Diabetes Education Program – Impact on Cardiometabolic Risk Factors and Predictors of Glycemic Control

Programa de Educação sobre Diabetes – Impacto nos Fatores de Risco Cardiometabólico e Preditores do Controlo Glicémico

L. Fonseca[1], S. Paredes[2], M. Vasconcelos[3], M. Saraiva[1], D. B. Duarte[1], T. Santos[1], S. Monteiro[1], F. Puga[1], I. Palma[1]

1 – Endocrinology Department, Centro Hospitalar e Universitário do Porto, Portugal.

2 – Endocrinology Department, Centro Hospitalar do Tâmega e Sousa, Portugal.

3 – Interna de Ano Comum, Hospital de Braga, Portugal.

Abstract

Background: Glycemic, lipidic and blood pressure control is the cornerstone treatment to reduce microvascular and macrovascular diabetes complications. Nevertheless, only a minority of patients attain the recommended therapeutic targets, which highlights the need for educational interventions that promote self-management and self-care behaviors that help reduce the burden of diabetes. The aim of this study was to determine the predictors of achieving glycemic control in a cohort of patients participating in an educational diabetes program. Secondarily, we evaluated the prevalence of several cardiovascular risk factors.

Methods: Retrospective study including patients with type 2 diabetes *mellitus* (T2DM) evaluated in a multidisciplinary diabetes education program between January 2015 and December 2019. This structured intervention is divided in 4 sessions, in each one; patients perform group educational activities and then receive individual assessment from experienced endocrinologists, nurses, nutritionists, podiatrists, psychologists and stomatologists.

Results: A total of 346 patients, mean age 59.6 ± 9.1 years-old with a median diabetes duration of 10 years were included. At the initial assessment, only a minority of patients presented cardiometabolic risk factors within the therapeutic range, approximately 78% had a glycated hemoglobin (HbA1c) > 7%, with a mean HbA1c of 8.4 ± 1.8%, 84% were overweight or obese, 79% had LDL-c above target. At the end of the intervention, patients presented a mean HbA1c reduction of 0.96% and a decrease in the obesity category (47.4% vs. 39.9%). Diabetes duration < 5 years and the absence of vascular complications predicted lower HbA1c levels at the end of intervention.

Conclusions: This study supports the benefit of a multidisciplinary intervention, particularly in patients with T2DM at an early stage of the disease, where complications are not yet established.

Keywords: type 2 diabetes *mellitus*; diabetes education program; multidisciplinary team; HbA1c; cardiovascular risk factors

Resumo

Contexto: O controle glicémico, lipídico e da pressão arterial é o tratamento básico para reduzir as complicações microvasculares e macrovasculares da diabetes. No entanto, apenas uma minoria dos doentes atinge os alvos terapêuticos recomendados, o que destaca a necessidade de intervenções educacionais que promovam comportamentos de autocontrolo e autocuidado que ajudem a reduzir o fardo da diabetes. O objetivo deste estudo foi determinar os preditores para alcançar o controlo glicémico numa uma coorte de doentes participantes num programa educacional de diabetes. Secundariamente, avaliámos a prevalência de vários fatores de risco cardiovascular.

List of Abbreviations

ADVANCE = Action in Diabetes and Vascular Disease: Preterax and Diamicron MR Controlled Evaluation; ApoA1 = Apolipoprotein A1; ApoB = Apolipoprotein B; BP = Blood pressure; BMI = Body mass index; CAIPaDI = Centro de Atención Integral al Paciente con Diabetes; CHD = Coronary Heart Disease; CI = Confidence interval; CV= Cardiovascular; CFRD = Cystic fibrosis-related Diabetes; CTED = Consulta de Terapêutica Educacional da Diabetes; DM = Diabetes *mellitus*; EAS = European Atherosclerosis Society; ESC = European Society of Cardiology; GLP-1RA = Glucagon-like peptide-1 receptor agonist; HbA1c = Glycated hemoglobin; HDL-c =High-density lipoprotein cholesterol; iDPP-4 = Dipeptidyl peptidase-4 inhibitors; INTERHEART = The Effect of Potentially Modifiable Risk Factors Associated with Myocardial Infarction; iSGLT2 = Sodium-glucose cotransporter type 2 inhibitors; LDL-c = Low-density lipoprotein cholesterol; MODY = Maturity-Onset Diabetes of the Young; NADIR =The Need Associated with Diabetes Primary Care and the Impact of Referral to a Specialist-Centered Multidisciplinary Diabetes Program; Non-HDL-c = Non-high-density lipoprotein cholesterol; OR = Odds ratio; PATER 2 = Therapeutic Standards and Glycemic Control in a Population with Type 2 Diabetes Referred to a Specialized Consultation; PHTD = Post-hepatic transplant Diabetes; PRTD = Post-renal transplant Diabetes; SCORE = Systemic Coronary Risk Estimation; SIDM = Steroid-induced Diabetes; STENO-2 = Intensified Multifactorial Intervention in Patients with Type 2 Diabetes and Microalbuminuria; T1DM =Type 1 Diabetes *Mellitus*; T2DM =Type 2 Diabetes *Mellitus*; WHO = World Health Organization.

Métodos: Estudo retrospectivo incluindo doentes com diabetes *mellitus* tipo 2 (DM2) avaliados num programa multidisciplinar de educação sobre diabetes entre janeiro de 2015 e dezembro de 2019. Esta intervenção estruturada é dividida em 4 sessões; em cada uma os doentes realizam atividades educacionais em grupo e, em seguida, são submetidos a avaliação individual de endocrinologistas, enfermeiras, nutricionistas, podólogos, psicólogos e estomatologistas experientes.

Resultados: Foram incluídos 346 doentes, com uma média de idades de 59,6 ± 9,1 anos e duração mediana da diabetes de 10 anos. Na avaliação inicial, apenas uma minoria dos doentes apresentava fatores de risco cardiometabólico dentro da faixa terapêutica, aproximadamente 78% tinham hemoglobina glicada (HbA1c) > 7%, com HbA1c média de 8,4 ± 1,8%, 84% tinham excesso de peso ou obesidade, 79% tinham LDL-c acima do nível alvo. No final da intervenção, os doentes apresentaram redução média da HbA1c de 0,96% e diminuição da categoria de obesidade (47,4% vs. 39,9%). A duração da diabetes < 5 anos e a ausência de complicações vasculares previram níveis mais baixos de HbA1c no final da intervenção.

Conclusões: Este estudo apoia o benefício de uma intervenção multidisciplinar, particularmente em doentes com DM2 num estádio inicial da doença, quando as complicações ainda não estão estabelecidas.

Palavras-chave: diabetes *mellitus* tipo 2; programa de educação sobre diabetes; equipa multidisciplinar; HbA1c; fatores de risco cardiovascular

CORRESPONDENCE

Liliana Fonseca MD
Endocrinology Department
Centro Hospitalar e Universitário do Porto
Largo Professor Abel Salazar
4099-001 Porto
Portugal
Móvel/Mobile: 93 79 35 270
E-mail: lilianafonsecaa@gmail.com

> INTRODUCTION

Diabetes *mellitus* (DM), is present in 8.5% of the adult population and it was responsible for approximately 1.5 million deaths worldwide in 2012. [1] DM increases two to four-fold the risk of cardiovascular disease (CVD) comparing to the non-diabetic population. [2] In most cases, DM associates with other atherosclerotic risk factors such as hypertension, dyslipidemia and obesity, increasing global cardiovascular risk. [3] Thus, identification and control of risk factors are critical components to prevent CVD. There is evidence that an intensive approach to normalize glycemia, blood pressure and lipid profile in type 2 diabetes *mellitus* (T2DM) patients reduces both micro and macrovascular complications more significantly than a standard approach. This emphasizes how important it is to control effectively and without inertia the different cardiovascular risk factors presented usually by these patients. [4] Therapeutic education focuses on chronic disease self-care and is considered an additional treatment for several diseases. Diabetes education programs are designed to provide patients with the necessary knowledge and skills for successful diabetes self-management. This strategy is nowadays a cornerstone in diabetes care and it is considered a paradigm for diabetes self-management. [5-7] Its main goal is the progressive empowerment of day-to-day decision making in patients w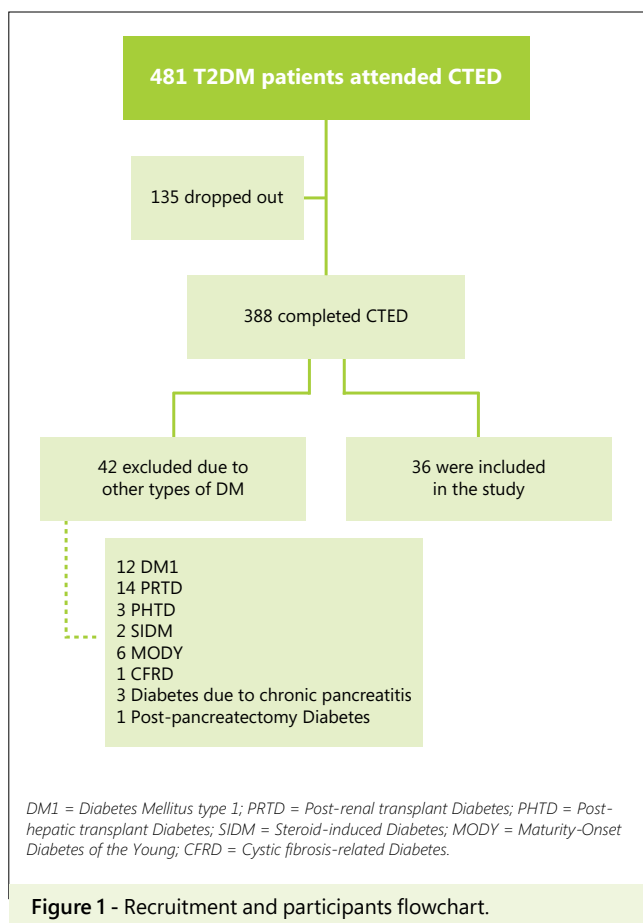ith T2DM and their families, in order to gift patients with autonomy and responsibility regarding disease management. Diabetes education requires resources, nevertheless it is costly-effective, since it contributes to increasing disease acceptation, improving clinical results, preventing hospital admissions and reducing global health costs. [1] A multidisciplinary approach is recommended for all T2DM patients and it is associated with a better glycemic control than a conventional approach. Furthermore, it also improves blood pressure and lipid profile as well as patient's quality of life [3,8] In accordance, the American Diabetes Association recommends that all patients should be referred to these programs at the diagnosis and at least every year. [9]

This study aimed to: 1) determine the predictors of achieving glycemic control in a cohort of patients participating in an educational diabetes program and 2) evaluate the prevalence of cardiovascular risk factors and the percentage of patients with low-density lipoprotein cholesterol (LDL - c) within target according to 2019 European Society of Cardiology (ESC)/European Atherosclerosis Society (EAS) guidelines for the management of dyslipidaemias.

> MATERIALS AND METHODS

Subjects and Study Design

Retrospective study including patients with T2DM that participated in the multidisciplinary diabetes education program in Centro Hospitalar e Universitário do Porto between January 2015 and December 2019. Patients who missed more than one session and patients who missed the last session were excluded from the analyses. From a total of 481 patients, we included 346 (Figure 1). This study was approved by the local Ethics Committee and due to its the retrospective nature, consent to participate was waived by the Ethics Committee.

481 T2DM patients attended CTED

135 dropped out

388 completed CTED

42 excluded due to other types of DM

36 were included in the study

12 DM1
14 PRTD
3 PHTD
2 SIDM
6 MODY
1 CFRD
3 Diabetes due to chronic pancreatitis
1 Post-pancreatectomy Diabetes

DM1 = Diabetes Mellitus type 1; PRTD = Post-renal transplant Diabetes; PHTD = Post-hepatic transplant Diabetes; SIDM = Steroid-induced Diabetes; MODY = Maturity-Onset Diabetes of the Young; CFRD = Cystic fibrosis-related Diabetes.

Figure 1 - Recruitment and participants flowchart.

Multidisciplinary Diabetes Education Program – *Consulta de Terapêutica Educacional da Diabetes (CTED)*

CTED has been developing its activities for more than one decade, receiving T2DM patients from intra-hospital appointments or from primary care. CTED was created with the purpose of empowering T2DM patients to self-manage and adapt to their chronic disease, helping them to succeed in their treatment and to delay or prevent T2DM complications, and thus improve quality of life.

This structured intervention was divided in 4 sessions, in each one; patients performed group educational activities and then received individual assessment from experienced endocrinologists, nurses, nutritionists, podiatrists, psychologists and stomatologists. Each session had a mean duration of 5 hours and was spaced apart 1 to 2 months.

In the first session patients received education about general knowledge on diabetes and the importance of nutritional medical therapy by endocrinologists and nutritionists. Every patient was then individually assessed

and pharmacological adjustments were performed, if necessary. Patients were submitted to an individual podiatric evaluation where peripheral pulses (pedious and posterior tibial), small fiber (thermal and pinprick) and large fiber (vibratory with a 128Hz diapason, protective with a 10g monofilament, proprioceptive and aquilian reflex) sensations, skin characteristics, nail lesions, structural changes and the type of shoes worn by the patient were assessed. The level of foot care (low, medium or good) and the knowledge on podiatric care, evaluated using a questionnaire, were also assessed.

In the second session patients received information on foot care, on the importance of capillary glycemia self-monitoring and on dental hygiene care by podiatrists, nurses and stomatologists, respectively. Then, patients were individually assessed by a nurse, an endocrinologist, a nutritionist (that tailored a dietary plan for each patient) and a psychologist (that applied scales such as the Hospital Anxiety and Depression Scale (HADS) and the Mini Mental State Examination). If necessary, patients also received consultation by the stomatologist.

In the third session there was a group educational activity with the psychologists and then, the physiatrists, where patients were educated on the importance of physical exercise in the treatment of diabetes and were taught weight-bearing exercises. Every patient was individually assessed by an endocrinologist and a nutritionist to clarify doubts, evaluate the adaptation to and the impact of the previous treatment adjustments.

In the fourth session there was a review of the acquired general knowledge, especially regarding diabetes, nutrition and foot care. Every patient was individually assessed by a nurse, an endocrinologist, a psychologist (who evaluated the need for post-education program referral) and a podiatrist. At the end of this session, patients were discharged to their primary care provider, or to an endocrinology consultation, if were still presenting poor glycemic control.

This program followed a standardized protocol and all data was recorded in medical records.

Physical examination was performed in all sessions and included anthropometric parameters (body mass index) and vital signs (blood pressure and heart rate) measurements. HbA1c was measured in the first and final session. Biochemical evaluation was conducted after an 8-h night fast in the second session. Lipid parameters included total cholesterol, high-density lipoprotein cholesterol (HDL-c), triglycerides, Apolipoprotein B (ApoB) and Apolipoprotein A1 (ApoA1). LDL-c levels were calculated through Friedewald's formula (10): LDL-c (mg/dL) = total cholesterol (mg/dL) − HDL-c (mg/dL) − triglycerides

(mg/dL)/5, unless triglycerides ≥400 mg/dL, in which case direct LDL-c measurement was performed. Non--HDL-c was calculated by subtracting HDL-c to total cholesterol. Liver and renal function and albuminuria were also evaluated.

Data Collection

Obesity was defined as a body mass index (BMI) ≥ 30 kg/m^2 and overweight as BMI ≥ 25 and < 30 kg/m^2. [11] Hypertension was defined as systolic blood pressure ≥140 mmHg and/or diastolic blood pressure ≥90 mmHg on at least two blood pressure measurements per visit and on at least two visits [12] and/or prescription of any antihypertensive medication. Patients were classified as smokers if they consumed at least 1 cigarette per week. A former smoker was defined as having quit smoking at least 6 months before assessment. Alcohol consumption was determined when patients reported drinking at least 10 g or 20 g of pure ethanol daily, for women and men respectively. Microvascular complications were defined by the presence of at least one of the three: retinopathy (referred by the patient or specified in the medical records), nephropathy (defined as urine albumin-to-creatinine ratio ≥ 30 mg/g and/or an estimated glomerular filtration rate (eGFR) < 60 mL/min/1.73 m^2) and neuropathy, namely distal symmetric polyneuropathy or autonomic neuropathy. [13] Macrovascular complications were defined by the presence of at least one of the three: ischemic heart disease, cerebrovascular disease and peripheral arterial disease, referred by the patient or specified in medical records.
HbA1c <7% was defined as the target of this intervention. [14] In order to stratify risk categories, patients were classified as having "very high risk", "high risk" and "moderate risk" accordingly to the 2019 ESC/EAS Guidelines for the management of dyslipidemias. [3] LDL-c targets were defined according to these guidelines [3] risk categories: LDL-c < 55, < 70 and < 100 mg/dL for very-high-, high-, and moderate-risk patients, respectively.

Statistical Analysis

Statistical analysis was performed using IBM SPSS® version 21.0 and a p value below 0.05 was considered statistically significant. For continuous quantitative variables, distribution normality was tested through histogram observation and Kolmogorov-Smirnov test analysis. Results are presented as mean values ± standard-deviation and median values (25 – 75 percentiles). The chi-square test was used to analyze differences between groups in categorical variables. The Student t-test for independent variables and the Mann Whitney test were used to compare continuous variables with normal and non--normal distribution between groups, respectively. A logistic regression model was performed in order to evaluate predictors associated with glycemic control, defined as HbA1c ≤ 7% in the last session, adjusting for potential confounders using a stepwise regression with a forward inclusion approach.

> RESULTS

General Baseline Characteristics

This study included a total of 346 patients diagnosed with T2DM. More than half were men (54.6%; n=189) and the mean age was 59.6 ± 9.1 years-old. Only one-third of the patients (32.1%, n= 111) were referred to CTED by their primary care physician. The others were referred after intra-hospital evaluation (67.9%, n=235), of which 43.4% (n=102/235) by endocrinology, 12.8% (n=30/235) internal medicine and 8.9% (n=21/235) by cardiology. The median diabetes duration was 10 years. About half had microvascular and nearly 30% had macrovascular complications (Table 1). In the first session the mean HbA1c was 8.4 ± 1.8% and 77.5% had an HbA1c > 7%.

Cardiovascular Risk Factors and Treatment Goals

The most prevalent cardiovascular risk factor was atherogenic dyslipidemia (79.2%, n = 274), followed by arterial hypertension (71.7%, n = 226), obesity (47.4%, n = 163) and overweight (36.9%, n = 127). The mean waist circumference was 101.3 ± 11.9 cm in males and 106.7 ± 15.3 cm in females. At baseline patients presented a median LDL-c level of 89 (66 – 114) mg/dL and the median triglycerides level was 136.0 (92.3 – 194.8) mg/dL. A complete lipid profile is exhibited in table 1. Regarding chronic kidney disease, most patients evidenced an A1 category [normal to mildly increased] (56.8%, n=191), according to the National Kidney Foundation classification [15] (Table 1). The most common cardiovascular risk category was the very-high risk (66.2%, n = 229) and the majority of patients presented a baseline LDL-c above target (78.9%, n = 273), 74.1% of high-risk patients had LDL-c above 70 mg/dL and 82.1% of very high-risk patients had LDL-c above 55mg/dL. Three-quarters of the patients were on statin therapy (74.5%, n = 248) and 9.2% (n = 32) were treated with fibrates. The most prevalent regimen was a moderate-intensity statin (66.1%, n = 164), whereas a high-intensity statin was used in only 31.9% (n=79).

Table I - General baseline characteristics.

		N	
Male sex		346	189 (54.6%)
Age (years)		346	59.6 ± 9.1
Duration of diabetes (years)*		346	10 (5 – 17)
Microvascular complications (55.8%; 193/341)	Retinopathy	340	87 (25.6%)
	Nephropathy	343	115 (33.5%)
	Neuropathy	339	67 (19.8%)
Macrovascular complications (29.2%; 101/344)	Cardiovascular disease	344	61 (17.7%)
	Cerebrovascular disease	344	35 (10.2%)
	Peripheral vascular disease	344	32 (9.3%)
Dyslipidemia		346	274 (79.2%)
Arterial hypertension		315	226 (71.7%)
Sedentarism		346	231 (66.8%)
Obesity		344	163 (47.4%)
Excess weight		344	127 (36.9%)
Smoking habit	Ongoing	346	32 (9.2%)
	Previous	346	123 (35.5%)
Alcoholic habit		346	129 (37.3%)
Waist circumference	Males (cm)	139	101.3 ± 11.9
	Females (cm)	171	106.7 ± 15.3
Albuminuria	A1 (<30 mg/g)	336	191 (56.8%)
	A2 (30-300 mg/g)	336	101 (30.1%)
	A3 (>300 mg/g)	336	44 (13.1%)
Total cholesterol (mg/dL)*		342	170 (139.3 – 191)
LDL-c (mg/dL)*		342	89 (66 – 114)
Triglycerides (mg/dL)		342	136.0 (92.3 – 194.8)
HDL-c	Males (mg/dL)	167	43 (35 – 53)
	Females (mg/dL)	142	49 (41.7 – 59)
Non-HDL-c (mg/dL)*		309	119 (94 – 142)
ApoB (mg/dL)		223	91.9 ± 25.6
ApoA1	Males (mg/dL)	100	146.5 ± 29.8
	Females (mg/dL)	123	134.5 ± 30.5
ApoB/ApoA1 ratio*		223	0.66 (0.55 – 0.81)

Data are presented as mean ± standard deviation, unless otherwise indicated by * corresponding to data presented as median, 25th and 75th percentiles. Categorical data is presented with absolute and relative frequencies. *LDL-c* Low-density lipoprotein cholesterol; *HDL-c* High-density lipoprotein cholesterol; *ApoB* Apolipoprotein B; *ApoA1* Apolipoprotein A1.

Outcomes

At the last session more patients were using biguanides, glucagon-like peptide-1 receptor agonists (GLP-1RA) and sodium-glucose co-transporter type 2 inhibitors (iSGLT2). On the other hand, fewer patients were using alpha-glucosidase inhibitors, dipeptidyl peptidase-4 inhibitors (iDPP-4), sulfonylureas, glinides and glitazones. Insulin treatment rates did not change during the intervention (Table 2).

We found a significant reduction in mean BMI (30.0 ± 5.0 *vs.* 29.4 ± 5.0 Kg/m^2) and a decrease in obesity categories (Table 3). The mean HbA1c decreased from 8.4 ± 1.8 to 7.5 ± 1.4 % (Table 3) and 43.4% (n=150) of patients achieved an HbA1c ≤ 7%.

A logistic regression (Table 4) identified shorter duration of DM, namely less than 5 years, and the absence of vascular complications as predictors of an HbA1c within target at the end of the intervention. The shorter duration of DM seems to be one of the factors with the greatest impact to reach the glycemic target (OR = 2.237 for diabetes duration under 5 years).

> DISCUSSION

Several studies have shown that in patients with DM, in addition to glycemic control, the reduction of cardiovascular risk also depends on smoking cessation and on weight, blood pressure and lipid profile optimization. [16] Despite the proven benefits of these interventions, only a minority of patients reach the therapeutic targets for these cardiometabolic parameters. [17, 18]

In fact, in this study 78% of patients had an HbA1c > 7%, [14] 84% were overweight or obese, 79% had LDL above target [3] and 31.9% were treated with a high-intensity statin.

Previous studies [19-21] suggest that referral to an integrated diabetes care center using a team-based treatment model, including both a dedicated physician as well as a diabetes education program can delay or prevent disease progression and even the development of diabetic complications.

Effect of a Multidisciplinary Intervention in HbA1c

In our study, an intervention with an average duration of 20 hours resulted in a mean HbA1c reduction of 0.96%. Moreover, despite only 22.5% of patients presented an HbA1c ≤ 7% in the initial assessment, this increased to 43.4% in the final evaluation. There was an increase in the use of biguanides, GLP-1RA and iSGLT2, which are preferred drugs, since they have a favorable profile regarding weight, lipid profile and hypoglycemia risk. GLP-1RA and iSGLT2 are available in Portugal only since 2015, thus it is possible that their use was underestimated. On the other hand, there was a decrease in sulfonylureas use and HbA1c improvements were attained without the need to increase insulin use. Chrava *et al*. reviewed 118 randomized clinical trials and identified common traits of an effective intervention, concluding that combining group and individual work for > 10h and patients with higher baseline HbA1c presented better results. [19] In fact, they demonstrated a significant HbA1c reduction between patients submitted to a multidisciplinary versus conventional intervention (0.74% *vs*. 0.17%). The Portuguese study PATER 2 evaluated glycemic control in a 250-patients cohort enrolled in a multidisciplinary specialized intervention that resulted in a HbA1c decrease of >1.3%, although patient enrollment started in primary care level and > 50% of patients were started on insulin treatment. [22] Studies like NADIR, including Canadian primary care patients, [20] and CAIPaDI from Mexico [23] reported similar results to ours regarding HbA1c reduction.

The results of the clinical trial STENO-2 prove that high risk T2DM patients benefit from an integrated MultiCare approach to reduce complication and mortality rates, [4] Furthermore, several meta-analyses based on UKPDS, ACCORD, ADVANCE and VADT showed a significant reduction of nonfatal myocardial infarction and all cardiac events associated with a mean HbA1c reduction of 0.9% over a mean follow-up time of 5 years. [24]

Predictors of HbA1c ≤ 7%

According to previous studies, many patients with diabetes fail to reach recommended therapeutic targets. [19] In our study, a recent DM onset and the absence of vascular complications predicted lower HbA1c levels at the end of the intervention, similarly to other studies. [13, 25-28] Bongaerts *et al*. [25] found in a systematic review and meta-analysis of the effectiveness of chronic care models for the management of T2DM in Europe, that in comparison to conventional diabetes care, a multifaceted approach improves HbA1c levels in patients with screen-detected diabetes [26,27] and patients with newly diagnosed diabetes, [28] but not for patients with T2DM and average diabetes duration greater than 5 years. [29,31] Furthermore, this effect seemed, at least partly, to be modified by disease duration and/or disease severity. Cleveringa *et al*. evaluated the effectiveness of practice nurse-managed software that supports diabetes management, medical decisions, and benchmarking and

Table II - Antidiabetic agents use before and after CTED.

	n	First session	Fourth session
Biguanides	342	251 (73.4%)	282 (82.2%)
GLP-1RA	342	33 (9.6%)	100 (29.2%)
Alpha-glucosidase inhibitors	342	5 (1.5%)	2 (0.6%)
iDPP-4	342	201 (58.8%)	177 (51.6%)
iSGLT2	342	45 (13.2%)	107 (31.2%)
Sulfonylureas	342	78 (22.8%)	40 (11.7%)
Glitazones	342	6 (1.8%)	0 (0.0%)
Insulin	342	177 (51.3%)	178 (52.0%)

Data is presented with absolute and relative frequencies. *GLP-1 RA* glucagon-like peptide-1 receptor agonists; *iDPP-4* dipeptidyl peptidase-4 inhibitors; *iSGLT2* inhibitors of sodium-glucose co-transporter type 2.

Table III - Blood pressure, body mass index and glycated hemoglobin before and after CTED.

	n	First session	N	Fourth session	*p*
Systolic BP (mmHg)	300	144.9 ± 20.6	300	142.9 ± 19.6	0.089
Diastolic BP (mmHg)	300	76.5 ± 11.1	300	74.6 ± 10.4	0.002
BMI (Kg/m²)	344	30.0 ± 5.0	343	29.4 ± 5.0	< 0.001
HbA1c (%)	346	8.43 ± 1.81	346	7.47 ± 1.38	< 0.001

Data are presented as mean ± standard deviation. *BP* Blood pressure; *BMI* Body mass index.

Table IV - Predictors of HbA1c ≤ 7% in the last session.

	OR	95% CI	*p*
Duration of diabetes			
• > 10 years		Reference	
• 5 -10 years	1.624	0.865 - 3.048	0.132
• < 5 years	2.237	1.202 – 4.162	0.011
Gender (Male)	2.491	(1.497 – 4.143)	<0.001
Initial HbA1c	0.574	(0.483 – 0.683)	<0.001
Absence of microvascular complications	1.614	(1.011 – 2.759)	0.048

Included covariables: age, vascular risk, macrovascular complications and initial IMC; *OR* Odds Ratio; *95% CI 95%* Confidence interval.

showed no difference in HbA1c compared to standard treatment one year after the intervention. Nevertheless, this Diabetes Care Protocol led to a global improvement in diabetes care, evidenced by a 1.4% higher reduction in 10-year coronary heart disease (CHD) risk estimate in the intervention group. The average duration of DM was 5.8 and 5.4 years, in the intervention group and in the control group, respectively. [30]
Our results highlight the importance of a multidisciplinary intervention in the early course of the disease, when complications are still absent.

Effect of Multidisciplinary Iinterventions in Blood Pressure Control and Body Mass Index

In this study, CTED intervention was associated with a decrease in the obesity (47.4% *vs*. 39.9%) category and a corresponding increase in the overweight (36.9% *vs*. 42.9%) category. In addition to non-pharmacological therapy, using GLP-1 RA and iSGLT2 and reducing sulfonylureas and thiazolidinediones, may partly explain the observed weight reduction. Although weight reduction is beneficial, especially in patients with higher BMI and waist measurements, [32] several studies showed that the effect of a multidisciplinary intervention in these parameters is only moderate. [21] Patients also presented a slight decrease in mean systolic and diastolic blood pressure, this effect can also be attributed, directly, as a consequence of iSGLT2 use or, indirectly, to iSGLT2 or GLP-1 RA induced weight loss. Previous systematic reviews have reported that a multidisciplinary approach versus conventional diabetes care may improve clinical and biochemical outcomes, including HbA1c levels, blood pressure and lipid concentrations. [25,33-37] CTED lasted 5 to 10 months, thus more studies with a longer follow-up are necessary in order to assess if these changes are sustained during time.

Limitations

Our study has limitations that deserve comment. First, it was a cross-sectional study with an associated bias not susceptible to rule out and thus, a prospective follow-up study is required to evaluate long-term medical implications of a multidisciplinary intervention. The cardiometabolic improvement that patients presented was globally evaluated and it is impossible to evaluate separately the effect of optimization of pharmacological therapy and lifestyle changes. Patient educational level was not systematically assessed in the final session, which could have influenced, to some extent, the global adherence to treatment. Finally, although lipid-lowering therapy was adjusted, the impact of these changes was not evaluated.

> CONCLUSION

This study presents a high number of patients with T2DM submitted to a multidisciplinary diabetes education program. We found that a shorter duration of DM and the absence of vascular complications were predictors of an HbA1c within target at the end of the intervention. These results support the benefit of a multidisciplinary intervention, particularly in patients with T2DM at an early stage of the disease, in which complications are not yet established. <

REFERENCES

1. Roglic G. Global report on diabetes: World Health Organization; 2016.

2. Yusuf S, Hawken S, Ôunpuu S, Dans T, Avezum A, Lanas F, et al. Effect of potentially modifiable risk factors associated with myocardial infarction in 52 countries (the INTERHEART study): case-control study. The Lancet. 2004; 364(9438): 937-52.

3. Mach F, Baigent C, Catapano AL, Koskina KC, Casula M, Badimon L, et al. 2019 ESC/EAS guidelines for the management of dyslipidaemias: Lipid modification to reduce cardiovascular risk. Atherosclerosis. 2019.

4. Gæde P, Lund-Andersen H, Parving H-H, Pedersen O. Effect of a multifactorial intervention on mortality in type 2 diabetes. New England Journal of Medicine. 2008; 358(6): 580-91.

5. Association AD. 10. Cardiovascular Disease and Risk Management: Standards of Medical Care in Diabetes—2020. Diabetes Care. 2020; 43(Supplement 1): S111-S34.

6. Lopes ICC. Literacia e Educação Terapêutica: Capacitar a pessoa com diabetes tipo 2 a lidar com a sua condição de saúde 2014.

7. Del Prato S, Felton AM, Munro N, Nesto R, Zimmet P, Zinman B. Improving glucose management: Ten steps to get more patients with type 2 diabetes to glycaemic goal: Recommendations from the Global Partnership for Effective Diabetes Management. International Journal of Clinical Practice. 2005; 59(11): 1345-55.

8. McGill M, Blonde L, Chan JC, Khunti K, Lavalle FJ, Bailey CJ. The interdisciplinary team in type 2 diabetes management: Challenges and best practice solutions from real-world scenarios. Journal of Clinical & Translational Endocrinology. 2017; 7: 21-7.

9. Association AD. 5. Facilitating Behavior Change and Well--being to Improve Health Outcomes: Standards of Medical Care in Diabetes-2020. Diabetes Care. 2020; 43(Suppl 1): S48.

10. Friedewald WT, Levy RI, Fredrickson DS. Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge. Clinical Chemistry. 1972; 18(6): 499-502.

11. Yumuk V, Tsigos C, Fried M, Schindler K, Busetto L, Micic D, et al. European guidelines for obesity management in adults. Obesity Facts. 2015; 8(6): 402-24.

12. Mancia G, De Backer G, Dominiczak A, Cifkova R, Fagard R, Germano G, et al. 2007 Guidelines for the management of arterial hypertension: The Task Force for the Management of Arterial Hypertension of the European Society of Hypertension (ESH) and of the European Society of Cardiology (ESC). European Heart Journal. 2007; 28(12): 1462-536.

13. Association AD. 11. Microvascular Complications and Foot Care: Standards of Medical Care in Diabetes– 2020. Diabetes Care. 2020; 43(Supplement 1): S135-S51.

14. Association AD. 6. Glycemic Targets: Standards of Medical Care in Diabetes—2020. Diabetes Care. 2020; 43(Supplement 1): S66-S76.

15. Selim M, Savitz S, Linfante I, Caplan L, Schlaug G. Effect of pre--stroke use of ACE inhibitors on ischemic stroke severity. BMC Neurol. 2005; 5(1): 10.

16. McCulloch DK, Nathan D, Mulder J. Overview of medical care in adults with diabetes *mellitus*. UpToDate Online Boston. 2009.

17. Wilson PW, Gagnon D. Diabetes *Mellitus* and Control of Cardiovascular Disease Risk Factors: A Challenge to Improve Usual Care. Am Heart Assoc; 2017.

18. Wexler DJ. Initial management of blood glucose in adults with type 2 diabetes *mellitus*. UpToDate. 2019.

19. Chrvala CA, Sherr D, Lipman RD. Diabetes self-management education for adults with type 2 diabetes *mellitus*: a systematic review of the effect on glycemic control. Patient education and counseling. 2016; 99(6): 926-43.

20. Bajaj HS, Aronson R, Venn K, Ye C, Sharaan ME. The need associated with diabetes primary care and the impact of referral to a Specialist-Centered Multidisciplinary Diabetes Program (the NADIR Study). Canadian Journal of Diabetes. 2016; 40(2): 120-5.

21. Odgers-Jewell K, Ball L, Kelly J, Isenring E, Reidlinger D, Thomas R. Effectiveness of group-based self-management education for individuals with Type 2 diabetes: a systematic review with meta-analyses and meta-regression. Diabetic Medicine. 2017; 34(8): 1027-39.

22. Magalhães C, Prudente M, Ribeiro R, Raposo J, Duarte R. Padrões Terapêuticos e Controlo Glicémico numa População com Diabetes do Tipo 2 Referenciados a uma Consulta Especializada–Estudo PATER 2. Revista Portuguesa de Diabetes. 2017; 12(2): 53-61.

23. Hernández-Jiménez S, García-Ulloa AC, Bello-Chavolla OY, Aguilar-Salinas CA, Kershenobich-Stalnikowitz D. Long-term effectiveness of a type 2 diabetes comprehensive care program. The CAIPaDi model. Diabetes Research and Clinical Practice. 2019; 151:128-37.

24. Heller SR, Group AC. A summary of the ADVANCE trial. Diabetes Care. 2009; 32(suppl 2): S357-S61.

25. Bongaerts BW, Müssig K, Wens J, Lang C, Schwarz P, Roden M, et al. Effectiveness of chronic care models for the management of type 2 diabetes *mellitus* in Europe: a systematic review and meta-analysis. BMJ open. 2017; 7(3).

26. Webb DR, Khunti K, Srinivasan B, Gray L, Taub N, Campbell S, et al. Rationale and design of the ADDITION-Leicester study, a systematic screening programme and randomised controlled trial of multi-factorial cardiovascular risk intervention in people with type 2 diabetes *mellitus* detected by screening. Trials. 2010; 11(1): 16.

27. Griffin SJ, Borch-Johnsen K, Davies MJ, Khunti K, Rutten GE, Sandbæk A, et al. Effect of early intensive multifactorial therapy on 5-year cardiovascular outcomes in individuals with type

2 diabetes detected by screening (ADDITION-Europe): a cluster-randomised trial. The Lancet. 2011; 378(9786): 156-67.

28. de Fine Olivarius N, Beck-Nielsen H, Andreasen AH, Hørder M, Pedersen PA. Randomised controlled trial of structured personal care of type 2 diabetes *mellitus*. Bmj. 2001; 323(7319): 970.

29. Frei A, Senn O, Chmiel C, Reissner J, Held U, Rosemann T. Implementation of the chronic care model in small medical practices improves cardiovascular risk but not glycemic control. Diabetes Care. 2014; 37(4): 1039-47.

30. Cleveringa FG, Gorter KJ, Van Den Donk M, Rutten GE. Combined task delegation, computerized decision support, and feedback improve cardiovascular risk for type 2 diabetic patients: a cluster randomized trial in primary care. Diabetes Care. 2008; 31(12): 2273-5.

31. Sönnichsen AC, Rinnerberger A, Url MG, Winkler H, Kowatsch P, Klima G, et al. Effectiveness of the Austrian disease-management-programme for type 2 diabetes: study protocol of a cluster-randomized controlled trial. Trials. 2008; 9(1): 38.

32. Wing RR, Reboussin D, Lewis CE, Group LAR. Intensive lifestyle intervention in type 2 diabetes. The New England journal of medicine. 2013; 369(24): 2358.

33. Si D, Bailie R, Weeramanthri T. Effectiveness of chronic care model-oriented interventions to improve quality of diabetes care: a systematic review. Primary Health Care Research & Development. 2008; 9(1): 25-40.

34. Stellefson M, Dipnarine K, Stopka C. Peer reviewed: The chronic care model and diabetes management in US primary care settings: A systematic review. Preventing chronic disease. 2013; 10.

35. Egginton JS, Ridgeway JL, Shah ND, Balasubramaniam S, Emmanuel JR, Prokop LJ, et al. Care management for Type 2 diabetes in the United States: a systematic review and meta-analysis. BMC health services research. 2012; 12(1): 72.

36. Elissen AM, Steuten LM, Lemmens LC, Drewes HW, Lemmens KM, Meeuwissen JA, et al. Meta-analysis of the effectiveness of chronic care management for diabetes: investigating heterogeneity in outcomes. Journal of Evaluation in Clinical Practice. 2013; 19(5): 753-62.

37. Pimouguet C, Le Goff M, Thiébaut R, Dartigues JF, Helmer C. Effectiveness of disease-management programs for improving diabetes care: a meta-analysis. Cmaj. 2011; 183(2): E115-E27.