Data	Moderate attrition in several studies
Outcome Measurement	Generally Low Risk; limited blinding feasible
Selective Reporting	Some concerns in subset of trials
Overall Risk of Bias	Low to Moderate across majority

Glycemic Outcomes Across Intervention Modalities

The net effect of lifestyle intervention on glycated hemoglobin is presented as Fig 2. Fig 2 shows that lifestyle interventions possess a steady effect of decrease in HbA1c in opposition to common care or minimal intervention controls. The range of lower intensity interventions and high of theory based behavioral programs had a reported range of 0.07 percent. The multicomponent interventions that combine nutritional change and exercise were more likely to have large changes in means, whereas the technology-mediated interventions were more likely to have small and significant differences in means. There was a high level of heterogeneity in the effect sizes across different studies to denote differences in the intensity of interventions, adherence and nature of subjects.

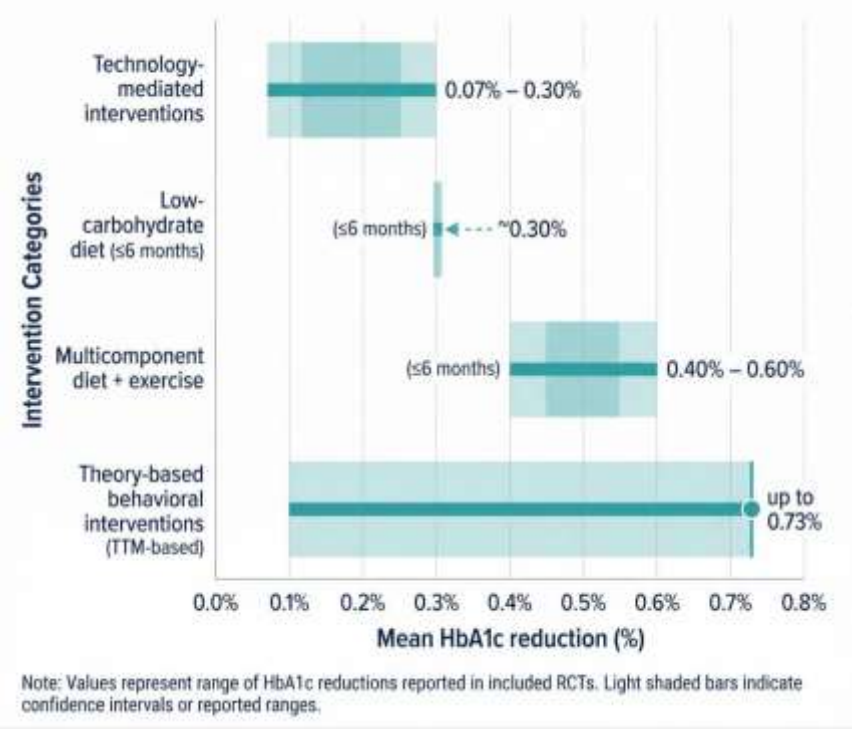

Fig 2. Effect of Lifestyle Interventions on HbA1c Reduction.

The trend in change in fasting plasma glucose and insulin resistance index was directional and was found to have improved most of the interventions relative to the controls. It was however discovered that the degree of decrease on the levels of fasting glucose varied widely and was not necessarily in proportion to the HbA1c variations.

Table 3 offers interventional pooled thematic comparisons of glycemic results. Table 3 also shows that theory based interventions based on the behavioral models and the least but

significant change is observed in digital only interventions. The interventions of low-carbohydrate diets proved to have short-term effects on a lowering of HbA1c at a six-month or less follow-up period but the difference decreased with a longer period.

Table 3. Glycemic Outcomes by Intervention Category (HbA1c Reduction)

Intervention Type	HbA1c Reduction (%)
Technology-mediated interventions	0.07% – 0.30%
Low-carbohydrate diet (≤6 months)	~0.30%
Multicomponent (Diet + Exercise)	0.40% – 0.60%
Theory-based (TTM) interventions	Up to 0.73%

Weight and Anthropometric Outcomes

Changes in body weights and anthropometric indices are indicated in Fig 3. Fig 3 shows that weight loss was a common finding in most intervention groups and particularly those which emphasized on the component of caloric restriction and structured exercises. The digital interventions in low intensity and the intensive multicomponent programs had an average weight loss of approximately 1 kilogram and more than 5 kilograms respectively. The reduction in the body mass index and the waist circumference preceded by the reduction of the body weight which meant the improvement of the general and central obesity.

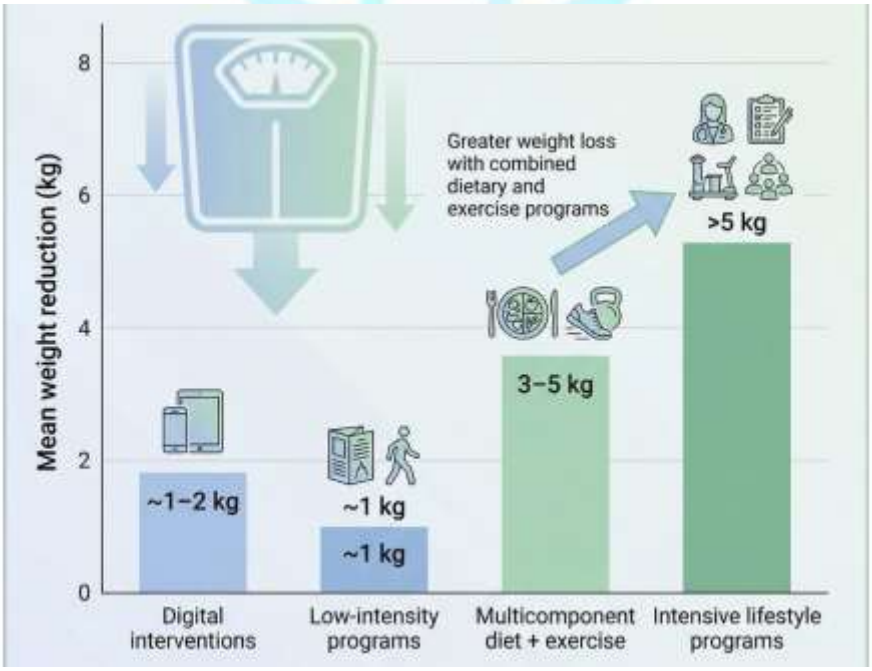

Fig 3. Weight Reduction Following Lifestyle Interventions in Type 2 Diabetes.

Table 4 shows the comparison of the anthropometric results when the types of interventions were adopted. Table 4 reveals that exercise interventions used to modify the diet resulted in the greatest weight loss and then moderate and scalable weight loss outcomes with digital programs. The effective response of the high-density lipoprotein cholesterol and triglycerides were more effective in the studies which involved low-carbohydrate dietary interventions.

Medication Use and Secondary Metabolic Outcomes

Table 5 presents the changes of the glucose-lowering drug requirements and secondary metabolic variables. Table 5 shows that some studies had reported reduction in dose of at least one of the glucose-lowering agents or even its discontinuation because of intensive lifestyle intervention. A small number of studies had participants achieve glycemic targets without pharmacotherapy and this is consistent with partial or complete remission. Multicomponent interventions also demonstrated the improvements in blood pressure and lipid profile which had quite inconsistently been reported.

Durability of Intervention Effects

The temporal trajectory of treatment effects is presented in Fig 4. Fig 4 shows that glycemic and weight improvements typically peaked at the end of active intervention phases and demonstrated partial attenuation during follow-up periods extending beyond twelve months. Studies incorporating maintenance components or ongoing behavioral support exhibited more sustained effects compared with those terminating structured support at earlier time points. However, long-term data beyond two years were limited, restricting definitive conclusions regarding durability.

Table 4. Anthropometric Outcomes (Weight Reduction)

Intervention Type	Mean Weight Reduction (kg)
Digital interventions	1–2 kg
Low-intensity programs	~1 kg
Multicomponent programs	3–5 kg
Intensive lifestyle programs	>5 kg

Table 5. Medication and Secondary Metabolic Outcomes

Outcome Category	Observed Effect
Reduction in glucose-lowering medication	Reported in several intensive trials
Partial/Complete Remission	Observed in small subset of studies
Blood Pressure	Improved in multicomponent interventions
Lipid Profile (HDL, Triglycerides)	Improvement particularly in low-carb diets

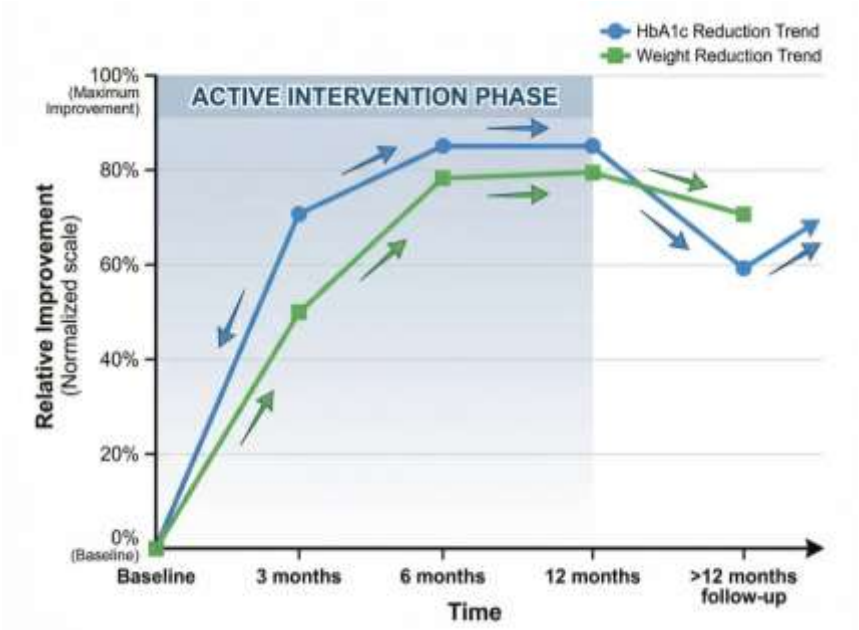

Fig 4. Durability of Glycemic and Weight Outcomes Over Time.

Summary of Quantitative Patterns

Lifestyle interventions demonstrated long-term results of glycemic control, body weight, and selected cardiometabolic outcomes in comparison with control conditions in all 42 randomized controlled studies. The magnitude of effect was influenced by intensity of interventions, theoretical framework and dietary composition and modality of delivery. Technological interventions equated to traditional face to face way of decreasing weight and a slight alteration in the HbA1C. The most clinically significant and largest changes were those associated with dietary change particularly when used together with structured exercise and behavior counseling. Despite these positive outcomes, these large heterogeneity rates and inconsistency of methods suggest that the sole way of measuring the enduring clinical impact is to apply standardized intervention guidelines and follow-up.

4. DISCUSSION

It is a meta-analysis of literature that recapped and outlined the existing evidence regarding randomized controlled trials about the application of lifestyle interventions to handle type 2 diabetes and what the potential and the ongoing limitations that characterize the field. The findings indicate that lifestyle interventions are never exhibited without positive glycemic control in different populations and interventions packages, the effect size of which are small to moderate to large in relation to the intensity, duration, and behavioral goals of the intervention. However the synthesis also illuminates much of the heterogeneity of treatment effects, lack of clarity about the most effective components of interventions and ways of delivery and a variety of methodological limitations that inhibit the trustworthiness of effect estimates and restrict the extrapolation of research results into clinical practice.

These results should be put in the context of how the lifestyle interventions influence the glycemic control in type 2 diabetes. Improved glycemic outcomes might be achieved by a wide variety of mechanisms including the effects of weight reduction and lowered insulin resistance, direct actions of exercise on postprandial glucose uptake and insulin sensitivity, changes in diet that alter postprandial glycemic variations, and behavioral modification that facilitates medication and self-monitoring. These mechanisms would tend to have a relative contribution to interventions and populations which adds to some of the heterogeneity in treatment effects. As far as the effects of physical activities on the glycated hemoglobin are related to the improvement, it is possible to consider that weight loss and dietary modification might have a stronger impact on the glycemic improvements than physical activity alone, even though physical activity has considerable cardiovascular effects that do not depend on the effects on glycemic ones.

By comparing the previous large scale reviews, we find the continuity and development of evidence base. Past systematic reviews establish the efficiency of lifestyle interventions in diabetes prevention and control, flag trials have demonstrated the reducing incidence of diabetes and enhancing cardiovascular risk factors. These findings are extended to new evidence researching on new modalities of intervention particularly technology-based interventions that have evolved over the past five years in the current review. The finding that digital interventions are just as effective or more effective than face-to-face programs at twelve months is also a tremendous development that can be implemented in interventions, scaling, and accessibility. The outcome is consistent with more broad-based mover motions towards digital integration of health in chronic disease management and suggests that technology-based approaches have the potential to mitigate certain obstacles to the implementation of lifestyle interventions, including geographic access, flexibility of timing, and cost.

However, the majority of the studies are short-term, yet this leaves much to be desired in the regard of the long-term characteristics of the treatment effects. The trials that were

incorporated most of the results at at least twelve months or were few giving results after twelve months. The influence of weight loss and glycemic level is mostly the most active in active intervention and further deterioration, which means that lifestyle interventions may require consistent encouragement to maintain initial benefits. The best manner of how maintenance interventions like the frequency of maintenance, intensity and modality of delivery should be arranged has not been elucidated exhaustively and it is a worthy subject of research in future.

The theoretical implications of these findings extend beyond the management of chronic diseases with regards to knowledge of the behavior change processes. The given efficiency of interventions that are grounded on the theoretical notions, in particular, the Transtheoretical Model, demonstrates the fact that the effectiveness of behavioral interventions can be the most efficient in case they are developed with the distinct consideration of the psychological processes that will be involved in changing behavior. However, the great heterogeneity of effects and the extremely low confidence of the level of evidence indicate the gap between the theory and the empirical validation. More research is required to differentiate pure testing of the theory based interventions with adequate sample, follow-up as well as intensive measures of the theorized mediating mechanisms to advance the information on how and why of lifestyle interventions.

The synthesis has practical implications, both with regard to the clinician and health care systems. First of all, the change in lifestyle should be considered as effective components of the general diabetes treatment, and its capacity to improve glycemic regulation and reduce the number of medication requirements may be justified by the literature in the regards to their application in the correctly selected patients. Second, the intervention modalities should be guided by the choice of the patient, resources available, and by the practical factors, including access to geographical regions and the potential to fit in the schedule as digital modalities will emerge as the possible alternative to conventional face-to-face programs. Third, the level and length of intervention should be sufficient to produce a clinically significant behavior change, and it should be known that short-term interventions may result into initial improvement that will be lost over time unless supported over time. Fourth, changes in diet that targets weight loss, but does not especially focus on the ratio of the macronutrients, appear central to glycemic control, and low-carbohydrate diets can be beneficial in the short-run, which must be compensated by the issue of sustainability.

The gaps in research that exist are distant and vast indeed. The most effective part of this study that should be researched using long follow-up is the duration and intensity of lifestyle interventions in order to ensure glycemic control. The relative efficacy of different feeding habits like low-carbohydrate, Mediterranean, vegetarian, and energy-restricted should be compared to each other in a head to head fashion using huge

sample size and paying particular attention to compliance and acceptability. The integration of lifestyle strategies to refer to the pharmacological treatment with interventions to deprescribe drugs in the situation where the glycemic control is more favorable has been understudied, though it is a clinical issue. The opportunity of innovation will be presented due to the application of new technologies to the process of personalization of interventions and real-time monitoring of the glucose level based on continuous monitoring, which should be evaluated carefully. Finally, to apply the research results to population health outcome, implementation research exploring the mechanisms of introducing effective lifestyle interventions into routine clinical practice using various healthcare systems is required.

5. LIMITATIONS OF THIS REVIEW

This systematic review has several weaknesses that are worth being mentioned. Such a selection in only randomized controlled trials and at the same time to offer the best evidence to obtain a causal response disqualified the possibly informative outcomes of well-established observational researches and quasi-experimental designs. This restriction to English language publications may have created bias against the language that may have omitted the possibly available studies on other languages. The high amount of heterogeneity of the included studies prevented the majority of the results to be quantified by means of meta-analysis and, therefore, limited the extent to which the effect estimates could be valid. The glycemic outcomes are clinically relevant only to provide an incomplete picture on the effects of the intervention on the patient-important outcomes, including quality of life, diabetes distress, and complications. Finally, the rate of the evolution of the concept of lifestyle intervention research, in particular, the technologies-mediated ones, is that the results should be constantly updated as the new evidence is being generated.

6. CONCLUSION

The presented systematic review summarizes the available evidence on the topic that is grounded on the randomized controlled trials associated with the lifestyle interventions aimed at the management of the type 2 diabetes, and one can claim that the latter are the efficient means of improving the glycemic management in a broad range of populations and interventions models. The findings contribute to several key conclusions that can be made in research, clinical practice, and policy with regards to health. Firstly, the lifestyle interventions that incorporate changes in diet, exercise, and behavior change habitually produce glucated hemoglobin and other metabolic outcome improvements, and the extent of the effects is comparable to some glucose-lowering medications. Second, the technological-mediated interventions through telemedicine services, mobile applications, and digital tools yield the same effect, similarly to traditional face-to-face programs, which also offers scalable alternatives, which may address the access and engagement barriers. Third, dietary change particularly in combination with behavioral change support strategies appears to assume the leading position in terms of glycemic

effects and that low-carbohydrate diet has certain opportunities regarding short-term effects which are to be confirmed in long-term studies. Fourth, the theoretical-driven interventions that satisfy the readiness to behavioral change show the possibility of enhancing the consequences of the treatment despite the methodological problems that harm the level of confidence to the predictions of the effects and the requirement of the rigorous studies in the future. Fifth, research findings related to translation into clinical practice are yet to be fully developed and even where the clinical practice has evidence on the effectiveness of them, lifestyle interventions have not been implemented in the primary care facilities yet.

The overall implications of these findings include the conceptualization and management of type 2 diabetes in health care systems. Such that lifestyle interventions could produce clinically important changes and even remission not only challenges the notion of therapeutic nihilism that the course of the disease is unavoidable but it also propagates a paradigm shift in favor of the proactive and behaviorally-based approaches to the management of the disease. To achieve this potential will require long-term investment in interventions development, rigorously evaluating, and implementing science to identify how effective interventions can be introduced into standard care. The systems of infrastructure, training and reimbursements, needed to make lifestyle interventions occur, should be implemented by the healthcare systems due to the fact that it might lead to returns in the form of a reduced rate of medication, a decrease in rate of complications and improved quality of life of the increasing population of individuals with type 2 diabetes.

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