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ORIGINAL

Risk of developing Type 2 Diabetes Mellitus in a vulnerable community in northern Argentina

Riesgo de desarrollar Diabetes Mellitus Tipo 2 en una comunidad vulnerable del norte de Argentina

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ABSTRACT

Introduction: Prevention of diabetes requires sustained lifestyle changes as well as identification of groups at higher risk. **Objective:** The aim of this research was to estimate the risk of diabetes in vulnerable subjects from a primary care center in northern Argentina, with no known glucose abnormalities, using the FINDRISC questionnaire, investigate the relationship between survey variables and the final score, and explore its association with metabolic risk factors and body composition. **Methodology:** This cross-sectional design included 498 patients without type 2 diabetes or known glycemic abnormalities. All subjects underwent a complete medical history and completed the FINDRISC questionnaire. **Results:** The predominant age group was 18-45 years old. Around 64% were physically active and 44% reported daily consumption of fruit and vegetables. Most of them had a BMI higher than 25 kg/m^2. Regarding the risk of developing type 2 diabetes in the next 10 years, 24.3% were at low risk and the remaining fraction was distributed in slightly elevated, moderate, high and very high risk. All variables influenced the individuals' variance ($p < 0.05$). The hierarchical clustering and principal component analysis (PCA) revealed that elevated FINDRISC score was strongly associated with age > 65 years, fasting blood glucose, BMI ≥ 30 kg/m^2 and antihypertensives use. **Conclusion**: We found a high percentage of obesity and overweight, as well as a high risk of cardiometabolic disease and of developing T2D. In addition, in the population studied, the variables that compose the FINDRISC did not influence the highest score in the same way.

Keywords: Type 2 Diabetes; Body Mass Index (BMI); Questionnaire.

RESUMEN

Introducción: La prevención de la diabetes requiere cambios sostenidos en el estilo de vida, así como la identificación de los grupos de mayor riesgo. **Objetivo**: El objetivo de esta investigación fue estimar el riesgo de diabetes en sujetos vulnerables de un centro de atención primaria del norte argentino, sin anomalías glucémicas conocidas, mediante el cuestionario FINDRISC; investigar la relación entre las variables de la encuesta y el puntaje final; y explorar su asociación con factores de riesgo metabólico y composición corporal. **Metodología:** Este diseño transversal incluyó a 498 pacientes sin diabetes tipo 2 ni anomalías glucémicas conocidas. A todos los sujetos se les realizó una historia clínica completa y rellenaron el cuestionario FINDRISC. **Resultados:** El grupo de edad predominante era el de 18-45 años. Alrededor del 64 % eran físicamente activos y el 44 % declararon consumir fruta y verdura a diario. La mayoría tenía un IMC superior a 25 kg/m^2. En cuanto al riesgo de desarrollar diabetes tipo 2 en los próximos 10 años, el 24,3 % presentaba un riesgo bajo y la fracción restante se distribuía en riesgo ligeramente elevado, moderado, elevado y muy elevado. Todas las variables influyeron en la varianza de los individuos ($p < 0,05$). La agrupación jerárquica y el análisis de componentes principales (ACP) revelaron que la puntuación FINDRISC elevada estaba fuertemente asociada con: edad > 65 años, glucemia en ayunas, IMC ≥ 30 kg/m^2 y uso de antihipertensivos. **Conclusión:** Encontramos un alto porcentaje de obesidad y sobrepeso, así como un alto riesgo de enfermedad cardiometabólica y de desarrollar DT2. Además, en la población estudiada, las variables que componen el FINDRISC no influyeron de la misma manera en la puntuación más alta.

Palabras clave: Diabetes de Tipo 2; Índice de Masa Corporal (IMC); Cuestionario.

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INTRODUCTION

According to the International Diabetes Federation (IDF), in 2019, 463 million adults had diabetes, and this number is estimated to increase to 700 million by 2045 (1). It is associated with macrovascular and microvascular complications such as coronary artery disease, myocardial infarction, hypertension, peripheral vascular disease, retinopathy, end-stage renal disease, and peripheral neuropathy. Argentina is not exempt from this growing global prevalence and therefore represents a major health problem. The latest data refers until 2018, reporting an increase from 8.4% to 12.7% in fasting blood glucose assessed by self-monitoring (2).

Type 2 diabetes mellitus (T2D) is one of the most common chronic diseases worldwide. T2D is a complex metabolic disorder characterized by sustained hyperglycemia caused by insufficient insulin secretion or inability of insulin-sensitive tissues to respond properly to insulin. T2D is a health problem, especially in low-income countries where the mortality from diabetes-associated vascular complications is approximately 80% (3). The course and progression of this disease are influenced by social factors, which also have a negative impact on prognosis. Therefore, T2D is considered a social disease (4,5). Therefore, early diagnosis is important, and even more so, the identification of individuals at high risk of developing diabetes, particularly in vulnerable populations where, due to different factors, it is not performed. To detect these cases, low-cost and accurate screening tools are required. Several TD2 risk scores have been developed, although only a few have been developed for Latin America and the Caribbean (LAC) (6).

Several tools have been developed to predict diabetes in individuals without known glucose metabolism disorders, most of which are based on clinical and anthropometric variables and biochemical measurements (7). One of them is the Finnish Diabetes Risk Score (FINDRISC), which is a T2D risk score. The FINDRISC was the first lifestyle and clinical parameter predictive scale for identifying subjects at risk for T2D. It covers eight aspects: age, body mass index (BMI), waist circumference (WC), physical activity, diet, use of antihypertensive drugs, high blood glucose personal history, and family history of diabetes (8). However, in the literature consulted, only a few papers report its application in Argentina, and there is no analysis available on which parameters have the greatest influence on its results. In this context, the aim of this research was to estimate the risk of diabetes in subjects from a primary care center in northern Argentina, with no known glucose abnormalities, using the FINDRISC questionnaire, investigate the relationship between survey variables and the final score, and explore its association with metabolic risk factors and body composition.

METHODOLOGY

Study design/patient selection

This analytical and cross-sectional observational study included 498 patients without T2DM and with no known glycemic abnormalities (162 males/336 females) registered at a primary care center in Tucumán (Argentina), which mainly attends individuals from vulnerable areas, from September 2020 to March 2021. The calculated sample size was 302, considering a population of 1400 adults over 18 years of age attending the primary care center, with a confidence level of 97% and a power of 90%. To obtain an effective sample, 498 patients (162 males/336 females) were included using simple random sampling. For this purpose, a list of patients registered during the study period was prepared and a unique number was assigned to each patient. Microsoft Excel was used to generate random numbers. Patients corresponding to these numbers were selected from the sample.

The inclusion criteria were outpatients, residents of the city of San Miguel de Tucumán, over 18 years of age, and both sexes. All patients underwent a full clinical evaluation, including demographic, socioeconomic, and personal data, and family history of previous illnesses. Pregnant patients, individuals with any disability that prevented them from engaging in physical activity, pre-diagnosis of T2D, and incomplete data in the FINDRISC questionnaire were excluded from this protocol.

The variables studied were as follows: Sex: Male (M) and Female (F), Age: years, education: Subjects' education levels were assessed based on their completed years of schooling and stratified into primary, secondary, and university. Individuals with no prior education were considered at the primary level. This information was collected through self-report. Marital status: Single (S) or married (M). Economic income: Total monthly economic income was stratified into low-income (below $150) and middle income ($150-300). This information was collected through self-report.

Occupation: Working, retired, and unemployed. Excess weight (EW): classified as overweight or obese based on the BMI. Cardiovascular and metabolic risk: From WC measurements. For this purpose, the currently recommended cut-off points for identifying

CVD risk were used: high risk, individuals with mild visceral obesity (Female 80-88; / Male 94-102) and very high risk, subjects with established visceral obesity (female > 88; male > 102) (9).

Diabetes mellitus risk based on the results of the FINDRISC questionnaire. Weight and height were measured using a mechanical adult scale (Rome BPP-S w/Altimeter, Hijos de Francisco DINO S.R.L., Rosario, Argentina), with light clothing and no shoes, ankles together, relaxed shoulders, and both arms at the sides of the body. BMI was estimated using Quetelet's index (weight/size2). WC was measured with an anthropometric tape measure (Lufkin W606PM, New York) at the site of maximum circumference midway between the lower ribs and anterior superior iliac spine.

All participants completed the FINDRISC questionnaire to estimate the risk of developing T2D in 10 years. The total score ranged from 0 to 26 points. Less than 7 points: Low risk. It is estimated that 1 in 100 patients will develop the disease. 7 to 11 points: slightly elevated risk. It is estimated that 1 in 25 patients will develop the disease. 12 to 14 points: moderate risk. It is estimated that 1 in 6 patients will develop the disease. 15 to 20 points: high risk. It is estimated that 1 in 3 patients will develop the disease. More than 20 points: extremely high-risk. It is estimated that 1 in 2 patients will develop the disease.

Statistical analysis

Statistical analysis was performed using the IBM SPSS Statistics ver. 25.0 (IBM Co., Armonk, NY, USA). All data are expressed as frequencies and percentages for categorical data and medians with Q1 and Q3 for numerical data. Differences in the study participants' characteristics were compared across subgroups using the chi-square test. Statistical significance was set at p value < 0.05. Statistical power calculation was performed using the G*Power software ver. 3.1.9.6 (Franz Faul, University Kiel, Germany). Hierarchical clustering and principal component analysis (PCA) was performed using the statistical package ver. 4.0.3 (2020-10-10).

Ethical statement

Ethical approval for this study (Ethical Committee N° 21/2021) was provided by the Research Ethics Committee (CEI) of SIPROSA, Tucumán, Argentina, and written informed consent was obtained from all patients.

RESULTS

Demographic and clinical characteristics of the study participants are shown in Table 1. The predominant age group was 18-45 years old and mainly women. According to the education level, approximately 93% had completed basic studies. Among the participants, 76% reported low monthly income and were employed. In addition, 64% were physically active (at least 30 min of walking per day), and 44% reported daily fruit and vegetable consumption. One-third of the participants had a family history of diabetes mellitus, and only 15% had high blood glucose levels.

In agreement with the World Health Organization (WHO), overweight and obesity are defined as BMI values equal to or higher than 25 and 30 kg/m ^{2}, respectively, considered both EW patients (10). The general population showed a mean BMI of 28.06±5.48 kg/m^2. Only 30% were within the normal range, while the rest were EW. Additionally, significant differences were observed between sexes regarding the overweight and obesity proportion (females: 34% overweight and 34% obese vs. males: 45% overweight and 28% obese) (Table 2).

Cardiovascular and metabolic risk analyses were performed after excluding patients with a personal history of hypertension (n=109). This risk based on WC was very high for 44.3% (n=172) and high for 24.3% (n=93) of the participants. Table 3 shows the significant differences between sexes (very high risk was more prevalent in women).

Regarding the risk of developing T2D in the next 10 years, if the total population is considered, 24.3% were at low risk and the remaining fraction was distributed as slightly elevated, moderate, high, and very high risk. Table 4 presents the sex analysis, highlighting the major T2D risk in females.

TABLE 1. DEMOGRAPHIC AND CLINICAL CHARACTERISTICS OF THE GROUP STUDIED (N=498).

		n	%
Sex	Female	336	67.5
	Male	162	32.5
Age (years)	18-45	274	55.0
	46-54	86	17.3
	55-64	92	18.5
	>65	46	9.2
Alfabetización	Primary school	35	7
	Secundary school	314	63
	University	149	30
Current marital status	Married	294	59
	Unmarried	204	41
Monthly household income (US$)	<150	378	76
	151 - 300	110	24
Ocupation	Laborer	382	76.7
	Retired	38	7.6
	Not working	78	15.7
BMI (kg/m2)	Low or normal weight (<25.0)	153	30.7
	Overweight (25.0–29.9)	191	38.4
	Obese (≥30.0)	154	30.9
WC (cm)	Female / Male (<80 / <94)	82/47	24.4 / 29.0
	Female / Male (80-88 / 94-102)	63/52	18.8 / 32.1
	Female / Male (>88 / >102)	191/63	56.8 / 38.9
DPA	Yes	318	63.9
	No	180	36.1
DVC	Yes	220	44.2
	No	278	55.8
AU	Yes	107	21.5
	No	391	78.5
HBG	Yes	76	15.3
	No	422	84.7
FHD	No	184	36.9
	Yes, not fi rst degree	132	26.5
	Yes; fi rst degree	182	36.5
Score FR	Low (<7)	121	24.3
	Slightly elevated (7-11)	154	30.9
	Moderate (12-14)	96	19.3
	High (15-20)	103	20.7
	Very High (>20)	24	4.8

All data are expressed as frequency and percentage for categorical data. BMI: Body mass index; WC: waist circumference; DPA: daily physical activity; DVC: daily vegetable consumption; AU: antihypertensive use; HBG: history of high blood glucose; FHD: family history of diabetes; score FR: FINDRISK score.

TABLE 2. OBESITY AND OVERWEIGHT BY GENDER OF THE GROUP STUDIED (N=498).

BMI	Female		Male		*p*	β
	N	%	n	%		
Underweight (Below 18.5)	5	1.49	1	0.62		
Normal or Healthy Weight (18.5 – 24.9)	104	30.95	43	26.54		
Overweight (25.0 – 29.9)	114	33.93	72	44.44		
Obesity I (30 to < 35)	71	21.13	34	20.99	0.03	0.99
Obesity II (35 to < 40)	26	7.74	11	6.79		
Obesity III (40 or higher)	16	4.76	1	0.62		
Total	336	100	162	100		

BMI: body mass index. All data are expressed as frequency and percentage. Significant $p < 0.05$.

TABLE 3. CARDIOVASCULAR AND METABOLIC RISK ACCORDING TO WAIST CIRCUMFERENCE OF THE GROUP STUDIED (N=498).

CC	Female		Male		*p*	β
	n	%	n	%		
No visceral obesity (Female < 80; / Male <94)	79	28.62	45	39.82		
Slight visceral obesity (Female 80-88; / Male 94-102)	55	19.93	38	33.63	0.001	0.92
Established visceral obesity (Female > 88; Male > 102)	142	51.45	30	26.55		
Total	276	100	113	100		

WC: waist circumference. All data are expressed as frequency and percentage. Significant $p < 0.05$.

TABLE 4. RISK OF DEVELOPING DIABETES OF THE GROUP STUDIED (N=498).

FINDRISK -Score	Female		Male		*p*	β
	N	%	n	%		
Low (<7)	71	21.13	50	30.86		
Slightly elevated (7-11)	105	31.25	49	30.25		
Moderate (12-14)	68	20.24	28	17.28	0.03	0.70
High (15-20)	79	23.51	24	14.81		
Very High (>20)	13	3.87	11	6.80		
Total	336	100	162	100		

All data are expressed as frequency and percentage. Significant $p < 0.05$.

Figure 1 shows the clustering of subjects according to the qualitative variables studied. All factors influenced individuals' variance ($p < 0.05$). Furthermore, subjects were distributed in three clusters (cluster1=26.65%, cluster2= 37.87% and cluster3= 35.27%), and elevated FINDRISC score was strongly associated with age > 65 years, elevated fasting blood glucose, BMI ≥ 30 kg/m^2, and antihypertensive use and least with WC.

FIGURE 1. MULTIPLE CORRESPONDENCE AND CLUSTER ANALYSIS WITH Facto MineR

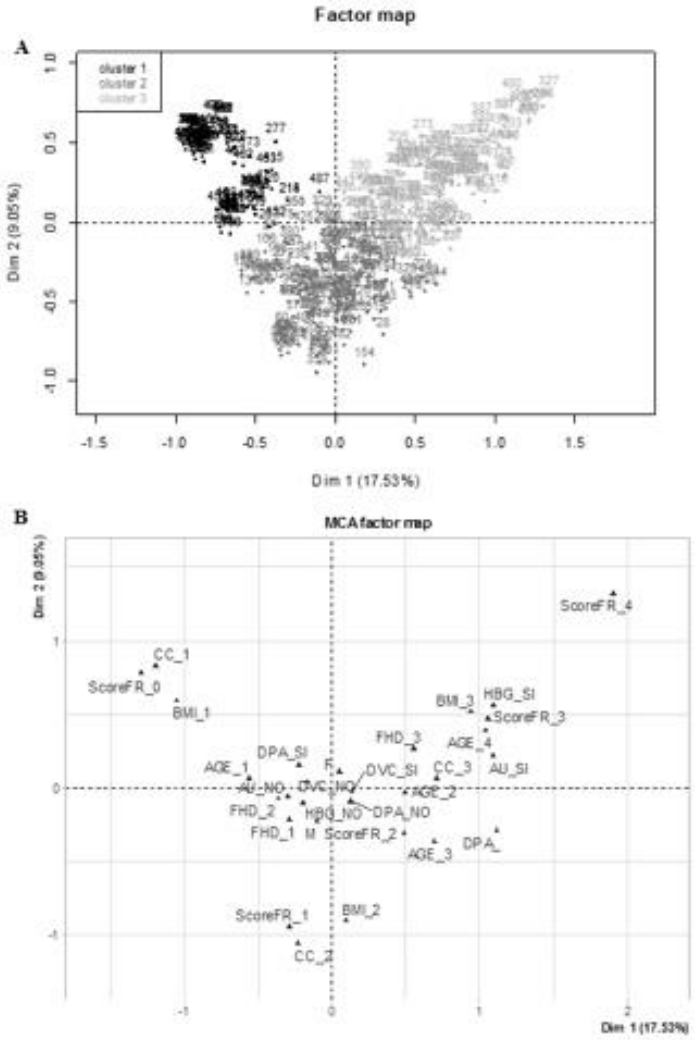

Figure 1. Multiple correspondence and cluster analysis with FactoMineR.
a) Hierarchical clustering. All subjects are shown colored according to the corresponding
b) Variable association map. Each variable is displayed in a triangle. Only the most cont
categories are represented. A greater proximity means a greater association. BMI: bo
index; WC: waist circumference; DPA: daily physical activity; DVC: daily vegetable consu
AU: antihipertensive use; HBG: history of high blood glucose; FHD: family history of d
score FR: FINDRISK score.

DISCUSSION

The global prevalence of chronic non-communicable diseases (NCD), such as diabetes, has increased considerably because of population growth and aging. In South and Central America, approximately 24% of adults with diabetes are undiagnosed, reaching 50% in some countries (11). According to the 2021 IDF data analysis, Brazil, Mexico, Colombia, Argentina, Venezuela, and Chile have the fastest growing prevalence of T2D in the world (12). This is a serious concern because an increased diabetes prevalence will lead to more acute and chronic diseases in the general population, which will affect healthcare demand, economic costs, and quality of life (13).

Available information from Argentina was derived from the report of the 4th national survey of risk factors for NCD. In addition, the FINDRISC is proposed to be applied to estimate the risk of developing T2D in the next 10 years at the population level. However, this information has not yet been published (14). Given the epidemic rate, early detection of diabetes in the non-symptomatic stages and management of risk factors are crucial to prevent its progression and/or associated comorbidities. The aim of this research was to estimate the risk of diabetes in subjects from a primary care center in northern Argentina, with no known glucose abnormalities, using the FINDRISC questionnaire, investigate the relationship between survey variables and the final score, and explore its association with metabolic risk factors and body composition.

Studies of Organization for Economic Co-operation and Development (OECD) countries use income to identify social classes. From a purely economic perspective, the middle class usually means having financial security and the ability to invest in the future (15). According to the socio-demographic indicators in this study, approximately 76% of the participants had low incomes and around 77% were actively employed. The educational level of the population studied suggests a limited ability to boost social mobility, thus highlighting vulnerability. These results are in accordance with data published by the latest National Institute of Statistics and Censuses of the Argentine Republic (INDEC) report (16). On the other hand, the 17th report of the Development Bank in Latin America revealed that the middle class has grown in the last decade, although it is more exposed when factors other than income are considered (17).

Latin America has experienced major socioeconomic and demographic shifts over the last few decades, with simultaneous changes in lifestyle and nutritional and epidemiological profiles. As the population becomes more sedentary and its dietary energy density increases, obesity and related NCD have emerged as major public health problems (18). Obesity has become a pandemic disease characterized by excessive or abnormal fat accumulation in adipose tissue, leading to health risks and implications. It is the most important factor causing insulin resistance and is mainly compensated for by hyperinsulinemia (19). A considerable finding of this investigation was that the patients were mostly overweight or obese. A study conducted in Argentina, based on the National Risk Factor Survey (ENFR) of NCD where 46555 subjects were surveyed, found a similar prevalence of overweight (37.1%) and obesity (20.8%) (20). Our results are consistent with those of Ruderman et al., who measured anthropometric variables such as weight, height, waist circumference, and hip circumference to calculate BMI, waist-to-hip ratio, and waist-to-height ratio in 6776 adult volunteers from Brazil, Chile, Colombia, Mexico, and Peru, revealing high percentages of obesity in all measurements (21). Given the characteristics of obesity, several studies have been conducted to establish its association with T2D risk. The evidence collected so far shows that, compared to normal BMI, overweight and obesity are significantly associated with T2D diagnosis risk. Therefore, clinicians should regularly monitor the weight of obese patients (22). However, BMI can confound muscle mass with regional or ectopic fat deposition; therefore, other indicators of body composition and adiposity have been evaluated, including WC.

In the analysis based on the FINDRISC questionnaire score, more than half of the participants were at moderate to high risk for T2D over the next 10 years. Our results are consistent with those of Atayoglua et al., who investigated the risk of T2D in 1500 healthy individuals in the Kayseri province (Turkey) (23). Silvestre et al., also evaluated the efficacy of a high FINDRISC score in identifying undiagnosed prediabetes and T2D in a New Zealand population of overweight and obese individuals, across a variety of ethnic groups and found similar results (24). Recent studies conducted in Mexico and Paraguay, which included 383 and 112 subjects, respectively, concluded that there is a high percentage of participants at risk of developing TD2 using the FINDRISK questionnaire (25,26). An interesting finding of this study was that in both women and men, abnormal values of different parameters and scales related to cardiovascular risk were more unfavorable in those with higher FINDRISC scores. Age, antihypertensive drug use, and abnormal glycemia were also found to have a greater influence on elevated FINDRISC scores.

We did not find relevant studies in Argentina that used this questionnaire; therefore, we could not compare it with other populations in our region. However, a study carried out in Madrid with 59,041 workers showed that people with FINDRISC scores above 15 had higher values for BMI and WC and a higher prevalence of hypertension and dyslipidemia than those with FINDRISC scores below 15 (27). Furthermore, a Turkish study demonstrated that there was a statistically significant relationship between FINDRISC total score, sex, BMI, and WC, finding that the diabetes risk was higher with higher scores as BMI and WC increased (23). A recent study in Burkina Faso showed that age, daily physical activity, antihypertensive medication use, and WC were score variables significantly associated with the risk of developing T2D (28). These results suggest that not all variables comprising the original FINDRISC influence the final score in the same way and should be analyzed according to the specificities of the populations. Therefore, it is important to validate the questionnaire for our population and consider changes (29,30).

In brief, keeping in mind that early detection of diabetes in asymptomatic stages is crucial to prevent progression and/or associated comorbidities, this study has interesting points: first, the population studied came mainly from vulnerable areas where information in our community is limited; second, we detected a high percentage of patients with overweight and obesity, as well as with high cardiometabolic risk; in addition, it also provided data

regarding the risk of developing T2D in subjects with no known history of glycemia alterations; and finally, we made a first approach to the factors most associated with an elevated FINDRISC score.

This study has some limitations: it is a cross-sectional design that only allows for association but not causality, and it is a preliminary study. On the other hand, the experimental design used does not allow us to validate FINDRISC for our population, although it does show the prevalence of T2D risk and the relationship between the different variables and the score.

AUTHORS CONTRIBUTIONS

AMN, LMC AND HLL have participated in the conception and design of the article. AMN, LMC, MMS, PM, CMM and HLL have participated in data collection and analysis. AMN, LMC have participated in data interpretation, statistical analysis and writing the article. AMN, LMC, MMS, PM, CMM and HLL have contributed ideas, reviewed drafts and approved the final version of the article.

DATA AVAILABILITY

Data are available upon request to the corresponding author.

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