Type 2 diabetes mellitus non-lab pre-screening in schoolchildren aged 3-6 years in Eastern Amazon, Brazil

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Abstract

Type 2 Diabetes mellitus is a chronic disease that affects more than 415 million people worldwide. Some risk factors to consider among children are poor diet, obesity, physical inactivity, family history, if the mother has been diagnosed with gestational diabetes mellitus and early weaning. Our objective was to propose a non-lab pre-screening test for Type 2 Diabetes mellitus among preschoolers aged 3 to 6 years old in the Amazon region, Maraba, Brazil. Our sample comprised (N=425) children enrolled in a public preschool and their respective caregivers/parents. A discriminant analysis was used to test the score's ability to maximize the differences between groups according to the relation to the risk factors for Type 2 Diabetes mellitus. Our results suggested that our proposed pre-screening test for Type 2 Diabetes mellitus-using assessment of risk factors is as simple as statistically significant based on heredity, overweight/obesity, physical inactivity, and habit of intake high-calorie foods. The proposed pre-screening test for Type 2 Diabetes mellitus using assessment of risk factors is a simple as statistically significant method for potentially identifying children at risk for Type 2 Diabetes mellitus in schools.

Keywords: Diabetes mellitus, type 2; Epidemiology; risk factors; child.

Resumo

Diabetes mellitus tipo 2 é uma doença crônica que afeta mais de 415 milhões de pessoas em todo o mundo. Alguns fatores de risco, relevantes entre as crianças, são: má alimentação, obesidade, sedentarismo, história familiar, diabetes mellitus gestacional e desmame precoce. O objetivo deste estudo foi propor um teste não laboratorial de pré-triagem para diabetes mellitus tipo 2 entre pré-escolares de 3 a 6 anos na região Amazônica, Marabá, Brasil. Nossa amostra foi composta (N=425) crianças matriculadas em uma pré-escola pública e seus respectivos responsáveis/pais. A análise discriminante foi utilizada para testar a capacidade do escore em maximizar as diferenças entre os grupos de acordo com a relação dos fatores de risco para Diabetes Mellitus tipo 2. Nossos resultados sugeriram que nosso teste de pré-triagem proposto para Diabetes Mellitus tipo 2 usando a avaliação de fatores de risco são simples, entretanto, são estatisticamente significativos com base na hereditariedade, sobrepeso / obesidade, sedentarismo e hábito de ingestão de alimentos altamente calóricos. O teste de pré-triagem proposto para Diabetes Mellitus tipo 2 usando avaliação de fatores de risco é um método simples e estatisticamente significativo para identificar potencialmente crianças em risco de desenvolver Diabetes Mellitus tipo 2 nas escolas.

Palavras-chave: Diabetes mellitus tipo 2; Epidemiologia; fatores de risco; criança.

Resumen

La Diabetes mellitus tipo 2 es una enfermedad crónica que afecta a más de 415 millones de personas en todo el mundo. Algunos factores de riesgo a considerar en los niños son la mala alimentación, la obesidad, la inactividad física, los antecedentes familiares, si la madre ha sido diagnosticada con diabetes mellitus gestacional y el destete precoz. Nuestro objetivo fue proponer una prueba de preselección no de laboratorio para Diabetes mellitus tipo 2 entre preescolares de 3 a 6 años de edad en la región amazónica, Maraba, Brasil. Nuestra muestra estuvo compuesta por (N=425) niños matriculados en un preescolar público y sus respectivos cuidadores/padres.

Se utilizó una análisis discriminante para probar la capacidad de la puntuación para maximizar las diferencias entre los grupos según la relación con los factores de riesgo para la diabetes mellitus tipo 2. Nuestros resultados sugirieron que nuestra prueba de preselección propuesta para la diabetes mellitus tipo 2, que utiliza la evaluación de los factores de riesgo, es tan simple como estadísticamente significativa en función de la herencia, el sobrepeso/obesidad, la inactividad física y el hábito de ingerir alimentos ricos en calorías. La prueba de preselección propuesta para la diabetes mellitus tipo 2 mediante la evaluación de los factores de riesgo es un método simple y estadísticamente significativo para identificar potencialmente a los niños en riesgo de diabetes mellitus tipo 2 en las escuelas.

Palabras clave: Diabetes mellitus tipo 2; Epidemiología; factores de riesgo; niño.

1. Introduction

Diabetes mellitus (DM) is a public health problem1, it is a chronic metabolic disease with several risk factors as the social level, nutrition, physical inactivity, environmental, and genetic susceptibility (Aye & Levitsky, 2003; Temneanu et al., 2016; Vitória & Guandalini, 2017). Type 2 diabetes (DM2) accounts for the vast majority (around 90%) of diabetes worldwide (International Federation, 2019).

DM affects more than 463 million people worldwide and this number is projected to reach 700 million by 20451. In South and Central America has 31.6 million cases of DM, in Brazil, approximately 16,8 million adults and more than 127,200 children have this disease. In the world ranking Brazil is second only to India and the United States (International Federation, 2019).

The incidence of DM2 increases with age and obesity1 with great majority of children with DM2 are overweight or obese (Fagot-Campagna, 2000; Zaccarelli-Marino et al., 2020). Also, obesity among youth is an important risk factor in developing DM22 and can increase the risk of DM2 in 3 times (Soliman et al., 2014; Zaccarelli-Marino et al., 2020). DM2 is associated with serious complications such as cardiovascular disease, kidney disease, retinopathy leading to blindness and limb amputations, contributing with contribute to high morbidity and mortality rates in patients with diabetes mellitus. That being said, the early diagnosis and early initiation of therapy may prevent or delay the onset of long-term complications (Temneanu et al., 2016). Moreover, adolescents and children with DM are at risk of developing complications in early adulthood o micro- and macrovascular complications, retinopathy, nephropathy and nerve damage (International Federation, 2019).

In addition, younger people present some common risk factors as a poor diet, obesity, physical inactivity, family history, if the mother has been diagnosed with gestational diabetes mellitus and early weaning. Type 2 diabetes is rising rapidly in children and adolescents worldwide (Serbis et al., 2021). DM2 has significantly affected approximately 1 million children annually in the word. In Brazil, Health policies have been implemented targeting this specific population, as the Health at School Program (PSE) that works through the intersectionality between primary health care and educational institutions working together to offer and to promote collective and individual care, reducing the risks and injuries that may harm the health of children and adolescents (Brasil, 2007; Serbis et al., 2021).

Literature shows a significant increase in DM2 among the young population (Zaccarelli-Marino et al., 2020), however few studies have been carried out in Brazil, specifically in the Amazon region. The occurrence of new cases of DM has been increasing in recent years, especially in the disadvantaged communities, with a significant increase in incidence and prevalence. This situation can be managed through health education, changing bad habits and lifestyle combined with medication as required. This way is possible to prevent DM2 and, in some cases it is possible to remiss DM2 (International Federation, 2019).

Therefore, our aim was to describe selected screening risk factors for DM2 among students aged 3 to 6 years old in the Amazon region, Brazil. This study becomes relevant especially in the preschool context, o it might contribute to the identification of selected risk factors, identifying exposed students according to the extent of the risk in the investigated schools.

2. Methods

This cross-sectional study that was conducted at the Nucleos de Ensino Infantil (NEI) in Maraba, Para Brazil, located in the Eastern Amazon that has a population of 271,594 inhabitants, 35 early childhood education schools with 7,945 enrolled students at the ages of 3 to 6 years old.
The sample was calculated considering a percent error of 5% and a reliability of 95% with an increase of 20%

considering the possibility of losses and refusals. All children present at school on the day and time scheduled for data collection, whose parents signed the consent form and answered the questionnaire, were examined. This present study was approved by the Brazilian Research Ethics Committee (CAAE 16693019.5.0000.0018). We recruited 425 children of 9 schools aged 3 to 6 years old, who were enrolled in school and whose parents/guardians signed the consent form.

Anthropometric measurements were performed according to the techniques recommended by the World Health Organization (WHO) and their classification by sex (Onis et al., 2007). A mechanical anthropometric scale with capacity of 150kg (Incoterm), and an anthropometric tape fixed on the wall was used to measure the height of children measured standing and barefoot.

The screening questionnaire for risk factors for DM2 in school children was developed specifically for this study, in compliance with municipal law 317.829 of December 28, 2017 to control DM2 in municipal public schools. After an extensive literature review, the questionnaire was presented to a team of specialists (2 nutritionists, 3 nurses, 1 social worker, and 1 pediatrician) from the municipality in order to verify the adequacy of the questions and their relevance in content and theme. The experts suggested small adjustments in the way of writing the question, considering the low schooling of parents of public-school students in the municipality. The questionnaire consists of 12 questions:

Questions			
Age	**Sex**	**BMI Results**	**Gestational diabetes**
3 to 4 years of age	Female	Severe acute malnutrition	No
5 to 6 years of age	Male	Moderate acute malnutrition	Don't remember/Not sure
Sex		Normal	Yes
Female		Overweight	No response
Male		Obesity 1st degree	
		Obesity 2nd degree	
		No response	
Complications or birth problems	**Birth weight ≥ 4kg**	**Family with DM**	**Use of medication for hypertension**
No	No	No, no one	No/Never
Don't remember/Not sure	Don't remember/Not sure	Yes: other relatives	Yes
Yes	Yes	Yes: grandparents, aunts/uncles, cousins	No response
		Yes: parents (mother and father), siblings	
		No response	
Hyperglycemia	**Physical Activity**	**Fruit/Vegetable intake**	**Fats, pasta, fried foods intake**
No	Always (everyday)	Always (everyday)	No/Never
Don't remember/Not sure	Often (3 days a week)	Often (3 days a week)	Rarely (once a week)
Yes	Rarely (once a week)	Rarely (once a week)	Often (3 days a week)
No response	No/Never	No/Never	Always (everyday)
	No response		

The questionnaire score was calculated by summing up all the 12 answers. The children were grouped into three

categories of risk levels: low risk (0-10 points), medium risk (11-20 points) and high risk (21-30 points).

The data collection was performed during two months at scheduled times by the schools' directors and coordinators. Parents were invited to participate in a meeting to learn more about the research and to complete the research questionnaire. Subsequently, alongside the local health team, anthropometric measures were performed during the class breaks.

A discriminant analysis was used to test the score's ability to maximize the differences between groups according to the risk factors for DM2. We opted for the independent method, which analyzes all the variables together with a significance level of 0.05 for the tests.

3. Results

A total of 425 children were examined and interviewed, distributed among nine NEI in the urban area of Marabá.

Our questionnaire showed a moderate reliability ($\alpha=0.750$), with scale statistics with a mean of 8.8 ± 3.3. Table 1 shows the descriptive analysis of the DM2 screening questionnaire for this sample. The average age of the children was 4.9 (±0.8) and the majority were male (54.1%) in the age group of 5 to 6 years old (59.8%).

Of the total sample (N=425), the majority of the children had a normal BMI result (78.1%); however, it is worth noting that 3 (0.7%) children were classified with severe acute malnutrition, 9 (2.1%) children with moderate malnutrition and 6 (1.4%) children with 2nd degree obesity (Table 1). Of the total number of participants (N=425), 374 (88.0%) children were classified as low risk and 50 (11.8%) as medium risk for DM2. Only one (0.2%) child was classified as high risk for DM2.

Table 1. Descriptive analysis of the screening questionnaire for DM2 among students ages 3 to 6 in public schools in Marabá, PA, Brazil, 2019 (N=425).

Variables	n	%
Age		
3 to 4 years of age	171	40.2
5 to 6 years of age	254	59.8
Sex		
Female	195	45.9
Male	230	54.1
BMI Results		
Severe acute malnutrition	3	0.7
Moderate acute malnutrition	9	2.1
Normal	332	78.1
Overweight	36	8.5
Obesity 1st degree	11	2.6
Obesity 2nd degree	6	1.4
No response	28	6.6
Gestational diabetes		
No	405	95.3
Don't remember/Not sure	13	3.1

Yes	4	0.9
No response	3	0.7
Complications or birth problems		
No	363	85.4
Don't remember/Not sure	10	2.4
Yes	52	12.2
Birth weight ≥ 4kg		
No	356	83.8
Don't remember/Not sure	25	5.9
Yes	44	10.4
Family with DM		
No, no one	204	48.0
Yes: other relatives	43	10.1
Yes: grandparents, aunts/uncles, cousins	161	37.9
Yes: parents (mother and father), siblings	16	3.8
No response	1	0.2
Use of medication for hypertension		
No/Never	422	99.3
Yes	2	0.5
No response	1	0.2
Hyperglycemia		
No	401	94.4
Don't remember/Not sure	17	4.0
Yes	2	0.5
No response	5	1.1
Physical Activity		
Always (everyday)	279	65.6
Often (3 days a week)	76	17.9
Rarely (once a week)	45	10.6
No/Never	24	5.6
No response	1	0.2

Fruit/Vegetable intake		
Always (everyday)	148	34.8
Often (3 days a week)	180	42.4
Rarely (once a week)	82	19.3
No/Never	15	3.5
Fats, pasta, fried foods intake		
No/Never	26	6.1
Rarely (once a week)	171	40.2
Often (3 days a week)	173	40.7
Always (everyday)	55	12.9

Figures 1A-1F show the difference between boys and girls taking into account the BMI percentiles. Figures 1B and 1C show that there were more boys aged 4-5 years with severe (<-3DP) and moderate (-3 to -2 SD) malnutrition. In the category of overweight (+1 to + 2 SD), we observed that girls aged 4-5 years have a higher BMI than boys. The levels of obesity I (+2 to +3 SD) and II (> +3 SD) are shown in figures 1E and 1F, respectively, and both were more frequent in boys aged 5 to 6 years.
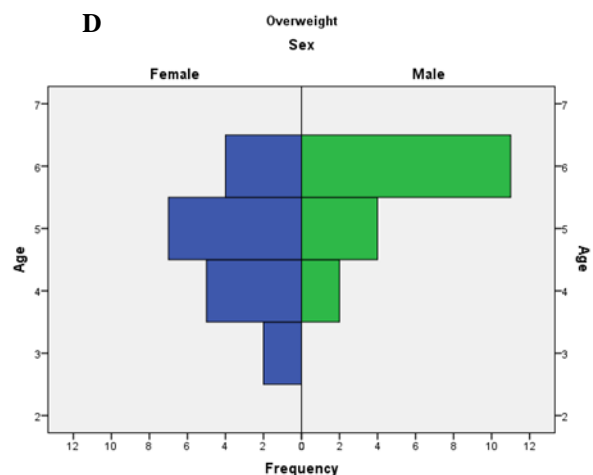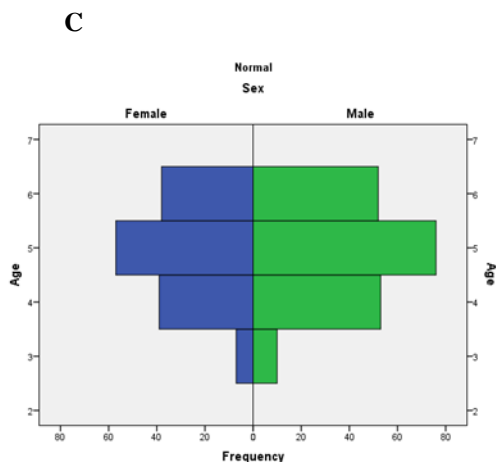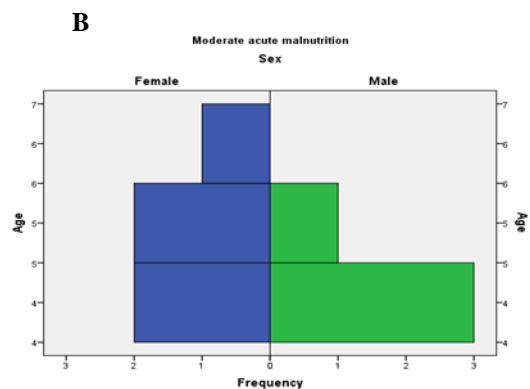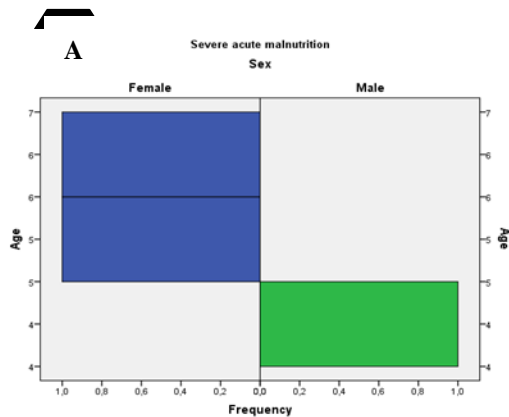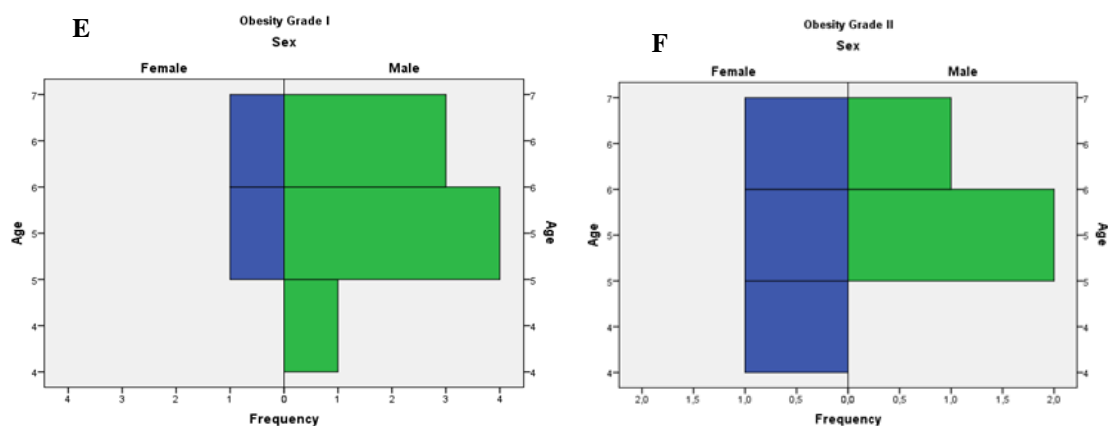
Figure 1A-F. Distribution of BMI by sex among students ages 3 to 6 in public schools in Marabá, PA, Brazil, 2019.

The discriminant analysis generated two linear discriminant functions to validate the risk classification for DM2 in the sample (Table 2). We also observed that the vast majority of the original cases (95.4%) and cases in cross-validation (92.0%) were correctly classified by the discriminant analysis (Table 3).

Table 2. Summary of the canonical discriminant function for the variables with results from the Wilks' Lambda test for each discriminant function.

Variables	Discriminant function*	
	1	**2**
Body Mass Index	0.068	0.390
Age	0.032	0.450
Sex	0.201	0.317
Gestational diabetes	0.113	1.148
Birth problem or complication	0.043	0.704
Weight at birth > 4K	0.253	.42
DM in the family	0.015	0.452
Medication for high blood pressure	-.879	0.978
Hyperglycemia	4.461	-0.633
Physical activity	0.080	0.619
Eating vegetables and / or fruit	0.051	0.575
Eating pasta, fried foods, salty or fatty meats	0.159	0.464
(Constant)	-1,025	3,756
Canonical discriminant function		
Self-worth	4.36	0.98
% variance	81.5	18.5
Canonical Correlation (R^2)	0.902	0.705
Wilks' Lambda Test	0.094	0.503
p-value	<0.001	<0.001

* Non-standardized coefficients of the canonical discriminant function.

Table 3. Classification of the canonical discriminant analysis for risk factors for DM2 among schoolchildren, Maraba PA, Brazil.

DM2	Predicted Group Membership			
	Low risk	**Medium risk**	**High risk**	**Total**
Original[a]	**n (%)**	**n (%)**	**n (%)**	**n (%)**
Low risk	321 (94.7)	18 (5.3)	0 (0.0)	339 (100.0)
Medium risk	0 (0.0)	49 (100.0)	0 (0.0)	49 (100.0)
High risk	0 (0.0)	0 (0.0)	1 (100.0)	1 (100.0)
Cross-validated[b]				
Low risk	313 (92.3.0)	26 (7.7)	0 (0.0)	339 (100.0)
Medium risk	4 (8.2)	45 (91.8)	0 (0.0)	49 (100.0)
High risk	0 (0.0)	1 (100.0)	0 (0.0)	1 (100.0)

a. 95.4% of the original cases were correctly classified.

b. 92.0% of the cross-validated cases were correctly classified.

The scatter plot graph represents the relationship between discriminant functions and clusters (Figure 2). The first function, shown on the horizontal axis, separates the high-risk group from the others. The second function separates the low and medium risk groups; however, the proximity of the centroids of these two groups suggests that the separation between the two is weak.

Figure 2. Scatter plot graph for risk groups for DM2 according to the Canonical Discriminant Function.
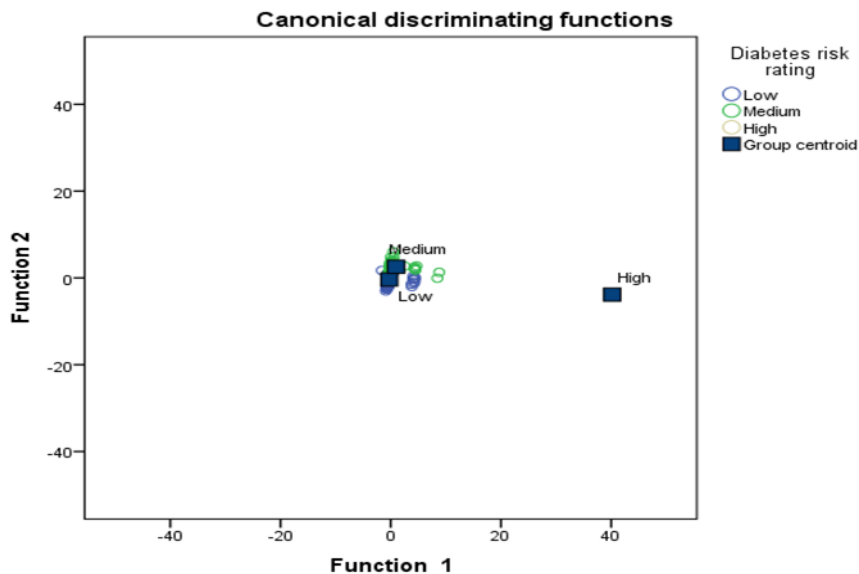
4. Discussion

Studies that address screening tools to assess selected risk factors for the development of Type2 Diabetes Mellitus (DM2) among children aged 3 to 6 are scarce, especially in the Eastern Amazon region in Brazil. Early identification of children at risk for developing the type 2 diabetes mellitus prevents long-term complications from the disease (Tillotson et al., 2021). Attempts of developing reliable screening tests for diabetes among nonsymptomatic children have been reported in literature. According to a study conducted in Taiwan that sampled 2,270,496 seventh-grade students, tested three different methods A, B, and C to predict diabetes among children. The screening methods A and B combined sequential urinalysis and risk scores, and the screening method C combined sequential urinalysis and two risk factors including the presence of overweight or positive family history of DM, concluding that Urinalysis screening followed by evaluation of risk factors is a simple and efficient way to identify children with diabetes in schools (Wu et al., 2020). Although we do recognize the importance of performing laboratory tests for screening tests in this population as well, we lack the public resources to perform laboratory tests for all children undergoing mass screening in our study. These specific limitations challenged us to focus on the development of a non-lab pre-screening test for DM2 for preschoolers proved to be fast and statistically reliable. Another important point for this discussion is the fact that our non-lab pre-screening test might be useful for health planning at the primary care level in municipalities marked by low availability of fundings and resources like Maraba. It also represents an attempt to identify the most vulnerable children in the school settings.

In this present study, we observed that besides the fact that the majority participants had a normal BMI (78.1%), a relevant number of children had some weight problem such as obesity (12.5%), overweight at birth - Weight at birth >= 4 kilograms (10.4%) or malnutrition (%). Other studies corroborate with our results (Brasil, 2007; International Federation, 2019; Soliman et al., 2014). At birth, weight is an important factor that indicates the child's survival in the first months of life. Environmental and behavioral conditions can represent risk factors for neonatal and infant morbidity and mortality (Oliveira et al., 2018). On the other hand, the child's overweight at birth is also worrying and may be linked to problems during pregnancy, such as the mother's weight gain and gestational DM (Czarnobay et al., 2019).

Overweight, more specifically the increase in fat mass, is an important risk factor for the increase in type 2 diabetes (Stefan, 2020). The same association has been seen among children. A study carried out in Denmark indicated an increasing prevalence of obesity without an increase in DM2 in the young population, however, further investigation of screening and monitoring of obese children for DM2 10 is necessary. In addition, there is a general lack of an initial health record, suggesting that the accurate diagnosis of type 2 diabetes in young people is still problematic, even for pediatric endocrinologists. The most common comorbidity associated with type2 diabetes among children and youth is obesity followed by family history of T2D (Pulgaron & Delamater, 2014). Of the total of 425 children that participated in our study, 221 (52.0%) have a relative with a diagnosis of T2D in their families, and 3.8% lived with either diabetic father or-and a diabetic mother. The literature reports that people who have at least one of the first- or second-degree relatives with the disease, combined with other genetic and behavioral factors in the family, are more likely to develop DM216-17. In the study conducted by (Eriksson et al., 2015), it was verified that the decrease in the action of insulin and hyperinsulinemia occurred in first-degree relatives, non-diabetics, of individuals diagnosed with DM2. In regards to the knowledge of mothers of preschoolers with DM2 about risk factors, researchers observed that almost half of the mothers did not know that acquiring diabetes during pregnancy increases the risk of developing DM2 among their children (Serbis et al., 2021). In our study, only 0.9% (04) of the mothers reported having the disease during pregnancy.

Our results showed that high BMI, being overweight at the time of the study, family history of diabetes, and high birth weight were the major components of the classification of the canonical discriminant analysis for risk factors for DM2 (low, medium, and high risk) among schoolchildren in our sample.

However, the absence of symptoms among children, poor diet, use of hypertensive and hyperglycemic medication are important warning signs for parents, educators and health professionals. As discussed previously in this section, childhood obesity contributes to increased incidence of DM2 and other metabolic disorders (Boney et al., 2005). At this early age children should not have nob-genetic risk factors to develop DM2 such as being overweight. Data from our study shows that 51.8% of the children had a family member with DM2 with a reported diet that had poor fruit/vegetable intake and high intakes of fats, pastas and fried foods. Children tend to acquire eating habits at home, according to the parents' lifestyle, and that the current lifestyle has led families to make more practical and faster choices which are not always the healthiest ones. In addition, the socioeconomic obstacles are risk factors for bad diabetes prognostic (Pulgaron & Delamater, 2014; Van Name et al., 2020). Diabetes can lead to other health complications such as diabetic kidney disease, retinopathy, and peripheral

neuropathy to the individuals and to a significant financial impact on public health resources due to the costs of treatment (Divers et al., 2002).

Our study has some limitations, including the impossibility of carrying out confirmatory laboratory tests for DM2 due to financial constraints. It was not possible to perform hypothesis tests to investigate the age differences between boys and girls according to BMI, because there was no pairing of the sample. Another limitation of the study is the impossibility to detect these differences between malnourished, normal and obese children due to the small sample size.

5. Conclusion

We conclude that our proposed pre-screening test for DM2 using assessment of risk factors is a simple as statistically significant method for potentially identifying children at risk for DM2 in schools. However, a larger and more representative sample and clinical aspects are necessary to achieve specific results to discriminate validation for this population. We also observed that some school children aged 3 to 6 years already have risk factors for DM2 such as heredity, overweight/obesity, physical inactivity, and high intake of fats and pasta in our study.

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