Comparison of Body Composition Bio Electrical Impedance Analysis of Type-1 Diabetes vs. Non-Diabetes in Children and Adolescent

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Abstract

Background: Analyzing the body composition of children and adolescents with diabetes is becoming more and more popular. For managing weight changes that may emerge from treatment and evaluating treatment response, it is essential to comprehend the body composition of diabetic children.

Objective: To compare body composition by Bioelectrical Impedance Analysis (BIA) among T1DM *versus* healthy children and adolescents in Pakistan.

Methods: This comparative cross-sectional study was performed during Jan-March, 2023. Type 1 diabetic children and adolescents were enrolled from the pediatric endocrinology outpatient clinic of the National Institute of Child Health whereas healthy children and adolescents were enrolled from a nearby school to the hospital location. Evaluation of anthropometry indices and bioelectrical impedance analysis was performed after obtaining the consent of parents.

Results: A total of 100 subjects were enrolled in the study, 50 each in the diabetic and healthy group. The mean age of participants was 10.4 ± 2.4 years. The majority of study subjects were females (61%). The mean duration of T1DM was 4.7 ± 0.8 years. Height (127.4 ± 11.7 *versus* 139.5 ± 15, p<0.001), Waist-hip ratio (0.8 ± 0.1 *versus* 0.7± 0.3, p=0.037) and resistance (686.2 ± 90.7 *versus* 651.1 ± 96.6, p=0.002) were significantly higher among T1DM group than healthy group. Percentage of muscle mass (45.1 ± 8.2 *versus* 50.3 ± 7.6, p=0.008), body cell mass (47.1 ± 3.8 *versus* 50.6 ± 4.5, p=0.045), reactance (56.3 ± 9.8 *versus* 62.4 ± 4.2, p=0.017) and phase angle (4.3 ± 0.9 *versus* 5.7 ± 0.6, p=0.012) were significantly lower in T1DM patients than healthy individuals.

Conclusion: BIA analysis showed that body composition parameters and body functional status were lower among T1DM children and adolescents than in the healthy group in terms of resistance, reactance, and phase angle.

Keywords: *Adolescents, body mass index, body fat, bioelectrical impedance, children, muscle mass, type 1 diabetes.*

INTRODUCTION

Chronic diseases known as diabetes mellitus (DM) can affect how carbohydrates, proteins, and fats are metabolized. It is brought on by the absence of insulin secretion as a result of abnormalities in insulin uptake in peripheral tissue or the gradual or marked failure of the pancreatic-Langerhans islet cells to create insulin. [1].

One of the public health problems with the quickest rate of growth is diabetes, which has several grave side effects. One of the most prevalent chronic endocrine illnesses in children and adolescents is type 1 diabetes mellitus (T1DM). Estimates from the 9th edition of the International Diabetes Federation Atlas for 2019 show that 1.98 billion children (0-14 years) had T1DM [2]. The 2019 International Diabetes Federation (IDF) Diabetes Atlas uses a type 1 diabetes (T1D) incidence rate of 0.5 cases per 100,000 children per year in Pakistan [3].

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Analyzing the body composition of children and adolescents with diabetes is becoming more and more popular. It has been demonstrated that monitoring interventions for weight growth or loss to ensure adequate organism development and planning measures to prevent diseases in adults can both benefit from an evaluation of nutritional status during childhood. Prior research has shown that people with type 1 diabetes frequently experience the emergency condition known as diabetes ketoacidosis [4] and are typically not obese. Obesity in type 1 diabetes (T1D), which was historically uncommon, is now becoming a more common issue [5, 6]. Throughout their lives, a significant portion of T1D patients experience obesity; this condition has been more common in recent years, with prevalence rates ranging from 2.8% to 37.1% [7].

When compared to the general population, patients with T1D have a higher frequency of obesity on the rise. Approximately 50% of T1D patients are now either overweight or obese. In addition, they are larger in the hip and waist departments when compared to healthy controls [8]. The higher prevalence of overweight children with T1D may be partially explained by intense insulin

therapy, and the increased body mass after intensive insulin therapy may be predominantly the result of fat accumulation [9].

Body mass index (BMI), the most widely used indicator of adiposity, is a poor predictor of body fat because it does not distinguish between fat mass (FM) and fat-free mass (FFM). Air-displacement plethysmography, Magnetic Resonance Imaging (MRI), Dual-energy X-ray Absorptiometry (DXA), and deuterium dilution are accurate ways to measure body composition, but their expense makes it difficult to use them in clinical and field settings [10, 11]. But even among those with diabetes, Bioelectrical Impedance (BIA) is a comparatively less expensive, non-invasive, trustworthy, and widely acknowledged way of estimating body composition [12, 13].

Body composition measurements can help with prognosis, early assessment of negative metabolic effects, and clinical diagnosis of disease. For managing weight changes that may emerge from treatment and evaluating treatment response, it is essential to comprehend the body composition of diabetic children. Studies examining the body composition of T1DM kids have been published in the literature [5, 6, 8]. However, studies are rare that compare comparing body composition of T1DM children and adolescents with healthy individual controls. Moreover, the anthropometry of Asians is different from Westerners and Africans [14]. In this scenario, it becomes important to evaluate the body composition of T1DM children in Pakistan as locally scanty literature is available. Therefore, the objective of the current study is to compare body composition by bio-electrical impedance analysis among type-1 diabetes *versus* non-diabetes in children and adolescents in Pakistan.

METHODOLOGY

This comparative cross-sectional study was performed during Jan-March, 2023. Type 1 diabetic children and adolescents were enrolled in the pediatric endocrinology outpatient clinic of the National Institute of Child Health whereas healthy children and adolescents were enrolled from a school nearby to the hospital location. Children aged 5-10 years and adolescents aged 11-15 years of either gender were included in the study. Clinically diagnosed T1DM children and adolescents regularly visiting out-patient clinics as per their schedule adhering to insulin therapy and T1DM management and having good glycemic control were enrolled in the study. Children and adolescents with any other autoimmune and chronic diseases and those who were not willing to participate in the study were excluded from this study. For T1DM children, their parents were asked to give consent to allow their child to participate in this study. On the other hand, for healthy children recruitment, permission was first taken from the school administration to perform the study in their school. Further parents of children were called to take their consent. Parents were also asked some questions including the history of the visit to the doctor because of any illness in the previous month, history of diarrhea, fever, nausea, vomiting, and any other symptom during the previous month that was managed at home and did not require medical to evaluate the health status of children.

The sample size was estimated using the online available calculator Open-Epi. Taking muscle mass of 44.61 ± 6.58 and 49.40 ± 7.59 for the T1DM group and healthy group receptively [15], a 95% confidence interval and a power of 80% yielded a sample of 35 per group.

A standard technique was followed to assess both body weight and height using an electronic scale and a stadiometer, respectively. Height was measured with a stadiometer and measured to the closest 0.1 cm. A computerized weighing scale was used to measure the weight to the nearest 0.1 kg. BMI was calculated by multiplying weight (in kilograms) by height (in square meters). The individuals were asked to stand with their heels together while having their waists and hips measured at the widest diameter across the greater trochanters and the midline between the lower rib edge and the iliac crest, respectively. Then, a waist-to-hip ratio (WHR) was determined. The waist and hip circumferences were measured using a Seca 203 ergonomic measuring tape.

Participants stood on their bare feet in a supine position on the posterior electrode base of the body composition analyzer machine (Tanita DC-430MA TANITA Corporation, Tokyo, Japan) to assess body composition utilizing a dual frequency non-segmental Bio-electrical Impedance analyzer. At a frequency of 50 kHz, the raw values of reactance (XC, in) and resistance (R, in Ohm) were recorded [16]. The arctangent of (Xc/R) was used to compute the phase angle [17]. The first author collected all measures to assure accuracy.

Data was entered in SPSS version 24 to perform statistical analysis. Frequency and percentage were computed for summarizing categorical variables. After confirming the assumption of normal distribution, numerical variables were expressed as mean ± standard deviation. Numerical variables were compared among T1DM and healthy groups using an independent t-test. Statistical significance was defined based on two-tailed p-values less than or equal to 0.05.

RESULTS

A total of 100 subjects were enrolled in the study, 50 each in diabetic and healthy groups with their age and gender-matched healthy control. The mean age of participants was 10.4 ± 2.4 years. The majority of study subjects were females (61%). The mean duration of T1DM was 4.7 ± 0.8 years. Table **1** displays a comparison of anthropometric indices among diabetic patients and healthy controls. Height and weight were significantly

Table 1: Comparison of anthropometric parameters among type 1 diabetic patients and healthy controls.

Anthropometric parameters	Diabetic patients mean ± SD	Healthy controls mean ± SD	p-value
Height (cm)	127.4 ± 11.7	139.5 ± 15	**<0.001
Weight (Kg)	26.8 ± 7.2	32.4 ± 10.7	**0.003
Hip (cm)	77.4 ± 11.2	78 ± 9.4	0.876
Waist circumference (cm)	69.1 ± 13.3	66.3 ± 10.6	*0.042
Waist hip ratio	0.8 ± 0.1	0.7± 0.3	*0.037
Body mass index (Kg/m^2)	16.3 ± 2.4	16.1 ± 2.4	0.775

SD: standard deviation, *Significant at p<0.05, **Significant at <0.01

Table 2: Comparison of bioelectrical Impedance Analysis among type 1 diabetic patients and healthy controls.

Parameters	Diabetic patients mean ± SD	Healthy controls mean ± SD	p-value
Percent body fat	13.3 ± 6.1	12.5 ± 6.1	0.487
Fat mass (kg)	22.6 ± 7.5	21.4 ± 9.4	0.268
Fat mass (% of body mass)	23.96 ± 9.50	22.49 ± 9.44	0.475
Fat-free mass (kg/m2)	29.3 ± 14.5	30.6 ± 11.6	0.751
Fat-free mass (% of body mass)	75.8 ± 9.0	76.1 ± 6.4	0.413
Muscle mass (kg)	19.6 ± 3.4	21.8 ± 2.8	0.239
Muscle mass (% of body mass)	45.1 ± 8.2	50.3 ± 7.6	**0.008
Body cell mass (kg)	15.4 ± 7.3	16.2 ± 7.4	0.207
Body cell mass (% of body mass)	47.1 ± 3.8	50.6 ± 4.5	*0.045
Resistance (ohm)	686.2 ± 90.7	651.1 ± 96.6	**0.002
Reactance (ohm)	56.3 ± 9.8	62.4 ± 4.2	*0.017
Phase angle (–)	4.3 ± 0.9	5.7 ± 0.6	*0.012

SD: standard deviation, *Significant at p<0.05

lower among diabetic patients as compared to healthy controls Table **2**.

DISCUSSION

Diabetes, a serious chronic non-communicable illness that has been linked to both obesity and chronic undernutrition, is becoming an increasingly significant burden on both health and society globally [18, 19]. Severe growth retardation has previously been linked to several factors, including type 1 DM. It is possible for type I diabetes to develop as a result of genetic, environmental, and immunological factors that cause the beta cells in the pancreatic islets of Langerhans to die. Monitoring glucose levels becomes an essential element of treatment for type I diabetes since it impacts children's physical and mental development. Additionally, to establish the severity of the condition, evaluation of body composition is required in combination with the testing of glucose levels [20, 21]. That's why this study was conducted to compare differences in body composition of T1DM children and adolescents with their healthy controls.

One of the long-term effects of T1DM is impaired development, which is defined as growth that is slower than what is normal for one's age and gender [22]. In this study, we found that T1DM patients and healthy controls differed considerably in height. Numerous studies have shown that metabolic management in people with T1DM is a significant factor in determining eventual adult height [23, 24]. However, numerous other research [25-27] have revealed that such children's growth is normal and unaffected by hemoglobin A1c (HbA1c) levels. However, other studies have demonstrated that the length of the illness rather than the level of metabolic control determines impaired height growth [28, 29]. The variation in findings could be many reasons including disease duration, age at diagnosis, glycemic control, puberty status, and differences in population features.

The fundamental pathophysiological mechanism causing chronic hyperglycemia in T1DM patients is absolute insulin shortage rather than insulin resistance, according to previous descriptions of these patients as slim, insulin-sensitive individuals. The waist-hip ratio was considerably larger in T1DM patients than in controls, which is consistent with research linking high levels of abdominal fat storage and HbA1c [30, 31]. However, in this study, we did not find significant differences among T1DM and healthy controls based on BMI. This finding is in line with many other studies reporting no significant differences in BMI among T1DM and their age and gender-matched healthy controls [27, 15]. Due to some of its limitations, such as the inability to differentiate between excess fat, muscle, or bone mass, and the lack of any information regarding the distribution of fat among individuals, the reliability of the BMI indicator in recent years has been repeatedly questioned [32].

The fast weight gain frequently seen with insulin therapy in children with newly diagnosed T1D has been linked to the anabolic action of insulin in kids with T1DM [33, 34]. Studies have shown that an excess of fat mass develops as a result of the effects of insulin therapy. In comparison to the non-diabetic group, Davis *et al.* found that children with type 1 diabetes had a much lower FM% and equivalent lean mass at the time of diagnosis. Following the introduction of insulin, the diabetic group experienced abrupt increases in fat mass and a little loss of lean body mass over the first six weeks of treatment. The authors attributed this event to a catabolic state at the time of type 1 diabetes diagnosis and significant insulin insufficiency [35]. In contrast to this study, our analysis did not find significant differences in body fat percentage, fat mass, and percentage and fat-free mass and percentage of fat-free mass among the two groups. These findings are consistent with the analysis of Nsamba *et al.* [27] and Więch *et al.* [15] but in contrast with Szadkowska *et al.* findings who reported higher fat mass among T1DM than controls [34].

Considerably higher resistance and lower reactance and phase angle values were observed in this study among diabetic patients in contrast to their healthy peers. Nsamba *et al.* [27] also reported higher resistance and lower reactance and phase angle values among

T1DM children and adolescents. In line with this study, Więch *et al.* [15] also analyzed that reactance was higher in the T1DM group than healthy group whereas resistance and phase angle were lower. Additionally, diabetes and insulin resistance are linked to abdominal obesity according to available research [34]. Because of this, it's crucial to comprehend the connections between T1DM, insulin hormonal therapy, and obesity to address cardiometabolic risk factors early on and prevent life-threatening consequences. This is interesting to see that BMI and BF were not significantly different among the two groups. Detailed BIA analysis showed that growth and nutritional status were undesirable in T1DM than control which simply indicates that only BMI evaluation is outdated and may portray misleading results. Thus, it is mandatory to replace BMI evaluation with BIA analysis when evaluating children for nutritional and growth status.

The present study suffers from various limitations. First, the study was cross-sectional which did not reveal the pattern of changes in body composition in T1DM children and adolescents at the time of diagnosis and throughout treatment. Second, we only enrolled the targeted population who had good glycemic control and were adhering to insulin therapy. Third, the sample size was not too large. Fourth, it was a single center. Fifth, we did not record puberty status and Hb1ac observations in this study. Thus a larger sample size study should be performed addressing the gaps of the current study for validating the findings of this study.

CONCLUSION

BIA analysis showed that body composition parameters and body functional status were lower among T1DM children and adolescents in comparison to their age and gender-matched healthy controls. The study findings suggest implementing BIA analysis in daily routine practice for the evaluation of children and adolescents living with type 1 diabetes.

ETHICAL APPROVAL

Ethical approval was obtained from the Institutional Ethical Review Board (IERB) of the National Institute of Child Health (NICH), Karachi (REF letter No. IERB-36/2022). All procedures performed in studies involving human participants were following the ethical standards of the institutional and/ or national research committee and with the Helsinki Declaration.

CONSENT FOR PUBLICATION

Written informed consent was taken from the participants.

AVAILABILITY OF DATA

The data set may be acquired from the corresponding author upon a reasonable request.

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None.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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AUTHORS' CONTRIBUTION

All the authors contributed equally to the publication of this article.

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