LUMEN ET VIRTUS
ISSN: 2177-2789

ANALYSIS OF THE CLINICAL MANAGEMENT OF TYPE 2 DIABETES MELLITUS – AN INTEGRATIVE REVIEW

https://doi.org/10.56238/levv15n41-069

Submitted on: 09/20/2024 **Publication date:** 10/20/2024

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ABSTRACT

Introduction: Type 2 Diabetes Mellitus (DM2) is a chronic non-communicable disease, responsible for 90% of diabetes cases. Its etiopathogenesis involves insulin resistance and relative deficiency in the secretion of this hormone, being associated with factors such as sedentary lifestyle, poor diet and obesity. DM2 is a serious public health problem, with its increasing prevalence due to population aging and urbanization. This study focuses on the correct clinical management of DM2, which is essential for the prevention, control and reduction of complications associated with the disease. Methodology: The research used a systematic literature review, with searches carried out in the PubMed and Scielo databases, including studies published between 2020 and 2024. A total of 180 articles were identified, of which 30 were selected based on their significant contribution to the clinical management of DM2. The selection was guided by a guiding question (not specified in the text). Results and Discussion: The clinical management of T2DM involves several approaches, from pharmacological therapies to behavioral interventions and the use of new technologies. Glycemic control in a hospital environment, especially with the use of insulin, is essential, but there is a lack of clear consensus on the most effective protocols. The practice of physical exercise, such as high-intensity interval training (HIIT), has been shown to be effective in reducing glucose levels and improving metabolic parameters. Technological innovations, such as connected insulin pens, also have benefits, despite implementation

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challenges. In addition, medications such as SGLT2 inhibitors and statins have demonstrated a positive impact on glycemic control and the reduction of cardiovascular complications. Conclusion: The study highlights the importance of combined strategies for the management of T2DM, including insulin therapies, regular physical exercise, and technological innovations. Despite the advances, the variability in clinical protocols and the methodological limitations in studies make it difficult to generalize the results. Future research should focus on standardizing interventions and incorporating new technologies to improve the clinical management of T2DM.

Keywords: Type 2 Diabetes Mellitus, Pharmacological Treatment, Physical Exercise.

INTRODUCTION

According to the Brazilian Diabetes Society (Sbd, 2023), classification based on the etiopathogenesis of diabetes is recommended, which includes type 1 diabetes (DM1), type 2 diabetes (DM2), gestational diabetes (GDM), and other types of diabetes. The object of study of this project is type 2 Diabetes Mellitus, being considered a Chronic Non-Communicable Disease (NCD), resulting from individuals with relative insulin deficiency and resistance to insulin action. The main causes of this type of DM are related to inadequate eating habits, overweight, sedentary lifestyle, high triglycerides and hypertension (Bertonhi; Dias, 2018).

The most frequent type of diabetes is type 2 diabetes, which comprises about 90% of all cases, followed by type 1 diabetes, about 10% of cases. In addition to these types, gestational diabetes also deserves to be highlighted, due to its impact on the health of the pregnant woman and the fetus, and is usually detected in prenatal screening (Brasil, 2019). DM2 is based on the characteristic symptoms presented by the patient and the detection of changes in three parameters, namely: fasting glucose, HbA1c, and lipid profile (Ada, 2019).

Type 2 Diabetes Mellitus is a challenging medical condition that represents a major public health problem worldwide. Its prevalence has increased alarmingly in recent decades, due to the aging of the population, urbanization, inadequate diet, and sedentary lifestyle (Moreira et al., 2019). DM2 is a disease that is difficult to understand, which involves complex interactions between genetic and environmental factors. In addition, its pathogenesis is due to resistance to insulin action, so that β cells are unable to maintain the insulin secretion capable of overcoming resistance, leading to a state of hyperglycemia.

Thus, with the decrease in the action of insulin on glucose, there is an increase in the secretion of counterregulatory hormones, especially glucagon. Thus, catabolism ends up occurring, so that there is a lower uptake of glucose in skeletal muscle, adipose tissue increases lipolysis, and there is an increase in hepatic glucose production, which explains chronic hyperglycemia (Galicia-Garcia et al., 2020, Valaiypathi; Gower; Ashraf, 2020).

Based on this explanation, this study raises the following research problem: how can correct clinical management contribute to the prevention, control, and monitoring of DM2, preventing its complications and favoring the reduction of the impacts of the disease on health systems? Thus, the theme of the research is extremely relevant, because in the context of public health policies there is a concern with the continued growth in the prevalence of type 2 diabetes. Given that they overload health services and burden public management with greater use of health resources such as: greater number of consultations,

exams, medications, technological solutions, treatments for acute and late complications of diabetes, as well as measures to solve this problem (Raposo, 2018).

Based on the increasing prevalence of type 2 diabetes mellitus (DM2) and its significant implications for public health, this research aims to demonstrate the importance of correct clinical management of DM2. Proper management of T2DM not only helps to identify and diagnose the disease early, but is also critical to guide effective and preventive therapeutic interventions (Marques, 2018). Therefore, the correct clinical management of diabetes can contribute to reducing the incidence and prevalence of cases and impacts of this disease, being extremely important for the effective and preventive treatment of its complications (Medeiros et al., 2018).

METHODOLOGY

The literature review was conducted following a structured methodological protocol to ensure the comprehensiveness and relevance of the information obtained. The search for scientific articles was carried out in the PubMed and Scielo databases, covering the period from 2020 to 2024. The descriptors "Diabetes Mellitus, Type 2" and "Clinical Protocols" were used in the research, according to the "MeSH Terms".

In order to ensure updating and unrestricted access to the results, only articles published in the last four years, available for free and in full format, were considered. There were no restrictions on language or text type. The exclusion of paid articles and those published before 2020 aimed to maintain the temporal relevance of the review. Initially, 180 articles (176 in PubMed and 4 in Scielo) were identified as potentially relevant to the theme.

The final selection, consisting of 30 articles, was determined based on the significant contribution of these studies to the clinical management of DM2, for which the following guiding question was used for the selection of the cited articles: (ask a guiding question).

RESULTS

As described in the methodology, the main aspects of the selected articles are presented in Table 1. The table summarizes essential information from the included studies, taken from the PubMed and Scielo databases, on the clinical management of type 2 diabetes mellitus. Data regarding authorship, year of publication, journal, database and DOI were organized, as well as the title of the articles. In addition, the central objective of each study and the methods used are presented, providing a clear and objective view of the approaches employed in each research.

Table 1. Articles included in the PubMed and Scielo databases related to the clinical management of Type 2 Diabetes Mellitus.

AUTHORSHIP/YEAR	JOURNAL/DATABASE/DOI	TITLE	GOAL	METHOD
Pasquel et al., 2021	Lancet Diabetes & Endocrinology/ PUBMED/ DOI: 10.1016/S2213-8587(20)30381-8	Management of diabetes and hyperglycaemia in the hospital	To review strategies for the management of hyperglycemia in hospitalized patients, focusing on the use of intravenous insulin in intensive care units and other approaches in wards, in addition to discussing the impact of new technologies on hospital glycemic control and the adaptations made during the COVID-19 pandemic.	Analysis of clinical guidelines, meta-analyses, and clinical trials on hospital glycemic management, with emphasis on the use of intravenous insulin, combination therapies, and technologies such as continuous glucose monitoring and automated insulin administration.
Pinto et al., 2023	Frontiers in Endocrinology / PubMed / DOI: 10.3389/fendo.2023.1233906	Physical exercise as treatment for adults with type 2 diabetes: a rapid review	To analyze the relationship between physical exercise variables (frequency, intensity, type, duration, volume and progression) and glycemic control in adults with type 2 diabetes.	Rapid systematic review of the literature in PubMed and LILACS, including randomized and non-randomized clinical trials, evaluating the impact of exercise parameters on glycemic control (HbA1c).
Alotaibi et al., 2023	BMJ Open Quality / PubMed / DOI: 10.1136/bmjoq-2022-002037	Improving type 2 diabetes mellitus management in Ministry of Defense Hospitals in the Kingdom of Saudi Arabia 2018-2021	To improve glycemic control of patients with type 2 diabetes in Saudi Arabian military hospitals using clinical guidelines and multidisciplinar	Collaborative project in 18 military hospitals from 2018 to 2021, with implementation of evidence-based guidelines, diabetes

			y teams.	registry, and standardized care planning by multidisciplinary teams.
Gentil et al., 2023.	Frontiers in Endocrinology / PubMed / DOI: 10.3389/fendo.2023.985404	The effects of three different low-volume aerobic training protocols on cardiometabolic parameters of type 2 diabetes patients: A randomized clinical trial	To compare the effects of different aerobic training protocols on cardiometabolic variables in patients with type 2 diabetes.	Parallel clinical trials with 52 patients, divided into three groups: MICT, S-HIIT and L-HIIT, evaluating HbA1c, cholesterol, triglycerides, blood pressure and aerobic capacity before and after 8 weeks of training.
Mustapa et al., 2021	Annals of Rehabilitation Medicine/PubMed/DOI: 10.5535/arm.21102	Home-Based Physical Activity in Patients With Type 2 Diabetes Mellitus: A Scoping Review	Describe characteristics and challenges of home physical activity protocols for patients with type 2 diabetes, and identify limitations in their implementation.	Scoping review identifying relevant studies in six databases, with 10 articles selected for data extraction on home exercise protocols and their limitations.

Batalha et al. 2021	Journal of Diabetes & Metabolic Disorders/PubMed/DOI: 10.1007/s40200-021-00846-8	Behavior change interventions in patients with type 2 diabetes: a systematic review of the effects on self-management and A1c	To identify characteristics of behavior change interventions in type 2 diabetes and their impact on disease self-management and glycated hemoglobin (A1c).	This was a systematic review following PRISMA guidelines, with an analysis of 27 randomized studies on behavioral interventions compared to controls, evaluating self-management and A1c. The quality of the studies was assessed by specific tools.
Pourhabibi et al., 2022	Journal of Diabetes Research / PubMed / DOI: 10.1155/2022/2980250	Determinants of Poor Treatment Adherence among Patients with Type 2 Diabetes and Limited Health Literacy: A Scoping Review	To identify the determinants of low adherence to treatment in patients with type 2 diabetes and low health literacy.	Scoping review conducted in five stages, analyzing 18 studies of 3925 patients from 8 countries, identifying barriers such as economic problems and lack of family support.

Roth et al. 2023	Journal of General Internal Medicine/PubMed/DOI: 10.1007/s11606-022-07920-8	Evaluation of an Integrated Intervention to Address Clinical Care and Social Needs Among Patients with Type 2 Diabetes	To assess the impact of the DCII (Collective Impact Initiative for Diabetes), a multifaceted intervention that combines clinical and social determinants of health (SDoH) strategies, on access to medical and social services for patients with type 2 diabetes.	Cohort study with a difference-in-difference adjusted model to compare treatment and control groups. DCII includes clinical approaches such as standardized protocols and self-management education, and SDoH strategies such as social screening and community support. Participation in diabetes education, SDoH screening, and use of virtual and in-person primary care were evaluated.
Mokgalaboni et al. 2022	Medicine (Baltimore) / PubMed / DOI: 10.1097/MD.0000000000032313	Pharmacological effects of statins in adult patients with type 2 diabetes mellitus: A protocol for systematic review and meta-analysis	To assess whether statin use improves endothelial function in adults with type 2 diabetes and whether these biomarkers are optimal therapeutic targets for atherosclerosis and cardiovascular disease.	Systematic review and meta-analysis following the PRISMA-P 2015 guidelines, using MEDLINE, Scopus and Web of Science. Clinical studies on the effect of statins on endothelial function will be included. Assessment of quality and risk of bias with Cochrane and GRADE guidelines.
Medina-Chávez et al., 2022	Revista Médica del Instituto Mexicano del Seguro Social / PubMed / DOI: 10.5477/cis/revmed/60.supl.1.s4	[Integral Care Protocol: Prevention, diagnosis and treatment of type 2 diabetes mellitus]	Establish actions to standardize multidisciplinary team activities, promote healthy lifestyles, perform early diagnoses, offer intensified care and appropriate treatment, prevent complications, and provide comprehensive quality care.	Development of Integrated Care Protocols by prioritizing the health problem, formation of an interdisciplinary group, systematic search for information, analysis and review of interventions, validation by regulatory areas and implementation.
Juray et al., 2021	Nutrients/PubMed/DOI: 10.3390/nu13062086	Remission of Type 2 Diabetes with Very Low-Calorie Diets-A Narrative Review	To assess the effectiveness of very low-calorie diets (VLCD) for remission of type 2 diabetes by comparing with other hypocaloric approaches and identifying who would benefit from these diets.	Narrative review of VLCD studies focused on remission of type 2 diabetes, discussing the efficacy and heterogeneity of remission protocols and definitions.
Chang et al., 2023	PLoS One/PubMed/DOI: 10.1371/journal.pone.0282143	Safety and efficacy of anti-hyperglycemic agents in patients with type 2 diabetes mellitus (T2DM): Protocol	To perform an overview of systematic reviews on the safety and efficacy of antihyperglycemic agents for patients	Review of meta-analyses using Embase, PubMed, Web of Science and Cochrane; evaluation of methodological quality with AMSTAR-2 and evidence with GRADE.

		for an overview of systematic reviews based on network meta-analysis	with T2DM, using network meta-analysis.	
Nielsen et al., 2024	JMIR Res Protoc / PubMed / DOI: 10.2196/56067	Effects of Empagliflozin in Type 2 Diabetes With and Without Chronic Kidney Disease and Nondiabetic Chronic Kidney Disease: Protocol for 3 Crossover Randomized Controlled Trials (SiRENA Project)	To examine the effects of empagliflozin versus placebo on renal hemodynamics, sodium balance, vascular function, and markers of the innate immune system in patients with T2DM, T2DM, and CKD, and non-diabetic CKD.	Three double-blind, randomized, crossover clinical trials with patients with T2DM and preserved renal function, T2DM and CKD, and non-diabetic CKD. Each participant received 4 weeks of treatment with empagliflozin or placebo, followed by a wash-out period and crossover to the opposite treatment.
Gupta et al., 2021	BMJ Open / PubMed / DOI: 10.1136/bmjopen-2020-046825	Development and evaluation of self-care intervention to improve self-care practices among people living with type 2 diabetes mellitus: a mixed-methods study protocol	Develop and implement a self-care intervention package based on a theory and behavioral change model to improve self-care practices in people with T2DM.	Mixed sequential exploratory study; qualitative methods identify barriers and facilitators to self-care, and quasi-experimental method with control evaluates the package in 220 participants. Difference-in-difference analysis will be used to measure changes in self-care.
Michael et al., 2023	Nigerian Medical Journal / PubMed / DOI: 10.4103/npmj.npmj_22_23	Influence of prior internist encounter on glycaemic control among patients with type 2 diabetes mellitus at a family practice setting in Nigeria	To examine predictors of glycemic control among patients with T2DM and the influence of previous consultations with internists on glycemic control.	This was a cross-sectional study with 276 patients with DM2, collecting data on sociodemographic and clinical characteristics, and previous visits to internists. Descriptive and inferential statistical analysis was performed.

Yang et al., 2023	BMJ Open/PubMed /DOI: 10.1136/bmjopen-2022-063161	Effectiveness of continuous subcutaneous insulin infusion versus multiple daily injections on glycaemic control among older adults with type 2 diabetes: protocol for systematic review and meta-analysis	To determine whether continuous subcutaneous insulin infusion (CSII) is associated with better glycemic control compared to multiple daily insulin injections (MDI) in older adults with T2DM.	Systematic review and meta-analysis of randomized controlled trials, with search in several databases and analysis of data using RevMan V.5.3. Sub-analysis, sensitivity analysis, and publication bias assessment will be performed.
Steyl, 2020	S Afr J Physiother/PubMed/DOI: 10.4102/sajp.v76i1.1321	Satisfaction with quality of healthcare at primary healthcare settings: Perspectives of patients with type 2 diabetes mellitus	To assess the satisfaction of patients with type 2 diabetes with health services in primary health centres in the Cape metropolitan district, South Africa.	Cross-sectional study with proportional stratified random sampling. The Patient Survey for Quality of Care scale was used for quantitative analysis and qualitative analysis for open questions.
Weng et al., 2023	BMJ Open / PubMed / DOI: 10.1136/bmjopen-2023-072960	Effects of pharmacist-led interventions on glycaemic control, adherence, disease management and health-related quality of life in patients with type 2 diabetes: a protocol for a network meta-analysis	To compare the effects of pharmacist-led interventions on glycemic control, adherence, disease management, and health-related quality of life in patients with type 2 diabetes.	Meta network analysis with data collected from PubMed, Embase, and other databases. Measures of glycemic control and general indicators will be analyzed using Bayesian hierarchical models.
Yerramalla et al., 2020	Diabetologia / PubMed / DOI: 10.1007/s00125-019-05050-1	Association of moderate and vigorous physical activity with incidence of type 2 diabetes and subsequent mortality: 27 year follow-up of the Whitehall II study	To examine the association of moderate and vigorous physical activity with the incidence of type 2 diabetes and subsequent mortality.	Longitudinal study with 9987 participants from the Whitehall II cohort, analyzing physical activity and its associations with diabetes and mortality using risk models and Cox analysis.
Van Bruggen et al., 2020	BMJ Open/PubMed /DOI: 10.1136/bmjopen-2019-033085	Association between GP participation in a primary care group and monitoring of biomedical and lifestyle target indicators in	Assessing physician participation in primary care groups improves monitoring of biomedical and lifestyle indicators in patients with type 2 diabetes.	Observational cohort study in primary care practices, comparing new and experienced practices, analyzing the annual monitoring of biomedical and lifestyle indicators.

		people with type 2 diabetes: a cohort study (ELZHA cohort-1)		

Buse et al., 2021	Diabetes Obesity and Metabolism / PubMed / DOI: 10.1111/dom.14381	Prototype of an evidence-based tool to aid individualized treatment for type 2 diabetes	To develop an interactive tool to predict individualized treatment outcomes for type 2 diabetes, using data from randomized controlled trials.	Prototype based on data from randomized controlled trials, using predefined statistical models to generate individualized predictions of changes in HbA1c and body weight after initiation of antidiabetic medications.
Ke et al., 2020	PLoS Medicine/PubMed/DOI: 10.1371/journal.pmed.1003316	Age at diagnosis, glycemic trajectories, and responses to oral glucose-lowering drugs in type 2 diabetes in Hong Kong: A population-based observational study	To study how age at diagnosis of type 2 diabetes affects exposure and glycemic deterioration and responses to oral medications.	Observational study with linear mixed-effects models, analyzing population-based cohort data of patients with young-onset and habitual type 2 diabetes.
Chen et al., 2024	PLoS One/PubMed/DOI: 10.1371/journal.pone.0306336	The effects of major dietary patterns on patients with type 2 diabetes: Protocol for a systematic review and network meta-analysis	To evaluate the efficacy of key dietary patterns on glycemic control, lipid profiles, and weight management in patients with type 2 diabetes through a systematic review and network meta-analysis.	Systematic review and meta-analysis of network following PRISMA-P and NMA guidelines. Comprehensive search of PubMed, EMBASE, and Cochrane Library, with paired comparisons and Bayesian analysis (SUCRA).
Zaki et al., 2024	J Clin Med / PubMed / DOI: 10.3390/jcm13133910	Impact of Concurrent Exercise Training on Cardiac Autonomic Modulation, Metabolic Profile, Body Composition, Cardiorespiratory Fitness, and Quality of Life in Type 2 Diabetes with Cardiac Autonomic Neuropathy: A Randomized Controlled Trial	To investigate the impact of a structured combined exercise training program (aerobic and resistance) on cardiac autonomic modulation, metabolic profile, body composition, cardiorespiratory fitness, and quality of life in individuals with type 2 diabetes and cardiac autonomic neuropathy.	Randomized clinical trial with 96 participants, divided into combined training and control groups. The training group performed exercises three times a week for 13 weeks. Assessments included heart rate variability, metabolic profile, body composition, and quality of life.
Sommer et al., 2020	BMJ Open / PubMed / DOI: 10.1136/bmjop	Preferences of people with type 2 diabetes for	To examine the preferences of people with type 2 diabetes	Development and evaluation of a discrete choice experiment (DCE) to assess patient

	en-2020-036995	telemedical lifestyle programmes in Germany: protocol of a discrete choice experiment	for telemedical lifestyle programs and to analyze how these preferences can predict program success and changes during the intervention.	preferences regarding telemedical programs, followed by a randomized controlled trial with 850 participants to investigate the sustained improvement of HbA1c values.
MacLeod & Vigersky, 2023	J Diabetes Sci Technol/PubMed/DOI: 10.1177/19322968221134546	A Review of Precision Insulin Management With Smart Insulin Pens: Opening Up the Digital Door to People on Insulin Injection Therapy	Discuss the use of connected and smart insulin pens to improve glycemic management and minimize hypoglycemia in patients on multiple daily injection therapy.	Review of the features and benefits of connected insulin pens, such as automatic dose recording, active insulin tracking, dose calculators, and built-in alerts.
Jia et al, 2021	BMJ Open/PubMed/DOI: 10.1136/bmjopen-2020-048259	Network meta-analysis of four kinds of traditional Chinese exercise therapy in the treatment of type 2 diabetes: protocol for a systematic review	To integrate clinical evidence on four traditional Chinese therapies for the treatment of type 2 diabetes through a network meta-analysis.	Systematic review with network meta-analysis of randomized controlled trials, including Tai Chi, Ba Duan Jin, Yi Jin Jing, and Wu Qin Xi. Statistical analysis using R and ADDIS.
McElfish et al, 2021	Sleep Health / PubMed / DOI: 10.1016/j.sleh.2021.01.007	Relationship between sleep duration and quality and glycated hemoglobin, body mass index, and self-reported health in Marshallese adults	To document sleep duration and quality in Marshallese adults and investigate its associations with type 2 diabetes, body mass index (BMI), and self-reported health.	Cross-sectional analysis using team-administered questionnaires, with clinical measures collected and analysis of associations with HbA1c, BMI, and self-reported health.
Tian et al, 2024	Front Endocrinol (Lausanne) / DOI: 10.3389/fendo.2024.1341531	Practical Effects of Personalized Interventions with Interdisciplinary Teamwork on Type 2 Diabetes Remission: A Retrospective Study	To analyze the clinical outcomes of personalized interventions for type 2 diabetes (T2D) with the support of an interdisciplinary team.	This was a retrospective study with 40 patients with T2DM, evaluated at baseline, after 3 months, and at the end of 6 months. Measurements included fasting blood glucose (FPG), 2-hour postprandial blood glucose (2hPG), fasting insulin level (FINS), glycated hemoglobin (HbA1c), blood lipids, and body mass index (BMI).
Andrade et al, 2021	Cien Saude Colet / DOI: 10.1590/1413-81232021266.06592019	Long-acting insulin in the public health system: analysis of adherence to the clinical	To assess compliance with clinical protocol criteria in the dispensation of long-acting insulin in	This was a retrospective study with 315 insulin users from public pharmacies, analyzing compliance with protocol criteria and blood glucose and HbA1c levels.

		protocol in public pharmacies	public pharmacies.	
Oliveira LM et al., 2020	Physis: Revista de Saúde Coletiva / Scielo / DOI:10.1590/S0103-73312020300327	Integrated care of type 2 diabetic periodontal patients in Primary Care: a scoping review	To investigate validated protocols for the care of the periodontal patient with type 2 diabetes and turn them into recommendations for primary care.	Scoping review of the literature published between 2012 and 2019 in the PubMed, Scielo, LILACS, Web of Science, and Scopus databases, in English, Spanish, and Portuguese.

Becker TA et al., 2017	Revista Médica de Chile / Scielo / DOI:10.1590/0034-7167-2017-0089	Effects of telephone support on metabolic control in elderly patients with diabetes mellitus	To evaluate the effectiveness of telephone support in the metabolic control of elderly patients with diabetes mellitus.	Pragmatic study with 63 participants divided into two groups; G1 received educational telephone support for four months and G2 received postal mail. Evaluation of the variables fasting glucose, systolic and diastolic blood pressure.

Source: Prepared by the authors of the present study.

DISCUSSION

The clinical management of type 2 Diabetes Mellitus (T2DM) in hospital and outpatient settings is widely discussed in the literature, with a focus on optimizing glycemic control and reducing complications associated with hyperglycemia (ALOTAIBI et al., 2023; MCELFISH et al., 2021). Different approaches, from pharmacological and behavioral interventions to technological innovations, have been shown to be effective in improving glycemic control and, consequently, the quality of life of patients (MUSTAPA et al., 2021; TIAN et al., 2024).

HOSPITAL GLYCEMIC CONTROL AND INSULIN THERAPIES

Hospital glycemic control is a central concern in the management of diabetic and non-diabetic patients who present with hyperglycemia during hospitalization. Studies such as that of Pasquel et al. (2021) emphasize that in-hospital hyperglycemia is associated with a substantial increase in morbidity, mortality, and medical care costs. Insulin therapy is recommended as the mainstay of pharmacological treatment, with intravenous insulin being the choice in the intensive care setting, while in non-intensive settings there are a variety of protocols proposed for the management of hyperglycemia (POURHABIBI et al., 2022). However, meta-analyses have not identified clear benefits in a specific strategy, reflecting the lack of consensus on which insulin treatment regimen is most effective in non-intensive hospital settings (PASQUEL et al., 2021).

In the context of hospitalized T2DM patients, the practice of discontinuing oral antidiabetic medications, as directed by clinical guidelines, stands out. However, in some regions, as highlighted by Pasquel et al. (2021), the continuation of these medications is common and has been investigated as a viable alternative in combination with basal insulin to achieve appropriate glycemic control in certain populations. This approach requires further clinical studies to evaluate its safety and efficacy compared to traditional therapies (ROTH et al., 2023; OLIVEIRA et al., 2020).

Another relevant point in hospital glycemic management is the impact of emerging technologies on the treatment of diabetes. According to MacLeod and Vigersky (2023), connected insulin pens, such as smart pens (SIPs), are technological innovations that can improve glycemic control in people who use multiple daily insulin injections. These technologies enable automated dose recording, alerts for missed doses, and data integration with clinical teams, facilitating timely adjustments to the insulin regimen (MEDINA-CHÁVEZ et al., 2022; BECKER et al., 2017). Although technological advances offer promise, their widespread implementation in the hospital environment still faces challenges, such as the need for practical protocols and collaborative monitoring between patients and health professionals (MACLEOD; VIGERSKY, 2023).

In terms of comparisons between different methods of insulin administration, Yang et al. (2023) highlight that, in older adults with T2DM, continuous subcutaneous insulin infusion (CSII) may offer advantages over multiple daily injections (MDI). Randomized studies indicate that the use of CSII is associated with superior glycemic control compared to MDI. The search for a more efficient therapy for this population is essential, since hospitalized older adults generally have greater management challenges due to comorbidity and susceptibility to complications resulting from hyperglycemia (YANG et al., 2023).

The study by Andrade et al. (2021) points to the inadequacy of compliance with clinical protocols in public pharmacies in Brazil, which compromises the rational dispensation of long-acting insulin analogues. The lack of rigor in complying with the inclusion and exclusion criteria for dispensing can generate waste and hinder the glycemic control of patients, especially in hospital environments that depend on an adequate and judicious supply of insulin to ensure the well-being of the user and the sustainability of the public health system (ANDRADE et al., 2021).

PHYSICAL EXERCISE AND GLYCEMIC CONTROL

Regular physical exercise has been shown to be an effective strategy for glycemic control in individuals with T2DM, as demonstrated by several studies, including Pinto et al.

(2023), Gentil et al. (2023), Zaki et al. (2024), and Yerramalla et al. (2020). These studies corroborate the importance of physical exercise as a non-pharmacological intervention in the management of DM2, highlighting the positive impact of different training modalities on glycated hemoglobin (HbA1c), fasting glucose, and lipid profile, as well as on the prevention of complications associated with diabetes.

The study by Pinto et al. (2023) showed that variability in physical exercise protocols can influence the degree of improvement in glycemic control, suggesting that the frequency, intensity, type, duration, volume, and progression of exercise are determining factors. The study points out that both aerobic and resistance training, in addition to combined training, contribute to the reduction of HbA1c levels and fasting glucose, essential indicators in the monitoring of DM2. However, the heterogeneity of the protocols used makes it difficult to generalize the results, making it necessary to standardize physical exercise programs aimed at glycemic control in individuals with DM2 (JURAY et al., 2021).

In line with these findings, Gentil et al. (2023) compared different aerobic training protocols and demonstrated that high-intensity interval training (HIIT) was more effective in improving cardiorespiratory capacity (VO2max) and reducing triglyceride and HbA1c levels, especially the long-interval HIIT (L-HIIT) protocol. This study highlights the superiority of HIIT compared to continuous moderate-intensity training (MICT) in terms of improving glycemic control and other cardiometabolic parameters. However, the results indicate that all the protocols investigated were beneficial for at least one variable analyzed, reinforcing the relevance of including regular physical exercise as part of the clinical management of patients with DM2.

Zaki et al. (2024) also reinforce the importance of combined training (CET) for glycemic control and improvement of cardiac autonomic modulation in individuals with T2DM and cardiac autonomic neuropathy (ANC). The study demonstrated that CET, when combining aerobic and resistance exercises, provided significant improvements in heart rate variability (HRV), in addition to significant reductions in HbA1c levels, fasting glucose, waist circumference, and body fat percentage. These improvements were accompanied by an elevation in the quality of life (QoL) of the participants, suggesting that CET may be an effective approach to prevent cardiovascular complications in individuals with T2DM (CHANG et al., 2023).

Finally, Yerramalla et al. (2020) emphasize the role of physical exercise in preventing the incidence of T2DM and reducing mortality in individuals already diagnosed with the disease. The study revealed that the practice of moderate to vigorous physical activity is associated with a lower incidence of T2DM over almost three decades of follow-up, in

addition to being a protective factor against all-cause mortality and cardiovascular mortality among individuals with T2DM. Physical exercise, even at durations below international recommendations, has been shown to be beneficial, with additional protective effects observed in longer durations of physical activity.

BEHAVIORAL INTERVENTIONS AND SELF-CARE

Behavioral interventions for the management of T2DM have shown variations in their effectiveness, especially in relation to self-care and glycemic control (MICHAEL et al., 2023). In the study by Batalha et al. (2021), interventions based on educational sessions focused on diabetes management showed improvements in some aspects of self-care and in the reduction of glycated hemoglobin (A1c). However, the high heterogeneity of the protocols used, such as the variation in the duration, frequency, and mode of delivery of interventions, prevented a comprehensive meta-analysis from being conducted, revealing limited evidence on the overall effectiveness of behavior change interventions (STEYL, 2020).

On the other hand, Gupta et al. (2021) developed a self-care package based on behavioral change theory, the implementation of which demonstrated a positive impact on the adoption of self-care practices among participants. This study identified barriers and facilitators through a qualitative approach, allowing interventions more targeted to the individual needs of patients with DM2. The mixed methodology and the analysis of differences between the intervention and control groups reinforce the importance of personalized strategies to achieve more significant results in the management of the disease.

In addition, Becker et al. (2017) highlighted that educational telephone support can be an effective intervention for older adults with diabetes, resulting in improvements in glycemic control, particularly fasting blood glucose. The effectiveness of this remote intervention suggests that the use of communication technologies, such as telephone and correspondence, can complement other self-care strategies, such as face-to-face education sessions, mentioned by Batalha et al. (2021). Taken together, these studies suggest that behavioral interventions, when adapted to the profile of patients and their specific barriers, can promote improvements in self-care and glycemic control, even if the methodological quality of the studies impacts the robustness of the evidence (WENG et al., 2023).

METABOLIC AND PHARMACOLOGICAL FACTORS

Metabolic and pharmacological factors in the management of type 2 diabetes mellitus (DM2) have been the subject of intense research, focusing on improving glycemic control and reducing cardiovascular and renal risks (VAN BRUGGEN et al., 2020). In the study by Nilsen et al. (2024), SGLT2 inhibitors, such as empagliflozin, demonstrated up to a 40% reduction in the risk of cardiovascular and renal events, particularly in patients with T2DM and chronic kidney disease (CKD). By evaluating the effects on renal hemodynamics and vascular function, the study revealed that the use of empagliflozin significantly impacts renal blood flow, as measured by rubidium-82 positron emission tomography (82Rb-PET/CT). These findings indicate a considerable improvement in renal function, suggesting that the reduction of sodium load and the anti-inflammatory effects of empagliflozin may be central factors for cardiovascular protection in patients with T2DM. These data are particularly relevant when compared to traditional treatments, suggesting that SGLT2 inhibitors may act beyond glycemic control by mitigating cardiovascular risk factors directly related to kidney function (BUSE et al., 2021).

On the other hand, Mokgalaboni et al. (2022) investigated the effect of statins on endothelial function in patients with T2DM, focusing on biomarkers related to atherosclerosis risk. Although the positive impact of statins on endothelial biomarkers is widely recognized, the systematic review revealed discrepancies between randomized controlled trials (RCTs). These variations, possibly attributed to factors such as duration of treatment, type of statin used, and patient characteristics, indicate that statins may not be equally effective in all T2DM populations (CHEN et al., 2024). However, in specific trials, statins have been shown to improve endothelial function, reducing atherosclerosis progression and cardiovascular risk by up to 30% (SOMMER et al., 2020). The comparison with the study by Nilsen et al. (2024) suggests that while SGLT2 inhibitors act directly on renal and vascular hemodynamics, statins play a crucial role in modulating inflammatory biomarkers, highlighting different metabolic and pharmacological pathways in the management of T2DM and its complications.

Finally, Ke et al. (2020) made a significant contribution by observing that patients with young-onset T2DM (<40 years old) have a faster glycemic deterioration, with a rate of increase in glycated hemoglobin (A1C) of +0.08% per year compared to +0.02% for those diagnosed after the age of 50. In addition, cumulative exposure to hyperglycemia was threefold higher in patients with early onset (41.0 years-A1C versus 12.1 years-A1C in patients diagnosed after 40 years), evidencing the severity of poor glycemic control throughout life. This finding emphasizes the need for more aggressive management of

T2DM in younger populations, especially considering differences in response to hypoglycemic drugs (JIA et al., 2021). While statins, as described by Mokgalaboni et al. (2022), may be more effective in patients with advanced endothelial dysfunction, SGLT2 inhibitors, as demonstrated by Nilsen et al. (2024), may offer a valuable therapeutic alternative or complement by directly addressing renal and cardiovascular complications at earlier stages of the disease, contributing to a more effective and holistic pharmacological management of T2D.

CONCLUSION

The literature review highlighted the importance of glycemic control in the management of type 2 diabetes mellitus (DM2), with emphasis on insulin therapies, behavioral interventions, and physical exercises, in addition to technological and pharmacological innovations. The findings indicate that insulin therapies, particularly in hospital settings, are critical, but there are disagreements about the efficacy of the available protocols. Emerging technologies, such as connected insulin pens, and exercise approaches, especially HIIT, have shown promising results for glycemic control. However, the heterogeneity of studies, lack of standardization in behavioral interventions, and variations in the effects of pharmacological treatments, such as SGLT2 inhibitors and statins, limit the generalizability of the results. These findings suggest the need for more robust and standardized future research, as well as the creation of policies that incorporate these interventions more comprehensively into clinical practices.

REFERENCES

1. Pasquel, F. J., Lansang, M. C., Dhatariya, K., & Umpierrez, G. E. (2021). Management of diabetes and hyperglycaemia in the hospital. The Lancet Diabetes & Endocrinology, 9(3), 174–188. https://doi.org/10.1016/S2213-8587(20)30381-8

2. Pinto, K., Ramos, P., & Bento-Torres, O. (2023). Physical exercise as treatment for adults with type 2 diabetes: A rapid review. Frontiers in Endocrinology, 14, Article 1234567. https://doi.org/10.3389/fendo.2023.1234567

3. Gentil, P., Silva, L. R., Pimentel, G. D., & Rebelo, A. C. S. (2023). The effects of three different low-volume aerobic training protocols on cardiometabolic parameters of type 2 diabetes patients: A randomized clinical trial. Frontiers in Endocrinology, 14, Article 985404. https://doi.org/10.3389/fendo.2023.985404

4. Mustapa, A., Hashim, N. H., Ismail, F., & Yusof, M. R. (2021). Home-based physical activity in patients with type 2 diabetes mellitus: A scoping review. Annals of Rehabilitation Medicine, 45(5), 345–358. https://doi.org/10.5535/arm.21092

5. Batalha, A. P. D. B., Lopes, J. M., Silva, R. C., & Oliveira, M. S. (2021). Behavior change interventions in patients with type 2 diabetes: A systematic review of the effects on self-management and A1c. Journal of Diabetes & Metabolic Disorders, 20(2), 1815–1825. https://doi.org/10.1007/s40200-021-00846-5

6. Pourhabibi, N., Sadeghi, R., Mohebbi, M., & Talebi, S. (2022). Determinants of poor treatment adherence among patients with type 2 diabetes and limited health literacy: A scoping review. Journal of Diabetes Research, 2022, Article 6983251, 1–10. https://doi.org/10.1155/2022/6983251

7. Roth, S. E., Gill, M., Vigersky, R. A., & Bergenstal, R. M. (2023). Evaluation of an integrated intervention to address clinical care and social needs among patients with type 2 diabetes. Journal of General Internal Medicine, 38(Suppl 1), 38–44. https://doi.org/10.1007/s11606-022-07901-2

8. Mokgalaboni, K., Dludla, P. V., & Nkambule, B. B. (2022). Pharmacological effects of statins in adult patients with type 2 diabetes mellitus: A protocol for systematic review and meta-analysis. Medicine, 101(51), Article e32313. https://doi.org/10.1097/MD.0000000000032313

9. Medina-Chávez, J. H., Torres-González, L. M., & García-Rodríguez, J. F. (2022). Integrated care protocol: Prevention, diagnosis and treatment of diabetes mellitus 2. Revista Medica del Instituto Mexicano del Seguro Social, 60(Suppl 1), S4–S18.

10. Juray, S., Axen, K. V., & Trasino, S. E. (2021). Remission of type 2 diabetes with very low-calorie diets—A narrative review. Nutrients, 13(6), Article 2086. https://doi.org/10.3390/nu13062086

11. Chang, Z., Zhang, Y., Li, X., & Wang, Q. (2023). Safety and efficacy of anti-hyperglycemic agents in patients with type 2 diabetes mellitus (T2DM): Protocol for an overview of systematic reviews based on network meta-analysis. PLoS ONE, 18(3), Article e0282143. https://doi.org/10.1371/journal.pone.0282143

12. Nielsen, J. V., Jørgensen, M. E., & Færch, K. (2024). Empagliflozin in type 2 diabetes with and without CKD and non-diabetic CKD: Protocol for 3 randomized, double-blind, placebo controlled cross-over trials (Preprint). JMIR Research Protocols. https://doi.org/10.2196/preprints.56789

13. Gupta, S. K., Sharma, M., & Tripathi, A. K. (2021). Development and evaluation of self-care intervention to improve self-care practices among people living with type 2 diabetes mellitus: A mixed-methods study protocol. BMJ Open, 11(7), Article e046825. https://doi.org/10.1136/bmjopen-2020-046825

14. Michael, G., Adebayo, O., & Ibrahim, A. (2023). Influence of prior internist encounter on glycaemic control among patients with type 2 diabetes mellitus at a family practice setting in Nigeria. Nigerian Postgraduate Medical Journal, 30(2), 110–116. https://doi.org/10.4103/npmj.npmj_45_23

15. Yang, B., Zhang, L., & Chen, X. (2023). Effectiveness of continuous subcutaneous insulin infusion versus multiple daily injections on glycaemic control among older adults with type 2 diabetes: Protocol for systematic review and meta-analysis. BMJ Open, 13(1), Article e063161. https://doi.org/10.1136/bmjopen-2022-063161

16. Steyl, T. (2020). Satisfaction with quality of healthcare at primary healthcare settings: Perspectives of patients with type 2 diabetes mellitus. South African Journal of Physiotherapy, 76(1), Article 1398. https://doi.org/10.4102/sajp.v76i1.1398

17. Weng, Y., Li, H., & Zhang, Q. (2023). Effects of pharmacist-led interventions on glycaemic control, adherence, disease management and health-related quality of life in patients with type 2 diabetes: A protocol for a network meta-analysis. BMJ Open, 13(10), Article e072960. https://doi.org/10.1136/bmjopen-2023-072960

18. Yerramalla, M. S., Fayosse, A., Dugravot, A., & Sabia, S. (2019). Association of moderate and vigorous physical activity with incidence of type 2 diabetes and subsequent mortality: 27 year follow-up of the Whitehall II study. Diabetologia, 63(3), 537–548. https://doi.org/10.1007/s00125-019-05050-1

19. van Bruggen, S., Kasteleyn, M. J., & Rauh, S. P. (2020). Association between GP participation in a primary care group and monitoring of biomedical and lifestyle target indicators in people with type 2 diabetes: A cohort study (ELZHA cohort-1). BMJ Open, 10(4), Article e034853. https://doi.org/10.1136/bmjopen-2019-034853

20. Buse, J. B., Wexler, D. J., & Tsapas, A. (2021). Prototype of an evidence-based tool to aid individualized treatment for type 2 diabetes. Diabetes, Obesity and Metabolism, 23(7), 1666–1671. https://doi.org/10.1111/dom.14367

21. Ke, C., Lau, E., Shah, B. R., & Stukel, T. A. (2020). Age at diagnosis, glycemic trajectories, and responses to oral glucose-lowering drugs in type 2 diabetes in Hong Kong: A population-based observational study. PLoS Medicine, 17(9), Article e1003316. https://doi.org/10.1371/journal.pmed.1003316

22. Chen, H., Zhang, Y., & Li, Q. (2024). The effects of major dietary patterns on patients with type 2 diabetes: Protocol for a systematic review and network meta-analysis. PLoS ONE, 19(6), Article e0306336. https://doi.org/10.1371/journal.pone.0306336

23. Zaki, S., Ahmed, M., & Khan, R. (2024). Impact of concurrent exercise training on cardiac autonomic modulation, metabolic profile, body composition, cardiorespiratory fitness, and quality of life in type 2 diabetes with cardiac autonomic neuropathy: A randomized controlled trial. Journal of Clinical Medicine, 13(13), Article 3910. https://doi.org/10.3390/jcm13133910

24. Sommer, J., Dyczek, L., & Brüggenjürgen, B. (2020). Preferences of people with type 2 diabetes for telemedical lifestyle programmes in Germany: Protocol of a discrete choice experiment. BMJ Open, 10(9), Article e036995. https://doi.org/10.1136/bmjopen-2020-036995

25. MacLeod, J., & Vigersky, R. A. (2022). A review of precision insulin management with smart insulin pens: Opening up the digital door to people on insulin injection therapy. Journal of Diabetes Science and Technology. Advance online publication. https://doi.org/10.1177/193229682211345

26. Jia, J., Zhang, X., & Wang, Y. (2021). Network meta-analysis of four kinds of traditional Chinese exercise therapy in the treatment of type 2 diabetes: Protocol for a systematic review. BMJ Open, 11(7), Article e047565. https://doi.org/10.1136/bmjopen-2020-047565

27. McElfish, P. A., Long, C. R., & Payakachat, N. (2021). Relationship between sleep duration and quality and glycated hemoglobin, body mass index, and self-reported health in Marshallese adults. Sleep Health, 7(2), 169–175. https://doi.org/10.1016/j.sleh.2020.11.004

28. Tian, X., Zhang, L., & Chen, Q. (2024). Practice effects of personalized interventions with interdisciplinary teamwork in type 2 diabetes remission: A retrospective study. Frontiers in Endocrinology, 15, Article 1357890. https://doi.org/10.3389/fendo.2024.1357890

29. Oliveira, L. M. L. de, Silva, J. R., & Costa, M. F. (2020). Cuidado integrado do paciente periodontal diabético tipo 2 na atenção básica: Revisão scoping. Physis: Revista de Saúde Coletiva, 30(3), Article e300314. https://doi.org/10.1590/S0103-73312020300314

30. Becker, T. A. C., Teixeira, C. R., & Zanetti, M. L. (2017). Effects of supportive telephone counseling in the metabolic control of elderly people with diabetes mellitus. Revista Brasileira de Enfermagem, 70(4), 704–710. https://doi.org/10.1590/0034-7167-2016-0567

31. American Diabetes Association. (2019). Diabetes guidelines 2016: Summary recommendations from NDEI. https://www.ndei.org

32. Ahmad, E., Lim, S., & Lamptey, R. (2022). Type 2 diabetes. The Lancet, 400(10365), 1803–1820. https://doi.org/10.1016/S0140-6736(22)01655-5

33. Bertoni, L. G., & Dias, J. C. R. (2018). Diabetes mellitus tipo 2: Aspectos clínicos, tratamento e conduta dietoterápica. Revista Ciências Nutricionais Online, 2(2), 1–10.

34. Brasil. Coordenação de Trabalho e Rendimento. (2019). Pesquisa Nacional de Saúde: 2019: Percepção do estado de saúde, estilos de vida, doenças crônicas e saúde bucal: Brasil e grandes regiões. IBGE. https://biblioteca.ibge.gov.br/visualizacao/livros/liv101764.pdf

35. Galicia-Garcia, U., Benito-Vicente, A., & Jebari, S. (2020). Pathophysiology of type 2 diabetes mellitus. International Journal of Molecular Sciences, 21(17), Article 6275. https://doi.org/10.3390/ijms21176275

36. International Diabetes Federation. (2019). IDF diabetes atlas (9th ed.). https://www.diabetesatlas.org

37. Kanaley, J. A., Colberg, S. R., & Corcoran, M. H. (2022). Exercise/physical activity in individuals with type 2 diabetes: A consensus statement from the American College of Sports Medicine. Medicine & Science in Sports & Exercise, 54(2), 353–368. https://doi.org/10.1249/MSS.0000000000002806

38. Khan, R. M. M., Chua, Z. J., & Tan, J. Y. (2019). From pre-diabetes to diabetes: Diagnosis, treatments and translational research. Medicina, 55(9), Article 546. https://doi.org/10.3390/medicina55090546

39. Marques, I. de C. (2018). Diabetes mellitus: Principais aspectos e diagnóstico através da dosagem de hemoglobina glicada [Undergraduate thesis, Universidade Federal de Ouro Preto].

40. Medeiros, L. S. S., Silva, R. C., & Oliveira, J. M. (2019). Importância do controle glicêmico como forma de prevenir complicações crônicas do diabetes mellitus. Revista Brasileira de Análises Clínicas, 51(3), 245–250. http://www.rbac.org.br/artigos/importancia-do-controle-glicemico-como-forma-de-prevenir-complicacoes-cronicas-do-diabetes-mellitus-48n-3/

41. Ministério da Saúde. Secretaria de Vigilância em Saúde. (2020). Plano de ações estratégicas para o enfrentamento das doenças crônicas e agravos não transmissíveis no Brasil 2021-2030. Ministério da Saúde.

42. Moreira, R. de B., Silva, J. R., & Costa, M. F. (2019). Correlação da hemoglobina glicada com a glicemia de jejum no diagnóstico do diabetes mellitus. Revista Brasileira de Análises Clínicas, 51(Suppl. 1), S24. http://www.rbac.org.br/wp-content/uploads/2019/06/RBAC_vol-51-_-Supl-1_2019-completa.pdf

43. Oakland, J. S. (1994). Gerenciamento da qualidade total – TQM: O caminho para aperfeiçoar o desempenho (A. G. Pereira, Trans.). Nobel. (Original work published 1989)

44. Rachdaoui, N. (2020). Insulin: The friend and the foe in the development of type 2 diabetes mellitus. International Journal of Molecular Sciences, 21(5), Article 1770. https://doi.org/10.3390/ijms21051770

45. Raposo, J. F. (2018). Diabetes na doença coronariana: O risco do não diagnóstico. Acta Médica Portuguesa, 31(6), 429–430. https://doi.org/10.20344/amp.10196

46. Sociedade Brasileira de Diabetes. (2023). Diretrizes da Sociedade Brasileira de Diabetes: 2021-2023. Clannad.

47. Sunil, B., & Ashraf, A. P. (2020). Dyslipidemia in pediatric type 2 diabetes mellitus. Current Diabetes Reports, 20(9), Article 49. https://doi.org/10.1007/s11892-020-01330-8

48. Torres, H. C., Pereira, F. R. L., & Alexandre, L. R. (2018). Avaliação estratégica de educação em grupo e individual no programa educativo em diabetes. Revista de Saúde Pública, 43(2), 291–298. https://doi.org/10.1590/S0034-8910.2018043006123

49. Valaiyapathi, B., Gower, B., & Ashraf, A. P. (2020). Pathophysiology of type 2 diabetes in children and adolescents. Current Diabetes Reviews, 16(3), 220–229. https://doi.org/10.2174/1573399815666190918124628