PREVALENCE OF TYPE 2 DIABETES IN SCHOOL: MULTIFACTORIAL INTERACTIONS

انتشار مرض السكري من النوع 2 في المدرسة
تفاعلات متعددة

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Abstract

The prevalence of diabetes continues to grow across the world at an epidemic pace. It concerns adults as well as children, women and men, affecting all continents and all social classes. The WHO forecasts for 2025 an increase of the 150 million diabetics registered in 1995.
Algeria is not immune to this pandemic; it is among the group of high prevalence countries. Diabetes ranks fourth in the ranking of non-communicable diseases.
The objective of this study is to estimate the prevalence of type 2 diabetes in-school adolescents and to show the interactions between several factors including overweight, physical inactivity and high blood pressure.
It is a cross-sectional and descriptive survey, which concerns a representative sample of students aged between 15 and 18, enrolled in public high schools dependent on the Algiers Academy. The number of subjects required is estimated at 2355 students.
Information was collected on students' sedentary lifestyle, weight, height, waist circumference, blood pressure and fasting blood sugar.
After multivariate analysis, multiple and significant relationships were demonstrated concerning the pathology studied with possible risk factors. The study found an obesity-pathogenesis relationship of diabetes ($p < 0.001$), the prevalence of high blood pressure increased with obesity and diabetes ($p < 0.001$). The prevalence observed in girls is slightly higher than that of boys ($p < 0.03$).

Our study concludes, contrary to popular belief, that the prevalence of type 2 diabetes is not negligible in this segment of the population. It reflects the tendency of adolescents to be overweight and obese. This weight gain which is itself a direct consequence of a sedentary lifestyle and dietary imbalance.

Keywords: **Type 2 diabetes; Adolescents; Risk factors; Interactions; high school student.**

ملخص

ان استمرار مدى الانتشار لمرض السكري من نوع 2 بوتيرة وبائية في جميع أنحاء العالم يخص البالغين و الأطفال وكذلك والنساء والرجال. ونجده في جميع القارات وجميع الطبقات الاجتماعية. وتتوقع المنظمة الصحية

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العالمية مضاعفة الرقم 150 مليونًا من مرضى السكر المسجلين في عام 1995 بحلول عام 2025. إن الجزائر لا تستثنى من هذا الوباء، فهي من ضمن مجموعة الدول ذات الانتشار المرتفع، ويحتل مرض السكري المرتبة الرابعة في ترتيب الأمراض غير المعدية .

ان الهدف من هذه الدراسة هو تقدير مدى انتشار مرض السكري من النوع 2 لدى المراهقين المتمدرسين وإظهار التداخلات ما بين عدة عوامل ، بما في ذلك زيادة الوزن والخمول البدني وارتفاع ضغط الدم.

دراستنا عرضية وذات طابع وصفى أقيمت على عينة ممثلة قدرت ب 2355 تلميذ. تتراوح أعمارهم بين 15 و18 سنة، كلهم يتلقوا تعليمهم في المدارس الثانوية العامة التابع لأكاديمية الجزائر العاصمة. تم جمع المعلومات عن نشاط الطالب وزنه، طوله، ومحيط خصره، وضغط الدم ونسبة سكر الدم بعد تحليل متعدد المتغيرات ، تم عرض علاقات متعددة وبليغة فيما يتعلق بمرض السكري من نوع 2 مع عوامل الخطر المحتملة. أظهرت الدراسة وجود علاقة ذات دلالة احصائية بين البدانة و المرض السكري P) <0.001)، كما أظهرت العلاقة ما بين مدى انتشار ارتفاع ضغط الدم مع السمنة ومرض السكري ب:(P<0.001). كما تجدر الاشارة الى أن مدى الانتشار للمرض لدى الفتيات أعلى بقليل مقارنة بالذكور P) <0.03).

كما أظهرت كذلك نتائج دراستنا ، خلافا للاعتقاد الشائع ، أن مدى انتشار المرض السكري نوع 2 لا يمكن الاستهانة به في هذه الشريحة من المجتمع. وهو يعكس ميل المراهقين إلى الزيادة في الوزن. وهذا الأخير يعتبر نتيجة مباشرة للخمول البدني واختلال التوازن الغذائي

الكلمات المفتاحية: **مرض السكري من النوع 2؛ المراهق؛ عوامل الخطر؛ تفاعلات؛ طلبة الثانوية.**

Introduction

Type 2 diabetes is a chronic pathology which can remain silent for many years; it is often discovered by chance during a blood test, or in case of complications. By its current epidemic appearance, it represents a major public health problem. The transformation of ways of life, the extension of life expectancy are essential factors of this progression (Sabatier., 2015; American Diabetes Association., 2004).

Until the recent past, it was thought that type 2 diabetes, as seen in adults, did not exist in children. In some parts of the world, it has even matched or surpassed the rate of type 1 diabetes.

In Japan, for example, its rate among children has doubled in 20 years. In some areas of the United States, there are 43% of new cases of childhood diabetes. In Canada, among an urban adolescent population, the incidence increased tenfold between 1982 and 1994. This figure would increase to 70% in China (Togo., 2010).

Type 2 diabetes is the most common form of diabetes, it is also a major vascular risk factor that contributes strongly to atherogenesis, alongside other risk factors such as hypertension, obesity, sedentary lifestyle, smoking and dietary imbalance (Malek., 2005). It can cause complications that can occur after blood sugar imbalance ranging from 10 to 20 years. The disease accelerates atherosclerosis, which is the cause of myocardial infarction, stroke or arthritis of the lower limbs. It can also alter microvessels. Besides, it can cause retinopathies, peripheral neuropathies, nephropathies, liver diseases or scarring problems. It can also participate in neurodegeneration (Sellers and Hadjiyannakis., 2010).

Algeria is not immune to this pandemic, as it is one of the high prevalence countries. It runs the risk of an unbridled increase in cardiovascular morbidity and mortality. Currently, it is in a phase of demographic and epidemiological transition characterized by the decline in the proportion of deaths from communicable diseases and the increase in those from non-communicable diseases, Biad et al (2010).
The objective of this study was to estimate the prevalence of type 2 diabetes in-school adolescents and to identify the factors associated with this disease in terms of obesity, overweight, high blood pressure and physical inactivity, to set up a preventive school physical activity program.

It is a descriptive cross-sectional survey that concerns a representative sample of students aged between 15 to 18, enrolled in public high schools dependent on the academy of Algiers. The number of subjects required is estimated at 2355 students. With more than a third of the population under 18 (Ref) and more than 15% of whom are already overweight, the increase in the incidence of this disease in children represents a threat to public health, This is why it is essential to aim for primary prevention by setting up an appropriate strategy for the diagnosis and treatment of the disease.

1. Goals

-Estimate the prevalence of type 2 diabetes in high school students
-Identification of factors associated with diabetes such as obesity, overweight, hypertension and sedentary lifestyle.

2. Methodology

2.1. Sample

Our survey is descriptive and cross-sectional; it concerned a representative sample of students aged between 15 and 18, educated in public high schools dependent on the Algiers Academy.
We carried out a geographical stratification of Algiers using the territorial division of the Ministry of National Education into 3 directions.
A clustering effect of 2 was taken into account in the calculation of the sample size. The number of subjects required has been estimated at 2355.

2.2. Experimental design

All data is recorded on a prior technical sheet for identification, questioning, anthropometric measurements, and blood pressure measurement.
Fasting blood glucose is carried out in the analysis laboratories (selected by the investigator) on a venous sample in a tube containing an antiglucolytic such as sodium fluoride, after 8 hours of fasting. Blood glucose is measured by the enzymatic colorimetric method using glucose oxidase using RAN-DOX brand reagents.
The subject's weight is taken in light clothing, without shoes, the measurement is made to the nearest 100 grams and the size is taken without shoes, subject standing against a wall, the measurement is made to the nearest centimeter.

The abdominal perimeter is obtained using a tape measure placed halfway between the costal rim and the iliac crest in a student standing in exhalation.
The blood pressure is taken after 3 minutes of rest and placement of the cuff at 1 or 2 cm from the elbow, arm at a heart level, placed on a support and the subject in a seated position. Two measurements are taken one minute apart; the lower measurement is taken into account.

2.3. Definition criteria

A case of overweight or obesity was defined as being a subject with a body mass index (BMI = weight in kilograms height in meters²) according to the BMI limits for girls and boys aged 5 to 18 (Cole et al., 2000 IOTF standards).
A case of abdominal obesity was defined as being a subject having an abdominal circumference according to the Limit Values for the waist circumference beyond which abdominal fat mass is considered excess, according to Taylor et al 2000).
A case of type 2 diabetes was defined as a subject on hypoglycemic treatment and/or with a fasting blood glucose level > 1.26 gram/litre
A case of hypertension was defined as being a subject under hypertensive treatment and/or presenting systolic blood pressure and/or diastolic blood pressure according to the French table by André J-L et al. 1980.
The measurement chosen is the lower of the two blood pressure measurements taken one minute apart. A 5 minute rest period was required before taking blood pressure.
A case of a sedentary lifestyle: a person who does not have a regular or intense physical activity such as playing sports (less than two hours/week).

2.4. Statistical Analysis

All data collected was coded and captured on Epi-Info version 6 software (CDC, Atlanta, USA). The qualitative variables were compared using the chi-square test or possibly Fisher's test in case of reduced numbers.

Quantitative variables were compared using the t-test or possibly the Wilcoxon test in case of reduced numbers. A P value < 0.05 was considered significant.

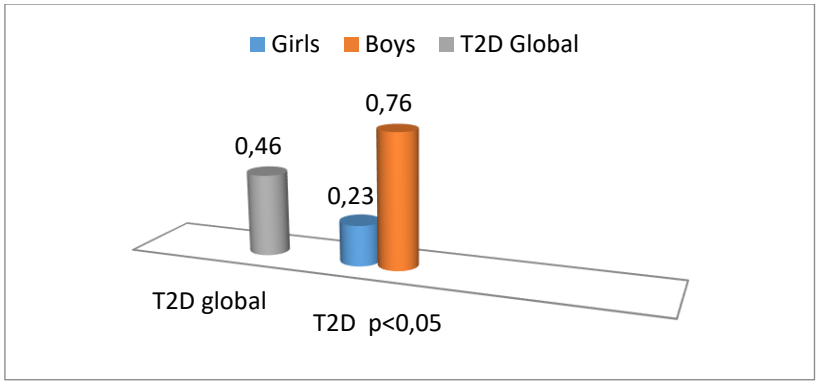
3. Results

Table 1: Distribution of pupils by sex

Sex	Group	percentage
Boys	1039	44.1
Girls	1316	55.9
Total	2355	100

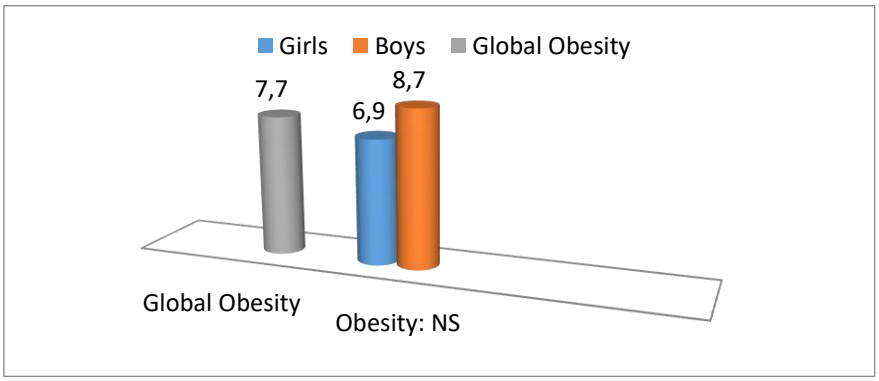
Our overall sample of 2355 subjects in urban schools is mainly composed of girls (55.9%).

Figure 1: Overall prevalence by sex of Type 2 Diabetes (T2D) in the sampled population



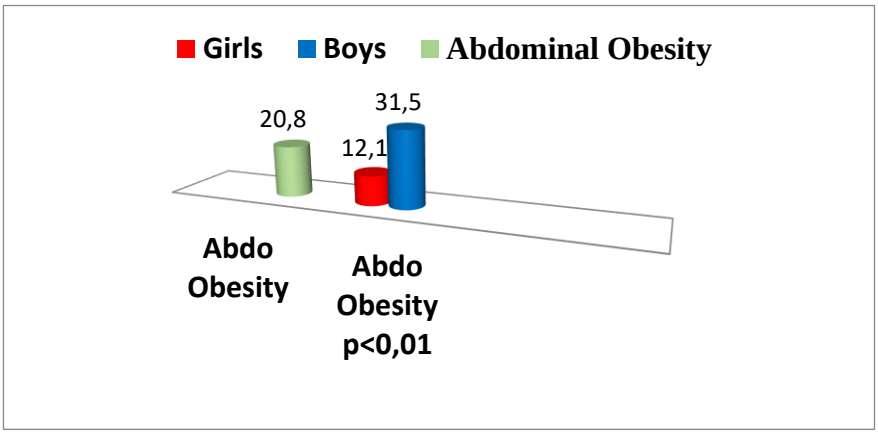
The percentage of girls with T2D is less important than that of boys, respectively 0.23% against 0.76% with a significant difference (p <0.05).

Figure 2: Overall prevalence and by sex of general obesity in the sampled population



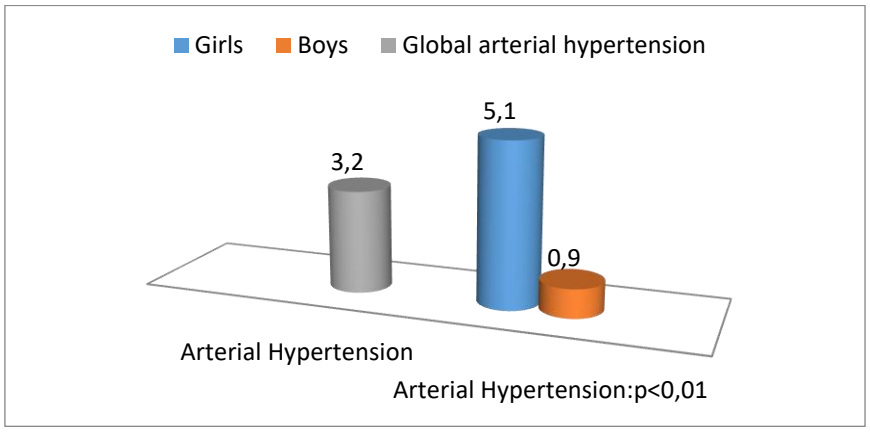
The prevalence of obesity is not significantly different between both sexes. It is 8.7% for boys and 6.9% for girls.

Figure 3: Overall prevalence and by sex of abdominal obesity in the sampled population



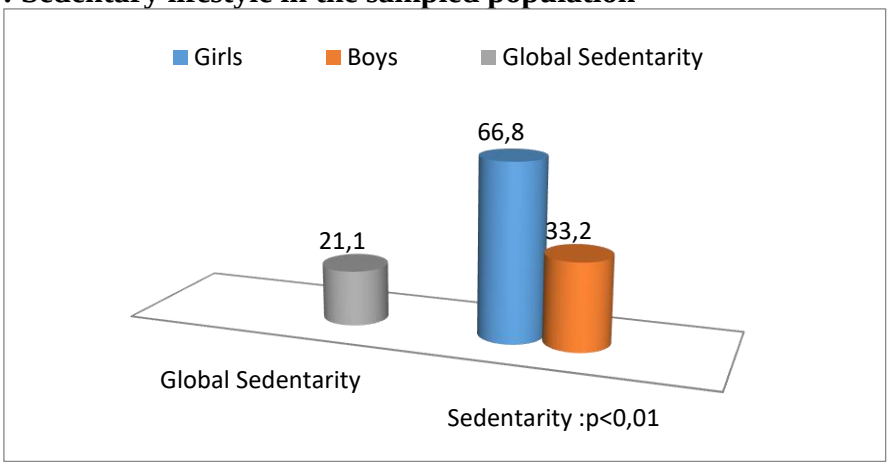
The distribution of abdominal obesity by sex shows a clear male predominance in our sample, ie 31.5% against 12.1%. The difference between both sexes is statistically significant (p <0.01).

Figure 4: Overall prevalence and by sex of hypertension in the sampled population



Girls are more hypertensive than boys (p <0.01), respectively 5.1% against 0.9%.

Figure 5: Sedentary lifestyle in the sampled population



Girls are more sedentary than boys (p<0.01), respectively 66.8% versus 33.2%.

Table 2: T2D and General Obesity

	Obese		Non-obese			P
	Group	%	Group	%	TOT	
T2D	9	4.97	2	0.09	11	<0.05
Non T2D	172	95.03	2172	99.9	2344	
Total	181	100	2174	100	2355	

The above results show that there is a significant link between T2D and obesity in adolescents. Indeed, in the population there are 4.97% of diabetics among the obese

and only 0.09% among the non-obese. This difference is statistically significant (p <0.05).

Table 3: Relationship between T2D and abdominal obesity

	Abdominally obese		Abdominally non-obese			P
	Group	%	Group	%	TOT	
T2D	10	2.05	1	0.05	11	<0.01
Non-T2D	480	97.95	1864	99.95	2344	
Total	490	100	1865	100	2355	

The above results show a significant association between T2DM and abdominal obesity in adolescents. In fact, in our sample, we find 2.05% of diabetics among obese abdominals and only 0.05% among non-obese abdominals. This difference is statistically significant (p <0.01).

Table 4: relationship between T2D and Arterial Hypertension

	Arterial Hypertension		Non Arterial Hypertension			P
	Group	%	Group	%	Total	
DT2	7	9.33	4	0.18	11	<0.01
Non DT2	68	90.67	2276	99.82	2344	
Total	75	100	2280	100	2355	

The above results show that there is a significant association between T2DM and high blood pressure in adolescents. Indeed, in our sample, we find 9.33% of diabetics among hypertensive and only 0.18% among non-hypertensive. This difference is statistically significant (p <0.01).

Table 5: Relationship between T2D and sedentary lifestyle

	Sedentary		Non-sedentary			P
	Group	%	Group	%	Total	
T2D	9	1.80	2	0.1	11	<0.01
Non-T2D	489	98.2	1855	99.9	2344	
Total	498	100	1857	100	2355	

The above results show the existence of a significant association between T2DM and sedentary lifestyle in adolescents. In fact, in our sample, we find 1.8% of diabetics among the sedentary and only 0.1% among the non-sedentary. This difference is statistically significant (p <0.01).

4. Discussion

An assessment of the prevalence of type 2 diabetes faces limitations due to the diagnostic criteria used according to the American Diabetes Association (2004). Our results show a prevalence of type 2 diabetes estimated at 0.46% which represents a

very high rate, because it is higher than those reported by some foreign studies, 12 / 100,000 in the USA, 2.5 / 100,000 in Europe (Diabetes type 2 currently represents 5% of childhood diabetes cases in Europe). Globally, the incidence of type 2 diabetes in children is estimated to increase by 50% over the next 15 years (Panagiotopoulos et al., 2013). Besides, ethnicity is another risk factor for type 2 diabetes. In North America, young aborigines are most affected by this disease. 44% of new cases of pediatric type 2 diabetes in Canada between 2006 and 2008 were diagnosed in Aboriginal youth. Likewise, a recent Canadian study found an annual incidence of type 2 diabetes in those under 18 years of age of at least 1.54 per 100,000 children or adolescents (Van Hulst et al., 2017; Michael et al., 2013). The data are similar in the United States where a study has shown that in addition to a disproportionate incidence, young aborigines achieve poorer glycemic control. The risk of type 2 diabetes is also higher in young people of African, Arab, Hispanic and Asian origins (Van Hulst et al., 2017).

Also, several studies show that the prevalence of type 2 diabetes is increasing almost parallel to that of obesity (Gremeaux and Bouillet., 2012); Després., 2007), we talk about this type of diabetes that now occurs more frequently in young people (Wens et al., 2003).

The diagnosis of type 2 diabetes is made in 5 to 45% of new diabetics in the pediatric population in the United States. This observation follows epidemic obesity in children and adolescents.

Likewise, obesity is shown to be the most important risk factor for the development of type 2 diabetes. It is currently the most frequent health problem in developed countries (Schwitzgebel., 2004).

Obesity is associated with resistance to the action of insulin, a key factor in the development of type 2 diabetes. Compared to adults, obese children seem to progress more rapidly from pre-diabetes to frank diabetes (D'adamo and Caprio., 2011).

In Algeria, a country with a population of 60% under the age of 18, there are more and more obese children.

Our results have shown that the numbers of high school students with general and/or abdominal obesity are high; rates are successively around 7.7% and 20.8%. This may partly explain the high numbers of children with diabetes. Given the different definitions of obesity which vary according to the different countries which apply their standards, the rates of the different studies (in terms of prevalence) are difficult to compare. On the other hand, it has been clearly shown that the incidence of type 2 diabetes increases in parallel with the BMI (kg/m2). One example is Japan, where the incidence of type 2 diabetes in adolescents has increased 36 times, from 0.2 / 100,000 in 1976 to 7.3 / 100,000 in 1995 (Feltbower et al., 2003), as in the United States, type 2 diabetes is present in 4% of obese adolescents (Sinha et al., 2002).

This age group is particularly interesting to observe because puberty is a time when the risk of type 2 diabetes is higher, due to physiological changes that lead to a temporary decrease in insulin sensitivity. During this period, healthy children of normal weight have a 50% decrease in their insulin sensitivity, which is compensated by a temporary increase in insulin secretion (Hannon et al., 2006). Besides, there are other risk factors

specific to adolescence, including those related to physical activity, diet, sleep and stress.

Our study also shows that a sedentary lifestyle affects 21.1% of our sample and the rate of diabetics among sedentary people reached 12.2%. To this end, numerous epidemiological studies have demonstrated that sedentary lifestyle and physical inactivity are indirectly associated with an increased risk of appearance of metabolic syndrome and its main components (in particular insulin resistance), but also obesity, glucose intolerance, type 2 diabetes (Gautier., 2004).

Observations made regarding the increasing rate of prevalence of obesity, despite the decrease in total energy and lipid intake, suggest the important role played by physical activity (Amisola., 2003).

This finding was the subject of a study which compared spontaneous ambulatory physical activity (measured by an actimeter) of 70 cases of type 2 diabetes to that of 30 controlled subjects without diabetes. The results show physical inactivity in type 2 diabetics, mainly linked to the presence of obesity (Fagour., 2011). Thus, a sedentary lifestyle is pointed out as being responsible for a reduction in insulin sensitivity. Indeed, in the absence of physical activity, the muscular capillary is reduced, thus hindering the distribution of insulin. A sedentary lifestyle is also accompanied by a decrease in slow type I muscle fibres, which consume a lot of glucose and free fatty acids due to their particular sensitivity to the action of insulin. All these changes then lead to hyperglycemia (Remillieux., 2016).

Another study showed a negative association between level of physical activity and indicators of obesity. The same study reports that boys are twice as likely to be overweight if they do not participate in physical activity (Dubot-Guais., 2005).

Likewise, Amisola et al (2003) report that according to prospective studies, physical activity plays a role in reducing weight gain over time without, however, completely preventing the phenomenon or promoting weight loss in population.

Two factors favouring diabetes and high blood pressure are sedentary lifestyle and obesity. People with high blood pressure have a greater risk of developing diabetes, and people with diabetes have an increased risk of developing high blood pressure (Altman., 2008). According to the WHO annual report published in 2014, one of three adults worldwide has high blood pressure, and one of ten has diabetes (WHO., 2017).

The results obtained in our study show, on one hand, a very high rate of arterial hypertension (3.2%) and on the other hand, the existence of a significant link between this arterial hypertension and type 2 diabetes in high school students.

In our sample, 9.33% of diabetics are found among hypertensive children and only 0.2% of diabetic children among non-hypertensive children. This difference is statistically significant at $p < 0.01$.

Another study carried out in Constantine (East of Algeria) on school adolescents aged between 12 and 18, also showed the existence of a high prevalence of arterial hypertension in population, in particular among overweight adolescents.

According to the Official publication of the College of Family physicians of Canada (2011), the pathogenesis of hypertension in diabetics is complex and involves several biological and environmental factors, as well as a genetic predisposition. Therefore, the

hypertension of diabetics presents a greater danger and complications. Furthermore, the same author adds that large randomized clinical trials, and meta-analyses of randomized clinical trials, have shown that pharmacological reduction in blood pressure alone is the most effective way to reduce blood pressure levels, death and disability in diabetics, including the risk of cardiovascular problems. In pediatrics, where the therapeutic arsenal remains limited due to the low quantity of approved drugs (Girardin and Schwitzgebel., 2007). Weight loss in obese children, a diet low in salt and high in fruits and vegetables, as well as regular physical activity, are of great importance in controlling blood sugar and high blood pressure. These general measures must always be integrated into both the prevention and treatment of already manifest arterial hypertension (Giacomo et al., 2011).

Also, studies have shown that insulin resistance appears to be a powerful determinant of arterial hypertension in children as well as in adults (BenMohammed et al., 2010) and that young people with type diabetes 2 develop microvascular and cardiovascular complications (retinopathy, neuropathy and nephropathy) more rapidly than young people with type 1 diabetes, and it is not uncommon for these complications to be already present at the time of diagnosis. This includes Canada, where 28% of new pediatric cases of type 2 diabetes had high blood pressure at the time of diagnosis (Van Hulst et al., 2017).

Conclusion

The prevalence of type 2 diabetes is high in our sample (0.46%). It is a reflection, in part, of overweight and sedentary lifestyle found in our population.

Recognizing and screening children at risk are key factors in avoiding complications related to this disease. The important factor in management is lifestyle modification, weight control and increased physical activity. The latter must have an important place because it has a hypoglycemic effect when it is practiced very regularly and sufficiently, even if the precise modalities of this physical activity (a type of activity, frequency, intensity, etc.) in patients with type 2 Diabetes remain debated, and different according to the various current recommendations.

The establishment of an appropriate strategy for diagnosis and early treatment, associated with a program of primary prevention of diabetes should be a priority in Algeria for our education and public health system.

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