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Factors associated with glycemic status and ability to adapt to changing demands in people with and without type 2 diabetes mellitus: A cross-sectional study

Bertha Cecilia Salazar-González[1], Esther C Gallegos-Cabriales[1], Alicia Rivera-Castillo[1], Arnulfo González-Cantú[2], Marco Vinicio Gómez-Meza[3] and Jesús Zacarías Villarreal-Pérez[4]

Abstract

Objectives: Type 2 diabetes mellitus studies focus on metabolic indicators and different self-reported lifestyle or care behaviors. Self-reported instruments involve conscious process therefore responses might not reflect reality. Meanwhile implicit responses involve automatic, unconscious processes underlying social judgments and behavior. No studies have explored the combined influence of both metabolic indicators and implicit responses on lifestyle practices in type 2 diabetes mellitus patients. The purpose was to investigate the explained variance of socio-demographic, metabolic, anthropometric, clinical, psychosocial, cognitive, and lifestyle variables on glycemic status and on the ability to adapt to changing demands in people with and without type 2 diabetes mellitus in Monterrey, Mexico.
Methods: Adults with (n = 30, mean age 46.90 years old, 33.33% male) and without (n = 32, mean age: 41.69 years old, 21.87% male) type 2 diabetes mellitus were studied. Glycemic status was assessed using Bio-Rad D-10 Hemoglobin A1c Program, which uses ion-exchange high-performance chromatography. Stroop 2 test was used to assess the ability to changing demands.
Results: In participants with type 2 diabetes mellitus, less years of education, negative self-actualization, and higher levels of cholesterol and triglycerides explained more than 50% of the variance in glycemic status. In participants without type 2 diabetes mellitus, the variance (38.7%) was explained by total cholesterol, metabolic syndrome, high-density lipoprotein, and self-actualization scores; the latter in opposite direction. The ability to adapt to changing demands was explained by total cholesterol, malondialdehyde, insulin resistance, and triglycerides. In participants without type 2 diabetes mellitus, the contributing variables were metabolic syndrome and nutrition scores.
Conclusion: Results showed significant effect on at least one of the following variables (socio-demographic, metabolic, or lifestyle subscale) on glycemic status in people with and without type 2 diabetes mellitus. The ability to adapt to changing demands was explained by metabolic variables but only in participants without type 2 diabetes mellitus. Preference for unhealthy behaviors (implicit or automatic responses) outweighs healthy lifestyle practices in people with and without type 2 diabetes mellitus.

Keywords

Diabetes/endocrinology, glucose metabolic disorders, lifestyle

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[1]Faculty of Nursing, Universidad Autónoma de Nuevo León, Monterrey, Mexico
[2]Centro de Investigaciones en Materiales Avanzados Unidad Monterrey, Apodaca, Mexico
[3]Faculty of Economics, Universidad Autónoma de Nuevo León, Monterrey, Mexico
[4]Faculty of Medicine, Universidad Autónoma de Nuevo León, Monterrey, Mexico

Corresponding author:
Bertha Cecilia Salazar-González, Faculty of Nursing, Universidad Autónoma de Nuevo León, Gonzalitos 1500 Nte., Mitras Centro, Monterrey, NL 64460, Mexico.
Email: bceci195@hotmail.com

Introduction

The increasing prevalence of type 2 diabetes mellitus (T2DM) worldwide is overwhelming, particularly in low- and middle-income countries where prevalence has been rising more rapidly.[1] In Mexico, a 3.4% increment in prevalence has occurred within a 12-year period (5.8%, 2000; 7%, 2006; and 9.2%, 2012). In addition, a large percentage of patients (75%) with poor glycemic control place the disease as a priority public health problem in the country.[2,3] Globally, self-care among patients with T2DM is and will remain a critical component to reach good glycemic control as well as prevent complications and disabilities.[4] In Mexico, follow-up visits and education to patients with T2DM are nurse's responsibilities, as well as coordination of visits to a nutritionist. However, to achieve this, nurses must be knowledgeable and skilled to perform a comprehensive needs assessment of the patients with T2DM. This requires a more comprehensive understanding of the different factors that influence disease progression and complications and comorbidities of T2DM. Results of such assessment could have impact on the quantity and quality of self-care in persons with T2DM.[5]

Chronic hyperglycemia is characterized by intricate metabolic processes, which contribute to the development of chronic complications of T2DM. Metabolic, psychosocial, cognitive, and behavioral factors have been associated with uncontrolled glycemia and obesity currently present in a high percentage of patients with T2DM. Uncontrolled glycemia and obesity are consistently associated with oxidative stress, a state where the levels of pro-oxidants in the tissues exceed the quantity of neutralizing substances, which affect glucose utilization and insulin-producing beta cells.[6,7] Oxidative imbalance leads to increased concentrations of malondialdehyde (MDA) and has been linked to behavioral and metabolic factors.[8] Some related factors, like malnutrition, insufficient exercise, smoking, and metabolic factors, such as dyslipidemia and metabolic syndrome (MS) are characterized primarily by insulin resistance (IR). In turn, peripheral IR leads to an increase in the flow of free fatty acids to the liver, thereby decreasing triglyceride (TG) output, causing hepatic steatosis and inducing oxidative stress.[9] Fatty acid metabolism, particularly of polyunsaturated fatty acid, increases pro-oxidants that can generate reactive oxygen species leading to increased blood glucose. Chronic hyperglycemia is responsible for the development of the microvascular-related T2DM complications[10] and further development of macrovascular complications, particularly in patients who have had T2DM for more than 5 years, and are older than 25 years.[11]

Emotional stress, among other factors, is related to hyperglycemia. High levels of diabetes stress, referred to as "the worries individuals with the disease experience," are characteristic of emotional overload. Stress and emotional overload are risk factors associated with poor glycemic control, low physical activity, and lack of adherence to drug and dietary treatments.[12–14] Likewise, the cognitive state, which is affected by chronic hyperglycemia, seems to be associated with deterioration in brain functions necessary for making critical decisions about self-care.[15]

On the opposite side, self-care in T2DM comprehends actions to achieve pharmacologic and non-pharmacologic treatments. Moreover, a vast proportion of patients with T2DM can reduce the possibility of developing long-term complications by improving self-care activities. However, the adherence to an integral self-care plan is low, particularly over the medium and long term.[16] Frequently, self-care in T2DM emphasizes the lifestyle dominion due to the importance of diet and physical activity in controlling blood glucose; however, these two factors are hardly influenced by professional interventions.[17]

Self-care is typically measured through self-reporting, in which performance of activities is frequently over-estimated. Information gathering based on implicit memory is a methodology used to assess implicit attitudes and concepts improving the accuracy of an answer. This involves automatic and unconscious processes underlying social judgments and behavior. The procedure assesses the association between a concept and an adjective dimension[18] in terms of latency or time elapsed from the input (picture presented on the computer screen) and the outcome (pressing one of two keys on the keyboard by participant). Keys are assigned with dual meanings.

A review of the published literature indicates many different factors that influence the glycemic control in patients with T2DM: socio-demographic,[19,20] metabolic,[6,7] anthropometric,[6] psychosocial,[12,13,16,21] and lifestyle practices.[17] However, it is necessary to explore the combined influence of the different variables: socio-demographic, metabolic, anthropometric, clinical, psychosocial, cognitive, self-reported lifestyle practices, and implicit responses to help nurses to better approach lifestyle practices (particularly in cases of inconsistencies between nutrition and exercise explicit and implicit responses) in T2DM patients and perhaps improving glycemic control.

It is highly recommended that the assessment of adults' experience with T2DM be comprehensive taking into consideration the variables that best explain their glucose levels and disparities in the short, medium, and long term. In turn, a tailored self-care plan can then be developed on the basis of those factors. From a nursing perspective, the individual is a whole being wherein the sickness affects all aspects of the person. Accordingly, self-care approach should be based on a holistic assessment.

Research objective

To investigate the contribution of socio-demographic, metabolic, anthropometric, blood pressure, cognitive, and lifestyle variables regarding the explained variance of glycosylated hemoglobin levels and the ability to adapt to changing demands in adults with and without T2DM in Monterrey, Mexico.

Methods

Study design

This was a descriptive, cross-sectional, and correlational study comprising two groups: participants with T2DM (diabetes mellitus group (DMG)) and participants without T2DM (control group (CG)).

Sampling and sample size determination

The target population was both male and female adults aged 18–59 years. A convenience sample was selected. The sample size was determined considering a 95% confidence level, power of 80, with a 0.80 effect size for multiple regression,[22] resulting in 30 participants for each group. But, of the participants who indicated they did not have T2DM, three had HbA1c ≥6.5%, suggesting the presence of T2DM according to the American Diabetes Association (ADA)[5] criteria. In order to decide which group should analyze the three cases newly identified with HbA1c suggesting T2DM, we adjusted regression models under three conditions: (a) retaining those cases in the CG; (b) eliminating the three cases, and (c) adding the three cases into the DMG. Results were similar, and taking into account the influence of biochemical variables, we decided to include the newly identified T2DM participants in the DMG.

The final sample included 30 patients for the DMG and 32 for the CG. Inclusion criteria were the participant's ability to read; distinguish the colors green, red, and blue presented on a sheet; and follow directions on a laptop screen.

Data collection

Data collected included metabolic, clinical, and anthropometric measurements. The independent variables were sociodemographic (age, sex, and education), metabolic MDA, total cholesterol (TC), low-density lipoprotein cholesterol (LDLc), high-density lipoprotein (HDL), IR, and MS), clinical (blood pressure and duration of T2DM), anthropometric ((body mass index (BMI)/waist circumference (WC)), psychosocial (general stress), cognitive (preferences for healthy behaviors (implicit responses)), and lifestyle practices (health-promoting lifestyle profile scores composed of six subscales). The dependent variables were HbA1c (metabolic) and the ability to adapt to changing demands (Stroop 2 scores represent the cognitive variable).

Instruments

The General Stressful Life Events Scale[23] evaluates life events perceived as threatening, aggressive, or disturbing. It is asked if each life event is currently present in participant's life or was present in the past. The response pattern goes from 0 = nothing to 3 = a lot. The scale has 53 items distributed in four themes: health, human relations, lifestyle, and economic and labor issues. Scores ranged between 0 and 159 points. A higher score means more stress. Factor analysis revealed two factors: personal events (related to way of being, health, and lifestyle) and contextual events (labor, social, and economic). Test–retest alpha coefficient was 0.65.[23]

Preferences regarding diet and physical activity were obtained through implicit responses. On a laptop screen, a series of figures representing physical activity versus being sedentary and eating healthy foods versus eating foods high in fat and carbohydrates were presented. The participant was asked to press the letter "E" if the figure on the screen stood for an unhealthy behavior and the letter "I" for a healthy behavior. Subsequently, the instructions were reversed on the keyboard (now E key stand for healthy behavior and I key for unhealthy behavior). A positive or negative adjective was then added to healthy or unhealthy figures. If a participant clicked the incorrect key, a big X appeared on the screen and he or she was not allowed to continue until the correct key was selected. Negative values indicated weakly, moderately, or very preference for unhealthy behaviors in comparison to healthy ones. Positive values indicated weak, moderate, or preferences for healthy behaviors compared to unhealthy ones. Test–retest reliability of implicit responses was piloted in 15 university students within an interval of 1 day. Intraclass coefficient 95% confidence interval (CI) was 0.79 (acceptable). Validity needs further exploration.

The Health Promotion Lifestyle Profile questionnaire (HPLP; Spanish version),[24] assesses the lifestyle practices of nutrition, exercise, health responsibility, stress management, interpersonal support, and self-actualization, each one representing a subscale. The Spanish version was validated by authors[24] using principal components factor analysis and revealing a six-component model accounting for 45.9% of the variance. Reliability coefficient was 0.92 and test–retest coefficient was 0.86;[24] in Mexican women, the alpha coefficient was 0.92 for subscales above 0.70.[25] The questionnaire has 48 items with a response pattern of 4 points, wherein 1 = never and 4 = routinely. Total scores range between 48 and 192 points, but sub-indexes (SI), 0–100 points were obtained for each subscale. High scores corresponded with better lifestyle practices.

The Stroop 2 test measures the ease with which a person is able to adapt to changing demands and suppress a habitual response in favor of a less frequent response.[26] This test consisted of two pages with 100 words presented in five columns of 20 words each. The participants were instructed to read as many words they could in 45 s. The first sheet contained the names of colors (red, green, and blue) printed in black ink. The second sheet contained names of colors (red, green, and blue) printed in a different ink color from the written word. To verify that the participant distinguished the printed colors, he or she was asked to read at least six words. A research assistant instructed participants when to start and stop reading the words aloud on the first sheet. For the second sheet, participants were instructed to state the color of each printed word. Another research assistant identified the number of words read correctly and the number of errors. More number of words read on the second sheet indicated a greater capacity to adapt to changing demands, implying mental flexibility. The Stroop 2 test is extensively used in Hispanic population from different countries (Colombia, Chile, Spain, and Mexico). Reliability in Mexican population through Cronbach's alpha coefficient was 0.767,[27] and in Colombian population was 0.70, and convergent validity between the Stroop 2 test and the Trail Making Test part B was ($r=0.14$, $p=0.01$).[28] Differences were established by age groups in the Mexican and Colombian samples, no significant differences were found by sex.[27,28]

Metabolic variables. MDA was processed using the MDA-586 method based on the reaction of a chromogenic reagent, N-methyl-2-phenylindole (R1, NMP) with MDA, at 45°C. One molecule of MDA reacts with two molecules of NMP to yield a stable carbocyanine dye. This biomarker is expressed in μm and includes reactive compounds of carbonyl, which is the most abundant MDA. A higher MDA value indicated increased oxidative stress with an acceptable range between 0.77 and 1.17 mmol/mg.

Insulin was processed using Roche Elecsys modular analytics Cobas e 411 (San Cugat del Vallès, Catalonia, Spain) for electrochemiluminescence immunoassay. Acceptable reference values were between 2.6 and 24.9 μU/mL. Insulin, blood glucose, and IR values were estimated using the Oxford University Homa Calculator (https://www.dtu.ox.ac.uk/homacalculator/).

Lipid values were determined using the dry spectrometry technique on a Johnson & Johnson Vitros BtT-60 chemistry system. The following cut-off points for lipid fractions were based on a no-risk criteria group proposed by the Third Report of the National Cholesterol Education Program (NCEP):[29] TC ≤200 mg/dL, TGs <150 mg/dL, high-density lipoprotein cholesterol (HDLc) >40 mg/dL in men and >50 mg/dL in women, and LDLc <100 mg/dL.

HbA1c was processed using Bio-Rad D-10 Hemoglobin A1c Program, which uses ion-exchange high-performance chromatography. The program is based on chromatographic separation of HbA1c in a cation exchange cartridge. The Bio-Rad D-10 program is an automated analyzer that separates the sample and determines the relative percentage of hemoglobin (A2, F, A1C) in whole blood. The reference values 3.0%–6.0% were used, and for participants with T2DM, <7% represented good control.[30]

Anthropometric and clinical variables. Anthropometric measurements of height, weight, and WC were taken following standardized procedures. Height and weight were used to estimate BMI using the following formula: weight (kg)/height^2 (m^2), wherein 18.0–24.9 was considered normal, 25–30 was considered overweight, and >30 was considered obese (NOM-015).[31] The WC was classified as without risk when it measured <102 cm for men and <88 cm for women. NCEP III29 criteria were observed for the presence of MS with the coexistence of risk levels in three of the following indicators: WC, TGs, high-density cholesterol, and serum glucose. The clinical variable blood pressure was measured following standard procedures using Welch Allyn Aneroid Blood Pressure Cuff. Normal systolic/diastolic blood pressure (S/DBP) was established at 120/80 according to the Mexican Norm.[31] Duration of T2DM was registered in years since diagnosis.

Procedures for data collection

Potential participants with T2DM who were enrolled in a diabetes education center and came to their control appointment during the time of the study (May–August 2014) were invited to participate in the study. Those who accepted were included until the sample size was completed (DMG). Adults without T2DM were invited verbally from those attending health promotion programs in community clinics (CG). The study was explained to those who accepted and signed inform consent.

The questionnaires were administered face-to-face to each participant, and the anthropometric and blood pressure measures were taken by research assistants. Metabolic measurements were performed by qualified staff, who obtained 20 mL of blood using venipuncture from all study participants who had fasted for 12 h. The procedure was adjusted to the standards of a laboratory certified by the Ministry of Health.

The instruments were applied in the following order: General Stress Scale and Health-Promoting Lifestyle Profile questionnaires. Subsequently, the Stroop 2 was applied, and finally the food and exercise preferences (implicit responses), were applied. Participant's age, sex, and education were registered in a general data sheet.

Ethics approval

Ethical approval for this study was obtained from Ethics Committee of the Universidad Autónoma de Nuevo León (UANL) School of Nursing (Record FAEN-P-1165, IRB Record 00002060). All participants signed an informed consent.

Data analyses

Statistical analysis included: (a) descriptive data of participant's characteristics and (b) regression analysis seeking the contribution of selected variables over glycemic status and on the capacity to adapt to changing demands (Stroop 2). The analyses were processed using SPSS version 20 (Armonk, NY: IBM Corp). A $p \le 0.05$ value was considered significant. Continuous variables showed normal distribution ($p > 0.05$, Kolmogorov–Smirnov test with Lilliefors correction).

Descriptive data were presented as means and standard deviations per group and were compared using Student's t-test. Variables with cut-off points indicating risk were analyzed in contingency tables using chi-square test. HbA1c levels and scores on the Stroop 2 test were analyzed by group as dependent variables in separate models using 11 and 6 independent variables in DMG and CG, respectively. Those variables previously showed bivariate correlation with the aforementioned outcome variables. Multiple-regression models were adjusted using the backward method, which eliminated variables $p \geq 0.10$ while adjusting progressive models. The corresponding final model was reported, and variables with the $p \leq 0.05$ were retained in the model.

For the model with HbA1c as an outcome variable, the independent variables were education (socio-demographic); TGs, HDLc, and MS; exercise, nutrition, self-actualization, health responsibility, and stress management subscales (lifestyle practices); and diastolic blood pressure (DBP). Variables not included in the analyses were age, sex, MDA, HOMA-IR, LDLc, glucose levels, SBP, general stress, preferences for healthy behaviors (automatic responses), and interpersonal support subscale (lifestyle practices). Backward method eliminated variables with $p \geq 0.10$.

When the Stroop 2 score (capacity to adapt changing demands) was the outcome variable, the independent variables were education (socio-demographic); IR, TGs, and MS; and nutrition subscale (lifestyle practice). Backward method eliminated variables with $p \geq 0.10$.

Results

The results corresponded to 30 participants with T2DM and 32 without T2DM. The final sample comprised 17 men (27%) and 45 women (73%). The descriptive variables were grouped under the following labels: socio-demographic, anthropometric, clinic, psycho-cognitive, and lifestyle and are presented by group (CG and DMG).

The proportion of women in each group was greater than that of men (66.7% and 78.1% in the DMG and CG, respectively ($p = 0.397$). The DMG was characterized by fewer years of formal education, more participants with typical abdominal obesity, and some metabolic variables with averages higher than the CG ($p < 0.05$). Both groups obtained similar values in psychosocial, cognitive, and blood pressure variables (Table 1).

Analyzing the frequencies of participants with values above risk levels, higher proportions were found in the DMG (MS (chi-square = 18.61, $p < 0.001$), TGs (chi-square = 15.26, $p < 0.001$), MDA (chi-square = 11.21, $p = 0.004$), and BMI (chi-square = 122.78, $p = 0.002$)) than in the CG. However, both the DMG and the CG were similar ($p > 0.05$) in terms of the number of direct relatives with T2DM (father, mother, mother and father, mother or father, and siblings) as well as the number of participants with abdominal obesity and hypertensive S/DBP. Around 50% of participants diagnosed with T2DM showed glycemic control according to ADA[5] criterion (HbA1c <7%).

Around 11 variables showed significant correlations to the outcome variables representing demographic (1), metabolic (4), lifestyle practices (5), and clinical represented by DBP (1). Therefore, these variables were introduced into models of regression analyses using backward method for both HbA1c and Stroop 2 test (ability to adapt to changing demands).

To determine the predictive capacity of the selected variables on HbA1c and the ability to adapt to changing demands, regression models with backward method were adjusted for each of the outcome variables. This method allows to eliminate the variables with the highest p value, leaving in the equation those contributing significantly to the explained variance.

Variables that predict HbA1c levels. The DMG showed that HbA1c levels were significantly ($p \leq 0.05$) associated with demographic, metabolic, and lifestyle-related variables. As shown in Table 2 (model 8), 51.9% of the variance ($p < 0.001$) in HbA1c was predicted by four variables (education, TC, TGs, and self-actualization). In the CG, four variables (TC, MS, HDLc, and self-actualization) contributed to the significance of the final model, which represented 38.7% of the explained variance (model 7). Self-actualization was significant in both groups; however, a negative influence ($\beta = -0.353$, $p = 0.014$) was observed in the DMG, whereas a positive influence was observed in the CG ($\beta = 0.444$, $p = 0.018$). Table 2 shows that all the models were significant.

Variables that predict the ability to adapt to changing demands. This analysis was performed under the assumption that actions in diabetes care are premised on an individual's capacity to adapt to changing demands. It implies to respond to the changing needs imposed by T2DM in ways that are different from behavior patterns formed throughout their life. The Stroop 2 test allowed for estimating the flexibility of people adapting to changing demands. Results of multiple-regression models with the backward method showed modest explained variance in the DMG (38.4%) and the CG (21.8%), revealing that four and two different variables contributed to the explained variance, respectively (Table 3). MDA, IR, and TGs were predictive factors in the DMG (T2DM), whereas MS and nutrition subscale scores were predictive factors in the CG; in addition, a trend was observed in years of education ($p = 0.078$; Table 3).

Implicit preferences-healthy behaviors. Analyses of variance in nutrition scores (DMG, $F_{2,24} = 1.74$, $p = 0.197$; CG, $F_{2,28} = 0.18$, $p = 0.836$) and exercise (DMG, $F_{2,24} = 0.33$, $p = 0.721$; CG, $F_{2,28} = 0.31$, $p = 0.730$) associated with implicit

Table 1. Characteristics and variables comparison between CG and DMG groups.

Variables	DMG		CG		t [60]	p value	CI 95%	
	M	SD	M	SD			Minimum	Maximum
Socio-demographics								
Age in years	46.90	9.15	41.69	11.35	−1.98	0.052	−10.47	0.049
Education in years	10.47	4.25	13.00	4.10	2.38	0.020*	0.409	4.65
Anthropometrics								
BMI[a]	31.91	7.15	27.95	6.02	−2.36	0.021*	−7.31	−0.61
Waist: men (cm)	98.50	6.13	98.57	12.89	0.01	0.988	−9.84	9.98
Waist: women (cm)	100.84	14.40	87.60	18.49	−2.58	0.013*	−23.60	−2.88
Metabolic								
HbA1c (%)	7.81	2.16	5.25	0.49	−6.50	<0.001***	−3.35	−1.77
Insulin (mIU/L)	15.36	7.30	10.11	6.67	−2.95	0.004**	−8.79	−1.69
IR	2.34	1.12	1.36	0.091	−3.78	<0.001***	−1.49	−0.46
TC (mg/dL)	185.70	31.99	186.21	33.16	0.06	0.950	−16.05	17.05
TG (mg/dL)	217.16	149.73	102.06	47.00	−4.13	<0.001***	−170.43	−59.46
HDLc: men (mg/dL)	40.90	8.17	46.28	12.89	1.05	0.306	−5.45	16.22
HDLc: women (mg/dL)	41.05	7.72	62.72	18.66	4.86	<0.001***	12.67	30.66
LDLc (mg/dL)	103.06	35.90	103.93	28.60	0.10	0.916	−15.56	17.31
MDA (mmol/mg)	3.72	1.88	2.76	2.41	−1.73	0.088	−2.06	0.14
No. factors MS	3.53	1.40	1.46	1.54	−5.48	<0.001***	−2.81	−1.31
Psycho-cognitive								
Stressful events (SEs)	22.75	10.00	20.25	8.55	−1.05	0.296	−7.26	2.24
Current SE index	47.02	25.49	45.48	18.70	−0.27	0.787	−12.84	9.72
Past SE index	38.67	20.03	44.05	19.32	1.07	0.286	−4.61	15.37
Stroop 2 test[b]	34.96	10.34	39.25	10.30	1.58	0.118	−1.11	9.68
Clinical								
Systolic blood pressure	129.46	18.70	116.34	14.24	−3.10	0.003**	−21.59	−4.65
Diastolic blood pressure	79.00	11.44	72.05	12.15	−2.30	0.025*	−13.04	−0.92
Duration of T2DM (years)[c]	5.23	5.71	–	–	–	–	–	–
Lifestyle								
HPLP Index	52.61	16.39	54.92	13.62	0.59	0.553	−5.45	10.08
Nutrition	56.70	22.82	57.52	22.20	0.14	0.888	−10.81	12.46
Exercise	28.96	24.70	44.30	31.53	2.08	0.041*	0.62	30.04
Responsibility in health	37.01	20.04	36.77	15.57	−0.05	0.959	−9.48	9.00
Stress management	49.26	17.92	48.07	15.52	−0.27	0.786	−9.82	7.46
Interpersonal support	58.94	20.92	62.21	15.40	0.69	0.492	−6.19	12.71
Self-actualization	70.20	19.56	71.54	14.31	0.30	0.762	−7.47	10.16

DMG: diabetes mellitus group; CG: control group; BMI: body mass index; M: men; W: women; HbA1c: glycosylated hemoglobin; IR: insulin resistance; TC: total cholesterol; TG: triglyceride; HDL: high-density lipoprotein; LDL: low-density lipoprotein; MDA: malondialdehyde; MS: metabolic syndrome; HPLP: Health Promotion Lifestyle Profile; T2DM: type 2 diabetes mellitus; SD: standard deviation; CI: confidence interval; DMG (n = 30); CG (n = 32).
[a]N = 59.
[b]N = 61.
[c]N = 27.
*≤. 05; **≤ .01; ***< .001.

preferences (high, medium, and low preference for unhealthy behaviors) were not significant. However, the nutrition variable showed an interesting outcome. As shown in Figure 1, participants of both groups revealed they had implicit preferences for unhealthy behaviors. The DMG exhibited contradictory behavior in relation to the high scores on the subscale of nutrition (regular food intake and appropriate selection) with high preferences for unhealthy foods, which confirmed the inconsistency between what these individuals say they do and what they may actually do.

Discussion

The objective of the study was to investigate the effect that different type of variables have on glucose levels in adults with and without T2DM. The results showed a significant effect on at least one of the following variables: socio-demographic, metabolic, and lifestyle practices on glycemic status in adults with T2DM. Less years of education and negative self-actualization scores as well as higher levels of TG explained more than 50% of the variance of blood glucose

Table 2. Summary of multiple-regression models with backward method with HbA1c as the dependent variable, in DMG and CG.

	DMG n=30								CG n=32						
	$F_{(11,17)}=2.77$; $p=0.029$; $R^2=0.410$	$F_{(10,18)}=3.22$; $p=0.015$; $R^2=0.443$	$F_{(9,19)}=3.77$; $p=0.007$; $R^2=0.472$	$F_{(8,20)}=4.46$; $p=0.003$; $R^2=0.497$	$F_{(7, 21)}=5.14$; $p=0.002$; $R^2=0.509$	$F_{(6,22)}=6.05$; $p=0.001$; $R^2=0.520$	$F_{(5, 23)}=7.22$; $p<0.001$; $R_2=0.526$	$F_{(4, 24)}=8.54$; $p<0.001$; $R_2=0.519$	$F_{(11, 19)}=2.31$; $p=0.052$; $R^2=0.326$	$F_{(10,20)}=2.67$; $p=0.029$; $R^2=0.359$	$F_{(9,21)}=3.08$; $p=0.016$; $R^2=0.385$	$F_{(8,22)}=3.41$; $p=0.011$; $R^2=0.392$	$F_{(7,23)}=3.93$; $p=0.006$; $R^2=0.407$	$F_{(6,24)}=4.43$; $p=0.004$; $R^2=0.407$	$F_{(5,25)}=4.79$; $p=0.003$; $R^2=0.387$
Models	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7
IVs included	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
Socio-demographic															
Education (years)	−0.141	−0.141	−0.136	−0.136	−0.158*	−0.160*	−0.151*	−0.151*	−0.021	−0.021	−0.020	−0.018	**−0.019**	X	X
Metabolic															
TC (mg/dL)	0.031*	0.031**	0.031**	0.031**	0.030**	0.029**	0.031**	0.029**	0.009*	0.009*	0.009**	0.008*	0.007*	0.007*	0.006*
TG (mg/dL)	0.003	0.003	0.003	0.003	0.004	0.004	0.004*	0.004*	**0.001**	X	X	X	X	X	X
HDLc (mg/dL)	−0.010	**−0.010**	X	X	X	X	X	X	−0.010	−0.009	−0.009	−0.010	−0.010*	−0.010	−0.010*
MS	0.621	0.619	0.699	**0.703**	X	X	X	X	0.695*	0.681*	0.634*	0.514*	0.571**	0.584**	0.561*
Clinic															
DBP (mm/Hg)	−0.027	−0.027	−0.029	−0.030	−0.023	**−0.023**	X	X	−0.008	−0.009	**−0.008**	X	X	X	X
Lifestyle															
Stress man	0.015	0.015	0.017	0.019	**0.019**	X	X	X	0.003	**0.003**	X	X	X	X	X
Exercise	0.005	0.005	**0.004**	X	X	X	X	X	0.007	0.007	0.007*	0.008*	0.008*	0.007*	0.005
Nutrition	**0.001**	X	X	X	X	X	X	X	−0.009	−0.009	−0.008	−0.008	−0.007	**−0.006**	X
Health-resp	−0.023	−0.023	−0.023	−0.021	−0.026	−0.018	**−0.020**	X	0.007	0.007	0.007	**0.005**	X	X	X
Self-actual	−0.031	−0.031	−0.031	−0.032	−0.034	−0.026	−0.029	−0.039*	0.018*	0.018*	0.019*	0.018*	0.021**	0.018**	0.016*

IVs: independent variables; DMG: diabetes mellitus group; CG: control group; TC: total cholesterol; TG: triglyceride; HDLc: high-density lipoprotein; MS: metabolic syndrome; DBP: diastolic blood pressure; Stress man: stress management; Health-resp: health responsibility; Self-actual: self-actualization.
Backward method eliminated variables with $p>0.10$. Variables (X) were eliminated to adjust subsequent models.
Bold values are not significant.
*<0.05; **<0.01.

Table 3. Summary of multiple regression models with backward method with ability to adapt to changing demands as the dependent variable, in DMG and CG.

	DMG n = 30				CG n = 32			
	$F_{(6,20)} = 3.79$; $p = 0.011$; $R^2 = 0.392$	$F_{(5,21)} = 4.61$; $p = 0.005$; $R^2 = 0.410$	$F_{(4,22)} = 5.39$; $p = 0.003$; $R^2 = 0.404$	$F_{(3,23)} = 6.39$; $p = 0.003$; $R^2 = 0.384$	$F_{(6,24)} = 1.85$; $p = 0.131$; $R^2 = 0.146$	$F_{(5,25)} = 2.27$; $p = 0.078$; $R^2 = 0.175$	$F_{(4,26)} = 2.89$; $p = 0.042$; $R^2 = 0.202$	$F_{(3,27)} = 3.79$; $p = 0.022$; $R^2 = 0.218$
Models	1	2	3	4	1	2	3	4
IVs included	B	B	B	B	B	B	B	B
Socio-demographic								
Education (years)	0.643	0.565	**0.556**	X	−0.631	−0.676	−0.704	−0.766
Metabolic								
TG (mg/dL)	−0.022	−0.019	−0.022*	−0.022*	−0.021	**−0.019**	X	X
MS (mg/dL)	**3.001**	X	X	X	−6.588	−7.729	−8.963*	−8.780*
MDA (nmol/mL)	2.545**	2.404**	2.430**	2.491**	0.485	0.491	**0.500**	X
HOMA-IR	8.410	7.792	8.788*	10.07**	**−3.188**	X	X	X
Lifestyle								
Nutrition	0.098	**0.081**	X	X	−0.205*	0.204*	−0.198*	−0.181*

IVs: independent variables; DMG: diabetes mellitus group; CG: control group; TG: triglyceride; MS: metabolic syndrome; MDA: malondialdehyde; HOMA-IR: homeostasis assessment model-insulin resistance.
Backward method eliminated variables with $p > 0.10$. Variables (X) were eliminated to adjust subsequent models.
Bold values are not significant.
*<0.05; **<0.01.

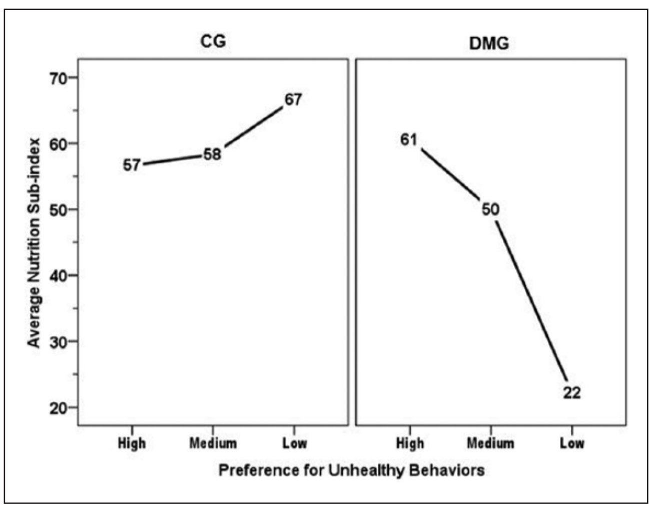

Figure 1. Relationship between preference for unhealthy behaviors and average in nutrition scores in participants in the CG (without T2DM) and DMG (with T2DM).

levels of the study sample. Notably, half of participants in the DMG showed good glycemic control, exceeding the 25% reported nationally.[3] These findings were similar to those observed in developed countries, such as Germany and Japan, which report 45% and 65% of patients with HbA1c < 7%, respectively.[19] This finding suggests some effectiveness in the education model followed by the health institution where most of the participants diagnosed with T2DM were recruited. However, it is possible that these results may be due to the consumption of medication, a direct relationship has been reported between medication adherence and glycemic control.[21]

Although prescribed as part of the treatment, diet and exercise showed no influence on glycemic results. Both behaviors reached low scores, thereby confirming what is frequently cited in literature.[20,32] Notably, most participants revealed implicit preferences for unhealthy food and exercise behaviors, implying a very important aspect to be approached by nursing practitioners. Different strategies have to be developed to facilitate changes on patients' dietary patterns framed in deep cultural-familial habits.[33]

In addition, the self-actualization subscale (lifestyle HPLP), which reflects the positive attitude people have toward the future, had low scores in participants with T2DM, suggesting a negative effect of a chronic, incurable disease. This aspect should also be addressed while assessing, planning, and monitoring T2DM progress because low adherence to treatment has been explained by the lack of interest from patients as well as nurses and health professionals.[34]

The group without T2DM showed metabolic risk indicators, such as high levels of MS and poor nutrition and exercise behaviors, characteristics akin to those previously with abdominal and general obesity. In turn, these factors have been shown to be strongly associated with T2DM and cardiovascular disease development.[8] In addition, both groups (with and without T2DM) had similar proportions of immediate relatives previously diagnosed with T2DM. It is well documented that having first-level family with T2DM increases the risk (40%–80%) of developing chronic illness,[35] independently of ethnicity.[36]

The variation in HbA1c levels in the CG (without T2DM) was explained by TC level, low percentage of subjects with MS (30%), self-actualization score, and low levels of HDL, the latter suggesting low level of exercise. These are metabolic and lifestyle factors associated with normal level of HbA1c. However, low scores in exercise and nutrition subscales, relatives with T2DM, and obesity (62%) placed some participants in the at-risk group, which may reflect the status of the general population in the northeastern area of the country, which are similar to that reported as prevalence of diabetes' risk factors worldwide.[37]

In summary, this study reveals the presence of risk factors for developing T2DM among those without T2DM and the probability of suffering complications among those with the disease, including the risk of cardiovascular disease and suffering from MS.[6,38]

It is also necessary to underline the low averages in lifestyle variables for both groups, yet it was expected that patients with T2DM would be more motivated and responsible in regard to nutrition and exercise lifestyle practices, given that most of them were enrolled in an education center. Motivation and responsibility are theoretically associated with assertive decision-making capacity and are needed for self-care and diabetes management.[4] But these variables were not measured in this study.

The variables that explain the capacity to adapt to changing demands and suppress usual responses in the DMG suggest alterations in biochemical fractions leading to beta cell dysfunction, such as MDA and IR.[7] Patients with T2DM who do not adhered to the type and quantity of food consumed and exercise presented overweight or obesity, highlighting the risks these patients posses of developing complications that further affect their health and quality of life.[9,11,20,36] These participants reported having average scores on the subscale of nutrition but paradoxically with implicit high preferences for unhealthy foods.

CG participants were educated, although not significant ($p = 0.078$) and had inexplicably negative effect on the Stroop 2 test, indicating that more years of education led to lower capacity to adapt to changing demands, indicating less flexibility. These results warrant further investigation as to whether higher education levels can make people more reluctant to change behaviors in favor of their health.

Upon the representation of scores in the nutrition subscale as related to the food preferences ratio, albeit lower compared to the DMG, the results were contrary to expectations, which suggested a possible discrepancy between what individuals think and what they do. Such situations have to be identified in the daily practice of nurses. Some authors attribute this pattern of responses to culture because socially, one expresses what others want to hear but then acts differently to derive satisfaction. In the case of food, they exhibited a taste for foods that are high in carbohydrates and fat and low in fiber. Moreover, they showed preference for sedentary rather than an active lifestyle.[39]

It is imperative to search for more effective health promotion and prevention strategies specific to reducing the risk factors observed in CG. This is assuming that these findings reflect the situation of the general population.

The results of this research should be considered with certain limitations such as small sample size and convenience sampling (self-selection bias). This may have influenced the high proportion of people without T2DM having relatives diagnosed with the disease. Drug treatment records for every patient were also omitted, which may alter biochemical results because the use of secretagogues (e.g. sulfonylureas, glinides) may increase plasma insulin levels and decrease sensitizers (e.g. biguanides, metformin).

Conclusion and implications for practice

Glycated hemoglobin and the ability to adapt to changing demands were explained by different set of variables. These findings suggest a major influence of metabolic factors on the capacity to adapt to changing demands compared to the other studied variables. The DMG was older, less educated, had more general and abdominal obesity, had a higher proportion of participants with MS, and had a higher risk levels in TGs and MDA than the CG, despite the fact that half of the DMG participants showed HbA1c lower than 7%. Responses from the DMG involved the whole person and not just the lifestyle practices and metabolic disorder, which resulted in hyperglycemia. The variation explained in this group illustrates how lifestyle practices, in addition to metabolic variables, can cause lack of glycemic control, increasing the probability of T2DM complications.

The typical treatment prescribed for T2DM includes pharmacological and non-pharmacological measures that should be equally handled by the patient through self-care activities. TC alterations, MDA production, and indicators of oxidative stress suggest that chronic disease progression can interfere with the care of the person, regardless of their attachment to habitual treatments. In addition, decision-making that is affected by subconscious mechanisms may also explain the failure to comply with such indications.

The findings of this study have implications for practice. Nursing care of patients with T2DM should be extended to their families, who in turn are at high risk to develop the chronic disease. In addition, dietary factor may be addressed because family plays an important role in family diet modifications. Dietary issues have to be managed considering their understanding of T2DM and diet as well as the attitudes and practices of the patient and family. Individual counseling and/or advice have to be based on these factors.

Education and monitoring self-care actions must be accompanied by an objective and comprehensive assessment of the patient because self-reporting does not correspond with chronic disease progression and further risk of health and the well-being of those with the disease. Literacy in health has to be determined and considered independently of the level of education. Occasionally, misunderstanding the risks of the disease and directions to self-care are the factors that impede patients' effective self-care behaviors.

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Informed consent

Written informed consent was obtained from all subjects before the study.

ORCID iD

Bertha Cecilia Salazar-González https://orcid.org/0000-0002-6610-8052

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