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Body Composition in Children and Adolescents with Type 1 Diabetes at the Pediatrics Department of the Abass Ndao Hospital Center about 101 Patients

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Background: Diabetes and its management have been associated with alterations in body composition parameters in various groups of children worldwide. Our objective is to evaluate fat mass in children and adolescents with type 1 diabetes.
Methods and Settings: This was a descriptive and analytical study, running from February 1, 2023 to May 31, 2023, including children and adolescents with type 1 diabetes, on insulin therapy and followed in the pediatric department during the study period.
Results: 101 patients were involved in the study. The average age of discovery of diabetes is 11 years. Cardinal syndrome was the main mode of discovery (60.4%). The mean HbA1c level was 11 ±2.7%. The mean BMI was -0.58 ±1.27 SD with a minimum of -4.7SD and a maximum of 3SD. Eight (8) patients were overweight, i.e. 7.9%, and three (3) were at the obese stage, i.e. 3%, including one (1) who had severe obesity. The WC/H was elevated in eight (8) patients or 7.9%. The mean GM was 23.9 ±7.9% with extremes of 9.5% and 47.8%. High FM (%) were found in 28.7% (n=29). All of the latter had a high WC/H, therefore reflecting the abdominal distribution of this excess fat. Among the patients with a normal BMI, twenty (20) patients or 36.4% had a high FM with a significant difference. Elsewhere, FM (%) was positively correlated with WC/H as well as screen time. Poor diabetes control with HbA1c >7.5% was associated with female sex, high FM, abnormal BMI and inappropriate screen time but this link was not statistically significant.
Conclusion: The increase in fat mass constitutes a cardiovascular risk factor in our diabetic subjects, thus potentially worsening the long-term prognosis. Assessment of nutritional status by BMI alone is not sufficient to determine body composition. Promoting body composition assessment by making bioelectrical impedance available.

Keywords: Body composition; diabetes; children; nutritional status.

1. BACKGROUND

Diabetes and its management have been associated with alterations in body composition parameters in various groups of children worldwide (Krishnan et al., 2011). Body composition refers to the distribution of different body components, such as fat mass (FM) and lean mass. It has been shown that a poor diet, associated with a lack of physical activity and the administration of exogenous insulin therapy, is responsible for weight gain in diabetics (Jacob et al., 2006). Body mass index (BMI) is commonly used in clinical assessments of youth with T1D, but it is not an accurate measure of adiposity. Assessment of body composition in children with diabetes is essential to inform clinical diagnosis, early assessment of metabolic risk and optimization of treatment (Krishnan et al., 2011). It is in this context that we carried out this work, the main objective of which was to evaluate fat mass (FM) in children and adolescents with type 1 diabetes (T1D).

2. METHODS AND SETTINGS

Our study took place in the pediatric department of the Abass Ndao Hospital Center in Dakar (Senegal). We conducted a cross-sectional, descriptive and analytical study from February 1, 2023 to May 31, 2023.

All children and adolescents with type 1 diabetes under insulin therapy and followed up in the pediatric department during the study period were included. Patients who were on both insulin and oral antidiabetics were not included. Free and informed consent was required for each eligible subject, before any investigation on the latter.

- **Anthropometric parameters:**

- Weight was Taken from Omron® (model HN-289, Kyoto, Japan) portable electronic scale
- Height was determined using a wall-mounted stadiometer
- Waist circumference (WC): measured with the patient standing, halfway between the last palpable rib and the iliac crest. Then related to height to assess fat mass distribution

- Interpretation of BMI (W/H^2) according to the WHO: https://www.who.int/fr/news-room/fact-sheets/detail/obesity-and-overweight

- Severe underweight defined by BMI ≤ -2 SD
- Moderate underweight defined by BMI between < -1 and >-2 SD

- A normal BMI defines between [-1 and +1] DS
- Overweight defined by BMI between >+1 and <+2 DS
- Obesity defined by BMI ≥ +2 SD
- Severe obesity by BMI ≥ +3 SD

• Interpretation of the waist/waist ratio (TT/T) was considered high according to the French High Authority for Health (HAS) if > 0.5 indicating excess abdominal fat (HAS, 2023).
• Fat Mass (FM) is considered high according to the American Council on Exercise (ACE):

- Ages 5 to 11:
  Boys: greater than 20%
  Girls: greater than 25%
- 12 to 18 years:
  Boys: if over 22%
  Girls: if over 30%

• Screen time is considered inappropriate, between ages 5 and 19, if it exceeds two (2) hours of time, according to the American Academy of Pediatrics (AAP) (Chassiakos et al., 2016).

The average HbA1c was calculated over the last 3 measurements taken every 3 months.

Data entry and analysis:

- The data were entered and analyzed, respectively, using Sphinx software version 5.1.0.2 and SPSS (Statistical Package for Social Sciences) version 18.

- The comparison of percentages on independent series was carried out using the Pearson Chi-square test or the bilateral Fisher exact test depending on their conditions of applicability. Comparison of means was carried out using the Student test. Pearson's correlation (r) was used to evaluate the correlations between body composition parameters and other parameters. The significance threshold will be set at a P value < 0.05.

3. RESULTS

We collected one hundred and one (101) type 1 diabetic patients on insulin therapy. We had 64 girls for 37 boys, a sex ratio of 0.58. The average age of our patients was 14.29 years with extreme values of 5 and 18 years. The age group of 15 to 18 was the most representative with 50.5%.

The average age of discovery of diabetes is 11 years. Cardinal syndrome was the main mode of discovery (60.4%). Human, rapid and premix insulins (3-injection regimen) were the most used (83.2%). The average HbA1c level was 11 ± 2.7%. Most of our patients were unbalanced (83.2%). (Table 1).

The mean weight in SD was -0.08 ±1.45 SD, with a median of -0.15 SD, a minimum of -3.04 SD and a maximum of 5 SD. Girls had a higher mean SD weight than boys, with 0.11 SD versus -0.40 SD respectively.

The mean height in SD of the patients was -0.01 ±1.19SD and extremes of -3.25SD and 2.4SD. Most of our patients had a normal height with 89.1%, however eight (8) patients (7.9%) had growth retardation including one (1) who presented severe growth retardation.

The mean BMI was -0.58 ±1.27 SD with a minimum of -4.7SD and a maximum of 3SD. Girls had a higher mean BMI in SD than boys. More than half of our patients had a normal BMI (54.5%). However, thirty-five (35) were underweight (34.7%). Eight (8) were overweight (7.9%), and three (3) were at the obese stage, ie 3%, including one (1) who had severe obesity. The proportion overweight/obesity patients is largely dominated by girls (90%). (Fig. 1). This link being significant (p=0.04).

The mean ratio of waist circumference to height (WC/H) was 0.43 ±0.06 with extremes of 0.34 and 0.7. The ratio of waist circumference to height (WC/H) was high in eight (8) patients (7.9%).
The average of fat mass (FM) was 23.9 ±7.9% with extremes of 9.5% and 47.8%. High FM (%) were found in 28.7% (n=29). All of them had a high WC/H, thus reflecting the abdominal distribution of this excess fat.

Among the patients with a normal BMI, twenty (20) patients ie 36.4% had a high FM with a significant difference (p=0.049). (Table 2).

In girls, FM (%), BMI and WC/H were higher than in boys. Mean FM (%) differed significantly between girls and boys (p=0.0001). Girls had higher values than boys. (Fig. 2).

Elsewhere, FM (%) was positively correlated with WC/H with a significant difference (r=0.674, p=0.000001) (Fig. 3). Also, FM (%) was positively correlated withscreen time (r = 0.467, p = 0.0001).

Table 1. Children and adolescent profil (n=101)

Age		**mean 14.29 ±3.41 years (min 5 - max 18 years), median at 15 years**
Gender		64 girls (63.4%) 37 boys (36.6%)
Origin		Dakar center 26.7% Dakar suburbs 63.3% Outside Dakar 9.9%
Socio-economic level		Good 6.9% Moderate 24.8% low 68.3%
Average age of discovery		11 ±3.97 years (min 10 months - max17 years), median 12 years
Duration of diabetes		Mean: 3.25 ±2.71 years (min 6 months and max 14 years). median at 3 years
Discovery mode		
• Cardinal syndrome		60.4%
• Ketoacidosis		39.6%
Insulin regimen		
• 3 injections (human insulin)		83.2%
• Basal-bolus (rapid analogues)		16.8%
Average insulin dose		0.82 ±0.21 iu/kg/day (min 0,46- max1,67 ui/kg/day
HbA1c	HbA1c level	Average 11 ±2.7%, median 11.5% (min 4.8%-max 15%).
	• ≤ 7.5%	16.8%
	• >7.5	83.2%
Physical activity		
• Yes		88.1% (4 hours per week)
• No		11.9%
Screen time		Average 3.52 hours per day. median at 4 hours and a maximum of 10 hours per day

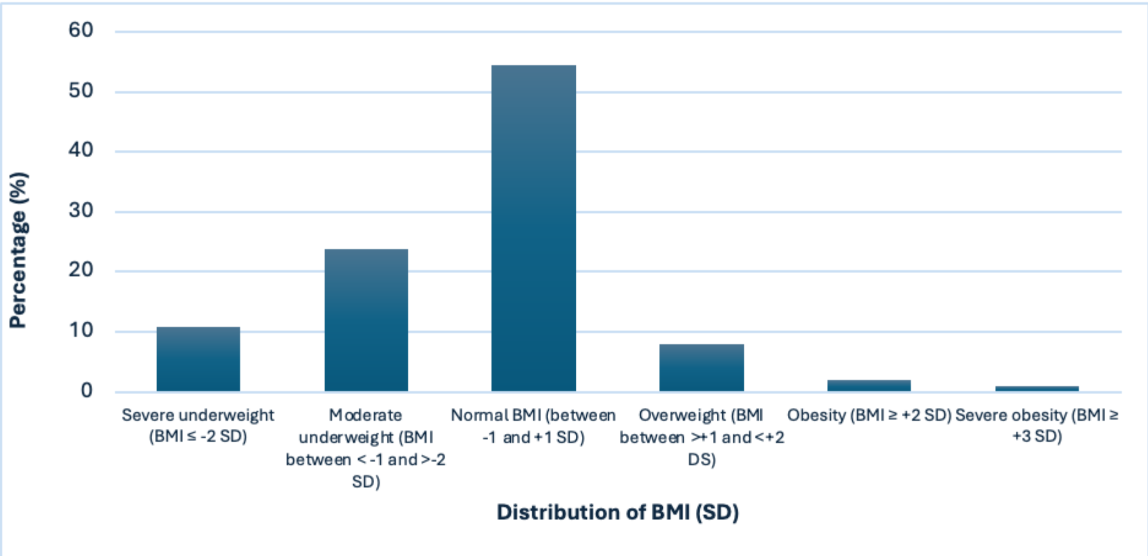

Fig. 1. Distribution of different nutritional statuses of the population

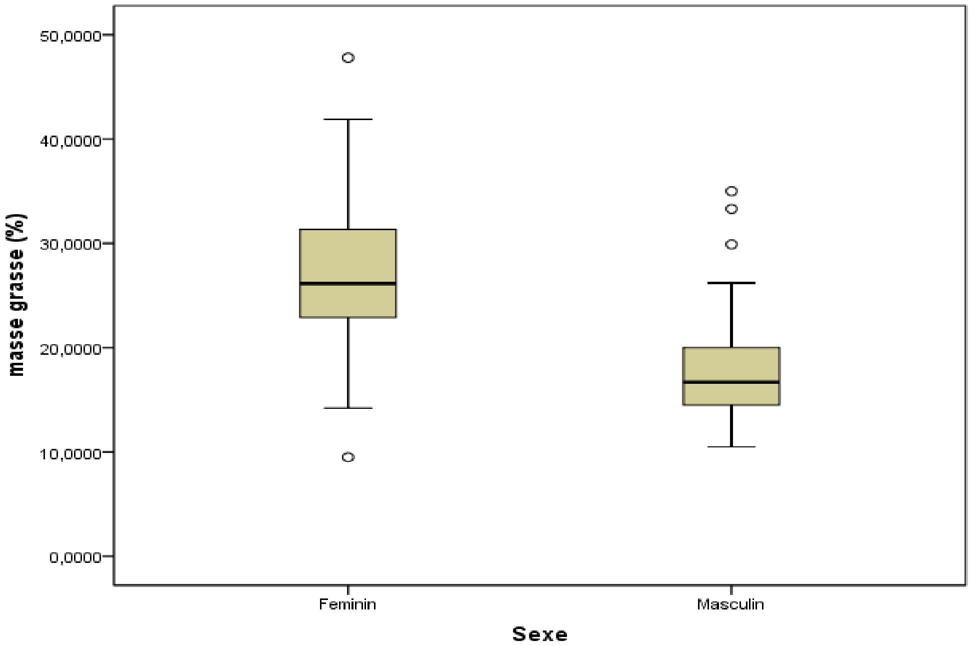

Fig. 2. Distribution of fat mass according to gender

Table 2. Normal BMI according to FM

Normal BMI	Fat mass		Total	p
	Normal	High		
Yes	35	20	55	0.049
	63.6%	36.4%	100.0%	
No	37	9	46	
	80.4%	19.6%	100.0%	

Table 3. Factors associated with glycemic control

	HbA1c ≤ 7.5% (balanced)	HbA1c > 7.5% (unbalanced)	pvalue
Fat mass			
• **High**	8	21	
• **Normal**	9	63	0.065
BMI			
• **Abnormal**	7	39	
• **Normal**	10	45	0.45
Sex			
• **Girl**	12	52	
• **Boy**	5	32	0.34
Physical activity			
• **Yes**	14	75	
• **No**	3	9	0.32
Screen time			
• **Inappropriate**	9	62	
• **appropriate**	8	22	0.087

Table 4. Characteristics of overweight or obese patients

	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5	Patient 6	Patient 7	Patient 8	Patient 9	Patient 10	Patient 11
Age (ans)	17	13	16	18	18	18	11	14	13	17	15
Sexe	M	F	F	F	F	F	F	F	F	F	F
Socio-economic level	Moderate	Moderate	Low	Low	Low	Low	Moderate	Low	Low	Low	Moderate
Duration of diabetes (years)	1.4	1.25	4	2	2	3	6	3	3	3	1
Plan	Regular insulin	Regular insulin	Regular insulin	Regular insulin	Regular insulin	Regular insulin	Basal bolus	Regular insulin	Regular insulin	Regular insulin	Basal bolus
Dose (IU/kg)	0.6	0.64	0.5	1	0.71	0.73	1.2	1.2	0.87	1.1	0.7
Physical activity (H/week)	5	3	2	0	4	2	3	0	5	2	2
Screen time (H/d)	2	5	5	5	6	5	3	10	3	8	6
Snacking	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes
HbA1c (%)	7,4	8,1	9,4	9,8	11,2	12,2	12,3	13,5	13,3	14	14,8

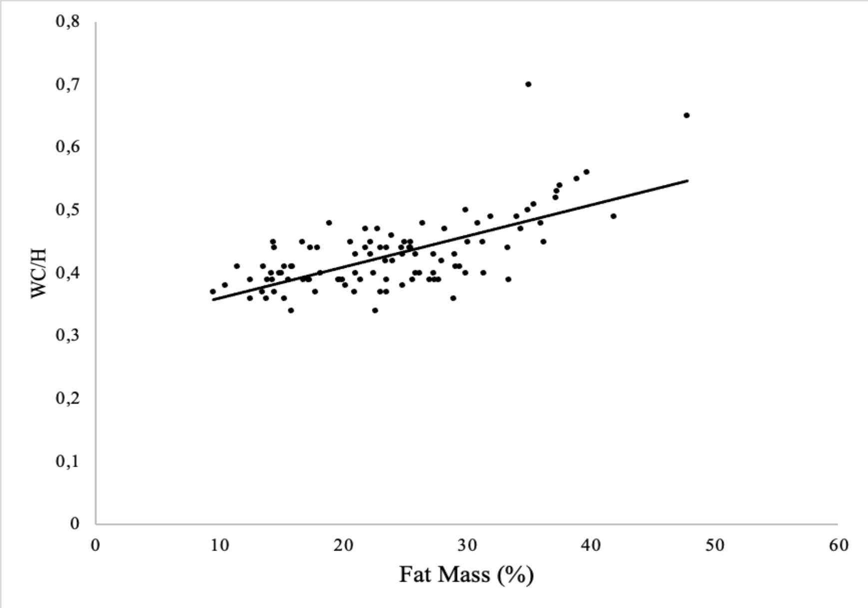

Fig. 3. Correlation between FM (%) and WC/H

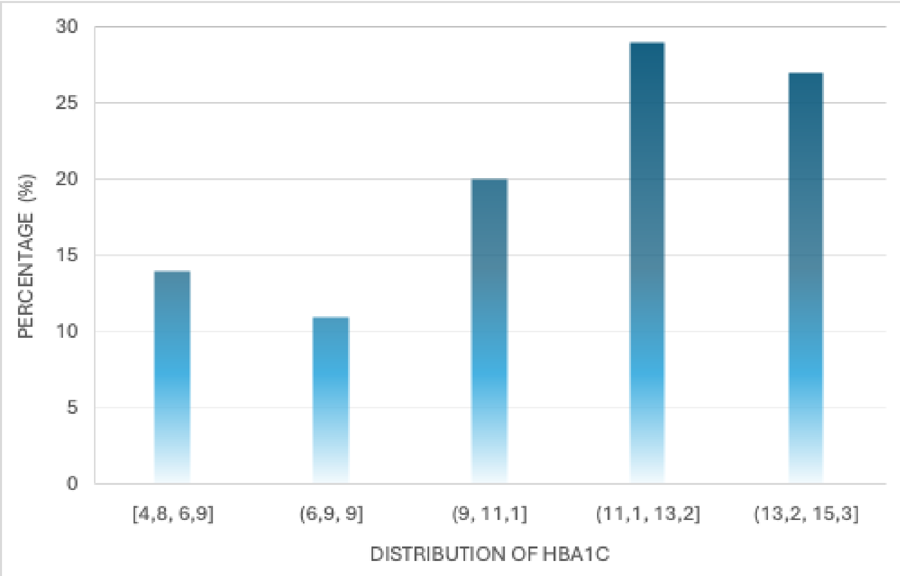

Fig. 4. Distribution according to HbA1c averages

Most patients were very unbalanced, with HbA1c levels above 9% in 75% of children (Fig. 4).

Poor diabetes control with HbA1c >7.5% was associated with female gender, high FM, abnormal BMI and inappropriate screen time but this link was not statistically significant (Table 3).

There were 11 overweight or obese patients. They were all adolescents, including one boy. They had a low socioeconomic level and their diabetes had been progressing for an average of 3 years. Only 2 had a basal bonus regimen with insulin analogues. The mean HbA1c was 11.4%, virtually identical to that of the whole cohort (Table 4).

4. DISCUSSION

Monitoring anthropometric measurements and physical development, using age-appropriate standards is a crucial element in the treatment of children and adolescents with diabetes (Fröhlich-Reiterer et al., 2022). In our series, the average weight was -0.08 SD. This result is fairly superimposable to the series of Magda et al. (2020), unlike in European series such as that of Galli-Tsinopoulou et al. (2009), where the average weight was quite high.

In our case, as well as in several other African series (Abd El Dayem & Battah, 2012; De Bock et al., 2022), the proportion of patients with underweight predominates among T1D. According to available data, underweight can be explained by inadequate control of diabetes leading to chronic hyperglycemia probably associated with loss of energy through glucosuria and subsequent weight reduction, but also by a spontaneous reduction in blood sugar. food intake favored by the state of ketoacidosis and an increase in energy expenditure due to increased gluconeogenesis (Fröhlich-Reiterer et al., 2022). Elsewhere, in industrialized countries, there is a trend towards an increase in the proportion of overweight and obesity. Thus, recent data from multiple international registries show higher rates of overweight and obesity in children and adolescents with T1D compared to their peers (Maffeis et al., 2018). There were 10.9% overweight/obesity, the majority of whom were female (p=0.04). This same predominance was found in the literature, where girls were more prone to the risk of overweight and obesity. The difference between the sexes is probably due to greater body fat gain during and after puberty in girls. Three main factors may contribute to this including higher insulin resistance in girls than in boys, alterations of the GH/IGF-1 axis in patients with T1D and the influence of sex steroids (Amiel et al., 1991). Regardless of sex, the Diabetes Control and Complications Trial (DCCT) and other studies have linked this weight gain to intensive insulin therapy (Nathan et al., 1993).

Abdominal obesity is considered an indicator of insulin resistance, which is a risk factor for cardiovascular disease. In adults, the component of abdominal obesity, expressed by waist circumference, is included in most definitions of metabolic syndrome. However, there is no documented threshold for waist circumference in children. Considering all the limitations mentioned, some authors consider the waist-to-height (WC/H) ratio as a good indicator of abdominal obesity. Central obesity can be diagnosed if the WC/H is greater than 0.5 and this value does not depend on age and sex (Szadkowska et al., 2009). The work of Szadkowska et al. (2009) and Bitsorri et al. (2009) proved that waist circumference and WC/H are better than BMI in predicting cardiovascular diseases. Elevated WC/H is common in those who do not engage in physical activity primarily due to the accumulation of abdominal fat (Szadkowska et al., 2009). BMI alone is insufficient to predict future health problems even though it is the most used and simplest measure to define a subject's nutritional status (Maffeis et al., 2018). Body composition analysis is generally considered more sensitive and specific than BMI when it comes to assessing a person's nutrition and overall health for several reasons. It offers a better understanding of tissue distribution and their impact on health unlike BMI which only takes into account the ratio of a person's weight to height. The second reason is that BMI does not distinguish between lean mass (lean muscle and tissue) and fat mass. A person may have a high BMI due to high muscle mass rather than excess fat. Similarly, a person can have a normal BMI even though their body fat level is high (Wells & Fewtrell, 2006). This assumes that individuals may appear lean and apparently healthy but have increased health risks due to excessive amounts of visceral fat and too little muscle mass. Among our patients, more than a third (36.4%) with a normal BMI had a high fat level.

The average body fat percentage in type 1 diabetics can vary significantly depending on several factors, such as age, gender, physical activity level, diet, and diabetes management. There is no specific body fat percentage that applies to all individuals with type 1 diabetes, as it depends on each person's unique body composition (Calella et al., 2020). The average value of the FM was 23.9%, in our population, results similar to several studies such as those of Pietrzak et al. (2009) and Majewska et al (2014), with 21.9% and 24, respectively. 5%.

According to the literature, the rate of FM is generally higher in girls than in boys. This difference can be explained by the higher insulin resistance in girls than in boys, alterations of the GH/IGF-1 axis in patients with T1D and the influence of sex steroids (Majewska et al., 2014). In our work, this same result was found with a statistically significant difference (p= 0.0001).

In our series, 28.7% of patients had a high FM rate. All of the latter had a high WC/H testifying to the abdominal location of this adiposity. FM (%) was positively correlated with WC/H. This correlation was well found in the series of Szadkowska et al. (2009) and Bitsori et al.

(2009). This high FM rate (%) as well as this increased central adiposity reflects the lipogenic effect of insulin on the body composition of diabetic children and adolescents (Nathan et al., 1993; Cengiz et al., 2022). However, according to Majewska et al. (2016), differences observed between children with T1DM and their healthy coevals – when similar in terms of age, body weight, and body fat mass – probably result from broken physiological adipo-insular regulations, independent of the disease duration, its metabolic control or insulin supply.

Changes in body composition in diabetic patients who are historically described as lean are the undesirable outcome of diabetes management, particularly central abdominal adiposity which is associated with dyslipidemia and insulin resistance (Szadkowska et al., 2009; Bitsori et al., 2009). These unfavorable weight changes, coupled with poor glycemic control, as demonstrated by elevated mean HbA1c levels, place diabetic patients at increased risk of macro- and microvascular diabetic complications, metabolic syndrome, and double diabetes if not not taken care of in time (Fröhlich-Reiterer et al., 2022).

In the literature, inappropriate screen time constitutes a behavioral risk factor for the occurrence of metabolic syndrome (Calella et al., 2020). In our series, a significantly positive correlation was found between screen time and FM (%) (r= 0.467, p= 0.0001). A similar result was reported by Heyman et al. (2012) (r = 0.60, p < 0.01).

Regarding body composition and diabetes balance, studies by Abd El Dayem & Battah (2012) and Nsamba et al. (2022) did not find an association between metabolic control and body composition. However, in our study we noted that patients with high FM had poorer metabolic control but this link was not statistically significant. The same was true for patients with an abnormal BMI. Poor metabolic control during childhood and adolescence is strongly associated with the development of complications later in life, such as nephropathy and retinopathy in adulthood (HAS, 2023).

5. CONCLUSION

Trend toward increased adiposity in diabetic children who were previously considered thin. These results indicate the presence of cardiovascular risk factors in type 1 diabetic patients due to excess fat, especially in girls, which could worsen long-term prognosis. Body composition analysis is more sensitive in assessing nutritional status than BMI alone. Regular assessment of body composition, particularly fat mass, may be useful to identify patients at risk of cardiovascular complications and adapt their management. Therefore, it is essentially justifiable to consider body composition in the management of type 1 diabetic patients, with emphasis on regular assessment by making bioelectrical impedance available.

CONSENT

As per international standards, parental written consent has been collected and preserved by the author(s).

ETHICAL APPROVAL

It is not applicable.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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