Effect of Coaching in Diabetes Program in Glycemic Control in Steelworkers

Efecto del programa de coaching en diabetes en el control glucémico en trabajadores del acero

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ABSTRACT

Background: *Coaching en Diabetes* (CoeD) is a multidisciplinary program created for steelworkers and their families with type 2 diabetes mellitus (T2DM) and HbA1c $\geq 9\%$ to improve blood glucose levels. **Objective:** To assess the program's impact on glycemic control after 2 years. **Methods:** This was a retrospective and longitudinal study of uncontrolled T2DM at *Hospital Clínica Nova* in Mexico. The effect of CoeD on glycemic control was evaluated from May 2017 to 2019. **Results:** CoeD included 153 (115 [75.2%] males) patients, with a mean (SD) age of 62.9 (11.2) years. The duration of T2DM was 9.7 (6.6) years. A decrease in HbA1c of 1.5% (mean [SD] 9.8% [1.5]-8.3% [1.6], $p \leq 0.05$) and in fasting glucose of 41.8 mg/dl (mean [SD] 180 mg/dl [67]-138.2 mg/dl [55], $p \leq 0.05$) was observed through 2-year follow-up. Emergency room visits or hospitalization rates and the incidence of most comorbidities related to diabetes remained stable over time. **Conclusions:** CoeD successfully improved and sustained glycemic control in male steelworkers and their families with HbA1c $\geq 9\%$ over a 2-year follow-up.

Keywords: Type 2 diabetes mellitus. Diabetes education. Glycated hemoglobin A. Chronic complications. Occupational health.

RESUMEN

Antecedentes: *Coaching en diabetes* (CoeD) es un programa multidisciplinario creado para los trabajadores del acero y sus familias con diabetes tipo 2 (DM2) y hemoglobina glucosilada (HbA1c) $\geq 9\%$, para mejorar los niveles de glucosa en sangre. **Objetivo:** Evaluar el impacto del programa en el control glucémico después de dos años. **Métodos:** Estudio retrospectivo y longitudinal de DM2 no controlada en el Hospital Clínica Nova. El efecto del CoeD sobre el control glucémico se evaluó desde mayo de 2017 hasta 2019. **Resultados:** El CoeD incluyó 153 (115 [75.2%] varones) pacientes, con una edad media de 62.9 (desviación estándar [DE]: 11.2) años. La duración de la DM2 fue de 9.7 (DE: 6.6) años. Una disminución en la HbA1c del 1.5% [9.8% (DE: 1.5) a 8.3% (DE: 1.6); $p < 0.05$] y en la glucosa en ayunas de 41.8 mg/dl (180 mg/dl [67] a 138.2 mg/dl [55]; $p < 0.05$) durante un seguimiento de dos años. La tasa de visitas a urgencias o de hospitalización y la incidencia de la mayoría de las comorbilidades relacionadas con la diabetes se mantuvo a lo largo del tiempo. **Conclusiones:** El CoeD logró mejorar y mantener el control glucémico en trabajadores siderúrgicos y sus familias, con HbA1c $\geq 9\%$ durante un seguimiento de dos años.

Palabras clave: Diabetes mellitus tipo 2. Educación en diabetes. Hemoglobina A glucosilada. Complicaciones crónicas. Salud ocupacional.

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INTRODUCTION

According to the International Diabetes Federation, diabetes is a global health problem, with a prevalence of 463 million people in 2019¹. In Mexico, according to the National Health Survey (ENSANUT 2018), 10.3% of 8.6 million interviewed adults (11.4% of women and 8.4% of men) had diabetes².

Lack of control in chronic degenerative diseases such as diabetes leads to greater risks for workers and the labor environment. Likewise, work absenteeism increases³. According to different studies, strict glycemic control has been shown to decrease the mortality and complications of diabetes^{4,5}.

Besides strict control with drugs, multidisciplinary management has improved diabetes outcomes, especially in groups with uncontrolled glycemia resulting from poor treatment adherence^{6,7}. This management type may include individualized or group sessions with an attending physician, a diabetes educator, a physical trainer, a nutritionist, or a psychologist, among other specialists⁸. However, these multidisciplinary treatment strategies have a variable response depending on the program's cultural appropriation and the type of patient group⁹⁻¹¹; they have not been evaluated in steelworkers with difficulties controlling their disease.

Hospital Clínica Nova (HCN) is a health system that cares for steelworkers and their families who work at the Ternium Company in Monterrey, Mexico. Medical services are provided to approximately 45,000 patients. The prevalence of type 2 diabetes mellitus (T2DM) in the past 3 years has been 10.17%. Of these patients, 9.73% have reported an HbA1c above 9% (data not published). Therefore, the clinic created a multidisciplinary intervention program named *Coaching en Diabetes* (CoeD) to improve steelworkers' health with poor adherence to medical treatment and an HbA1c $\geq 9\%$. It began in 2017 as an institutional intervention policy, and it remains active to date. However, how the program has influenced the glycemic control of the involved patients remains unknown, so we designed this study to analyze the effect at 2 years of the CoeD program on glycemic control in steelworkers with T2DM and their families at HCN.

MATERIALS AND METHODS

The study was retrospective and longitudinal and followed the STROBE guidelines¹¹. It included patients with T2DM managed in the CoeD program in the HCN between May 2017 and May 2019. It was approved by the local IRB (Ref.:29112019-a-MI-CN-CI) and conducted per the Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans. Due to the study's retrospective nature, the consent form was waived. However, the CoeD program did require participants to sign an informed consent form to participate.

The CoeD program consisted of selecting steelworkers or their families with poor adherence to medical treatment. This was defined according to the results in the monthly HbA1c laboratory report provided to the Internal Medicine department, low attendance to the clinic (< 1 time in a year), and poor attachment to medical, nutritional, and physical activity advice.

The inclusion criteria were individuals with a previous diagnosis of T2DM, according to ADA criteria, between the ages of 18 and 90 years, both genders, and HbA1c $\geq 9\%$, and an available electronic medical record. Patients were excluded if they had other types of diabetes, had lost their medical service, and were pregnant women.

Selected patients were invited to participate in the CoeD program through phone calls by social workers or occupational medicine department personnel. The program consisted of a single group medical visit and multiple individual visits with medical providers. The group medical sessions, each lasting 90 min, had a weekly schedule and were directed by a multidisciplinary team. This group was integrated by an internist (coordinator), a nutritionist, a diabetes educator, and social work staff. In cases where the patient was an active steelworker, an occupational medicine physician was included in the group. Every session included a maximum of three patients. Each patient could bring a companion if they wished, but it was not obligatory.

The session content was standardized and was the same for each patient. It began with a brief

introduction, and patients were asked to sign the informed consent form to participate in the program. Then, the coordinator gave a lecture concerning the importance of diabetes control using a culture-centered approach, emphasizing awareness of the disease's risks and the importance of a good quality of life for the patients and their families' quests to empower each individual. Each patient was guided to identify what personal factors hindered good patient adherence to treatment; if his conjectures were accepted, the patient shared his experience with the rest of the group.

In the past 20 min, the nutritionist presented recommendations on how to follow a healthy diet. At the end of the session, the patients signed a document of commitments and goals to achieve a glycemic target, and the social work staff scheduled appointments with internal medicine, nutrition, diabetes education, ophthalmology, and other specialties if needed. Follow-up was every 3-6 months, depending on the specialist's requirements.

We analyzed the following variables retrospectively: age, gender, duration of diabetes, marital status, blood pressure (mmHg), and body mass index (BMI). We also described the progression of comorbidities (presence/absence reported in the medical chart), such as retinopathy, peripheral neurological symptoms, renal disease, heart failure, stroke, amputations, heart attack, and angina.

Finally, we described changes in the medical prescription of oral drugs and insulin, death, need for emergency room (ER) visits, and hospitalizations. The analyzed biochemical variables were HbA1c (percentage) (equipment D-10, BioRad, U.S.A.), and fasting glucose (mg/dl) (equipment Architect c4000 Abbot U.S.A). All variables were recorded at 0, 6, 12, 18, and 24 months after attending the CoeD session.

The study is an interim analysis of the program's performance in its first 2 years. Two researchers reviewed the quality control of the database. Normality assumption was evaluated with the Shapiro-Wilk test and frequency histograms.

Descriptive statistics, such as mean, the standard deviation for quantitative variables, frequencies, and percentages for categorical variables, were

computed. Repeated measures ANOVA (to control multiple testing) and Cochran's Q analysis were used to evaluate the program's effect on continuous and categorical quantitative variables over time. A change in HbA1c of at least 0.5% during the intervention overtime was considered successful.

Missing data were handled with the analysis of complete cases and multiple imputations (< 20% of missing values). The sample size was calculated according to the repeated measures ANOVA formula. With an effect size of 0.5, five measurements, an alpha of 0.05, and a power of 80%, the sample size required for this study was 35 patients. Since only three patients are included per group session, individuals have different initiation dates and follow-up periods. We expect different sample sizes when analyzing each follow-up duration.

The statistical programs used were the G Power program, version 3.1.9.4, and SPSS, version 25. The analysis was two tailed. $p \leq 0.05$ was considered statistically significant.

RESULTS

The total of 153 patients that were accepted to participate in the CoeD program throughout the study period was analyzed. One hundred and fifteen patients (75.2%) were male steelworkers, 38 (24.8%) were female, and the metal industry workers' relatives. The mean (SD) age was 62.9 (11.2) years, and 148 (97%) patients were married. The duration of diabetes was 9.7 (6.6) years. Furthermore, 68 (44.4%) had arterial hypertension. The mean (SD) BMI was 30.8 (4.9).

From the initial sample, 149 (97.4%) have completed the 6-month follow-up, 102 (66.7%) at 12 months, 53 (34.6%) at 18 months, and 36 (23.5%) at 24 months.

Compared with the baseline value, HbA1c decreased in the first 6 months by 1.5% ($p = 0.032$) and was maintained throughout the 24-month follow-up. Fasting glucose decreased 34.2 mg/dl the first 6 months and a total of 41.8 mg/dl through 24 months ($p = 0.021$) (Fig. 1 and Table 1). Blood pressure and BMI remained unchanged ($p > 0.05$). Their blood

Table 1. Clinical and biochemical measurements

Characteristics/time	Baseline	6 months	12 months	18 months	24 months	p-value*
HbA1c (%)	9.8 (1.5) ^a	8.3 (1.7) ^b	8.4 (1.7) ^b	8.8 (2.3) ^b	8.3 (1.6) ^b	0.032
n (%)	153 (100)	117(78.5)	85 (83.3)	46 (86.8)	31 (86.1)	
Fasting glucose (mg/dl)	180 (67) ^a	145.8 (62.8) ^b	142.4 (50.8) ^b	142 (55.2) ^b	138.2 (55) ^b	0.021
n (%)	153 (100)	124(83.2)	85 (83.3)	46 (86.8)	32 (88.9)	
BMI (kg/m ²)	30.8 (4.9)	30.8 (5.1)	31.1 (5.1)	30.6 (4.1)	29.3 (4.6)	> 0.05
n (%)	147 (96.1)	116 (77.8)	86 (84.3)	41 (77.4)	34 (94.4)	
Systolic blood pressure (mm Hg)	124 (13.5)	125 (13)	127 (18)	126 (12)	124 (11)	> 0.05
n (%)	146 (95.4)	128 (85.9)	93 (91.2)	50 (94.3)	35 (97.2)	
Diastolic blood pressure (mm Hg)	76 (8)	76 (9)	78 (8)	74 (6)	73 (8)	> 0.05
n (%)	146 (95.4)	128 (85.9)	93 (91.2)	50 (94.3)	35 (97.2)	

Data are presented mean (SD) and frequencies (percentage). ANOVA of repeated measures was performed for comparisons over time. *p-value for multiple comparison ANOVA; ^a*post hoc* – comparison between groups: the group's different letters mean the statistical difference among them. SD: Standard deviation, BMI: Body mass index, HbA1c: Glycosylated hemoglobin

pressure was in the target range throughout the study. In Table 1, clinical and biochemical measurements are described. There was an increase in the prescription of alogliptin ($p < 0.001$), alogliptin/metformin ($p < 0.001$), dapagliflozin ($p = 0.027$), and glargine U-100 ($p = 0.017$). Prescription of sitagliptin/metformin decreased ($p < 0.001$) due to its scarcity in the clinic. Frequencies and changes in medications are presented in Table 2.

Patients increased attendance to internal medicine department from less than once a year to at least every 6 months through 2 years in 99% of the patients. The attendance to diabetes education, nutrition, physical activity, and ophthalmology department was 54-84% through the program period.

Peripheral neurological symptoms increased throughout follow-up ($p < 0.001$), while other comorbidities remained stable (Table 3). In the previous 3 months before starting the program, the ER visits were present in 40 patients (26.1%, $n = 153$; 0-3 events per patient). The main reasons were related to hyperglycemia in 11%, work accidents in 25%, and other 62%. After 2-year follow-up, it changed to 11 (30.6%, $n = 36$, 0-3 events per patient). The main reasons were angina in 9% angina, work accidents 18%, and other reasons 73%. Before the program, five patients were hospitalized (3.3%, $n = 153$, 0-2 events per patient), 20% in relation to

Figure 1. Change in HbA1c and fasting glucose. Change of HbA1c (%) and fasting glucose (mg/dl) through time. ** $p < 0.05$.

hyperglycemia, 20% in relation to work accidents, and 60% other reasons, and during 2-year follow-up, 3 (8.3%, $n = 36$, 0-2 events per patient) and 2 of them in relation to cardiovascular disease ($p > 0.05$).

Twenty-six (17%) patients abandoned the program. Their main reasons were 11 (42.3%) without a specific cause, 9 (34.6%) partially abandoned the program for at least 6 months but later returned, 2 (7.6%) lost their medical service, 2 (7.6%) patients became pregnant during follow-up, and 2 (7.6%) subjects died, one at the age of 54 and the other at the age of 64 years, due to cardiovascular disease.

Table 2. Oral drugs and insulin

Drugs/time	Baseline, n = 153	6 months, n = 140	12 months, n = 99	18 months, n = 52	24 months, n = 36	p-value*
Metformin	131 (85.6)	118 (79.2)	73 (71.6)	35 (66)	24 (66.7)	> 0.05
Acarbose	10 (6.5)	11 (7.4)	8 (7.8)	7 (13.2)	4 (11.1)	> 0.05
Sitagliptin/metformin	62 (40.5)	44 (29.5)	27 (26.5)	16 (30.2)	3 (8.3)	< 0.001
Pioglitazone	14 (9.2)	12 (8.2)	8 (7.8)	4 (7.5)	2 (5.6)	> 0.05
Glimepiride	9 (5.9)	8 (5.4)	4 (3.9)	1 (1.9)	2 (5.6)	> 0.05
Glibenclamide	2 (1.3)	1 (0.7)	3 (2.9)	1 (1.9)	0 (0)	> 0.05
Alogliptin	24 (15.7)	56 (37.6)	31 (30.4)	19 (35.8)	16 (44.4)	< 0.001
Alogliptin/metformin	19 (12.4)	41 (27.5)	34 (33.3)	20 (37.7)	21 (58.3)	< 0.001
Dapagliflozin/metformin	11 (7.2)	13 (8.7)	13 (12.7)	3 (5.7)	4 (11.1)	> 0.05
Dapagliflozin	43 (28.1)	45 (30.2)	43 (42.2)	29 (54.7)	17 (47.2)	0.027
Dulaglutide	19 (12.4)	21 (14.1)	12 (11.8)	13 (24.5)	12 (33.3)	> 0.05
Gargine (U-100)	40 (26.1)	37 (24.8)	23 (22.5)	16 (30.2)	12 (33.3)	0.017
Gargine (U-300)	27 (17.6)	24 (16.1)	12 (11.8)	7 (13.2)	8 (22.2)	> 0.05
NPH	2 (1.3)	2 (1.3)	2 (2)	3 (5.7)	1 (2.8)	> 0.05
Lispro	16 (10.5)	11 (7.4)	8 (7.8)	2 (3.8)	3 (8.3)	> 0.05
NPH/regular insulin	16 (10.5)	17 (11.4)	19 (18.6)	13 (24.5)	7 (19.4)	> 0.05

Data are presented as frequencies (percentage). Q Cochran was performed for comparisons over time. *p-value for multiple comparisons.

Table 3. Main comorbidities

Comorbidities/time	Baseline, n = 153	12 months, n = 99	24 months, n = 35	p-value*
Retinopathy	14 (9.2)	10 (9.8)	5 (13.9)	> 0.05
Peripheral neurological symptoms***	20 (13.1)	27 (26.5)	16 (44.4)	0.009
Renal disease**	13 (8.5)	12 (7.8)	10 (6.5)	0.05
Heart failure	6 (3.9)	6 (5.8)	5 (13.9)	> 0.05
Stroke	3 (2)	3 (2.9)	2 (5.6)	> 0.05
Amputations	0 (0)	0 (0)	0 (0)	> 0.05
Heart attack	5 (3.3)	5 (4.9)	3 (8.3)	> 0.05
Angina	3 (2)	4 (3.9)	2 (5.6)	> 0.05

Data are presented as frequencies (percentage). Q Cochran was performed for comparisons over time. *p-value for multiple comparisons. **Renal disease was considered positive with a glomerular filtration rate below 60 ml/min; calculated with CDK-EPI formula. Only one patient progressed to Stage 5 and required dialysis during follow-up. ***Peripheral neurological symptoms were obtained by a medical chart concerning dysesthesia, paresthesia, pain, and numbness.

DISCUSSION

CoeD induced a sustained reduction in fasting glucose and HbA1c over a 2-year follow-up. Among all comorbidities, only peripheral neuropathy increased in prevalence. ER visits and hospitalizations remained stable throughout time.

Previous meta-analyses results have reflected the effect of culturally appropriate programs to achieve glycemic control in the Latino/Hispanic population

with diabetes, with follow-ups ranging between 6 and 24 months and reporting decreases in HbA1c between 0.25 and 0.53%^{6,8}. The decreases in HbA1c in CoeD patients were greater (1.5%).

A study conducted in Mexico City that evaluated the impact of an institutional, educational program in patients with T2DM over a year showed decreases in fasting glucose of 33.7 mg/dl ($p < 0.001$) and reductions in HbA1c of 0.69% ($p < 0.001$)¹². Our population had worse baseline glucose control and was predominantly male. However, CoeD obtained

comparable results, whereby our patients' fasting glucose decreased (8.05 mg/dl more), as well as their HbA1c (0.81% more).

Another study conducted in the south of Mexico assessed an educational intervention on glycemic control in 39 subjects. They reported a change in HbA1c of -1.11% (from 9.25% to 8.14%; $p < 0.001$)¹³. In comparison, our patients had a sharp 6-month decrease in HbA1c of 1.5% (0.4% more, $p < 0.001$) sustained throughout follow-up.

Most of the previously reported studies have described a predominance of the female gender in their samples, and the most frequent follow-up period has been 6 months^{6-9,14,15}. Our study's novelty is our sample: 75.2% were Mexican male active workers in the steel industry. This group is very difficult to reach due to their work schedules, and their poor adherence to treatment is commonplace. Most of the steelworkers have families and are their sole economic support. This program reinforced, empowered, and focused on the need for medical control to benefit the entire family and improve their quality of life. The reduction of HbA1c was sustained throughout follow-up, and this may be a direct result of an increase in pharmacological and non-pharmacological adherence to medical and educational guidelines.

A study of 207 Mexican-Americans with HbA1c > 8% evaluated the effect of a culturally sensitive diabetes education program, in which patients had on target blood pressure readings since the beginning of the study⁹. CoED showed similar results.

According to ENSANUT 2016, the prevalence of hospitalizations and ER visits in patients with T2DM is 16% and 14%, respectively¹⁶. Our group had a higher baseline number of ER visits than reported nationwide (26.1%), and it did not change over time (30.6, $p > 0.05$). The higher rate could result from a high risk of acute complications in this specific group or a high risk dependent on the steel industry *per se*. Steelworkers' workdays are related to difficulty in mealtimes, drug attachment, and also, they have more work accidents such as fractures or injuries. However, our hospitalization rate was lower than that reported nationwide, 3.3%, and did not change over time. Furthermore, the lower rate of

hospitalization is directly related to a lower rate of work absenteeism.

The chronic complications in diabetes are rarely followed by multidisciplinary interventions and not frequently reported in the literature in minorities. We only found three previous studies on the African-American population⁶. However, differences have been reported in terms of diabetes complication rates among different populations. In the Hispanic population, end-stage renal disease and retinopathy are highly prevalent¹⁷. ENSANUT 2016 reported patients with T2DM retinopathy in 11.2% of cases and kidney disease leading to dialysis in 1.2%. Only one patient progressed to dialysis during follow-up in our population, and we observed no progression of retinopathy (13.9%). The second most frequent chronic complication was peripheral neuropathy. This complication progressed in our patients throughout follow-up, with rates similar to previously reported (44.4% at the end of follow-up)¹⁶.

In our study, two patients died due to cardiovascular disease during follow-up. It is well-known that patients with T2DM in Mexico have a risk of cardiovascular death¹⁸. The previous studies have shown the relationship between glucose variability and oxidative stress as a physiopathological component for developing cardiovascular complications in T2DM¹⁹.

Although our patients had a significant and sustained decrease in HbA1c, some did not reach a value below 7%. New strategies must be implemented to help these patients, such as a second-phase medical group visit and strong communication with the workers' leaders to help patients comply with the program. Educational programs for medical providers have also proved to be helpful²⁰. It is well known that losing weight is beneficial for glucose control and reducing cardiovascular risk²¹, so our team must also implement complementary strategies to help patients lose weight.

Other limitations to our study were the non-randomization and the lack of a control group. After these favorable results, formal clinical trials with changes in prescription doses must be addressed in the future. Finally, a longer patient follow-up must be conducted to evaluate the progression of other chronic complications.

CONCLUSIONS

CoeD successfully decreased and sustained lower HbA1c and fasting glucose values over 2 years in a group of male steelworkers with A1c $\geq$ 9%. We believe that this kind of intervention could be useful in populations where family support is pivotal to health care.

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CONFLICTS OF INTEREST

The authors declare that there is no conflicts of interest.

ETHICAL DISCLOSURES

Protection of human and animal subjects. The authors declare that no experiments were performed on humans or animals for this study.

Confidentiality of data. The authors declare that they have followed the protocols of their work center on the publication of patient data.

Right to privacy and informed consent. The authors have obtained the written informed consent of the patients or subjects mentioned in the article. The corresponding author is in possession of this document.

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