ORIGINAL ARTICLE

Bio-Electric Impedance Analysis of Body Composition and Glycaemic Control in Children and Adolescents with Type 1 Diabetes in South-East, Nigeria

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ABSTRACT

Background: Metabolic derangements in diabetes grossly affect components of body composition particularly the fat mass. Adequate glycaemic control is key to the reduction of risks of associated complications.

Objectives: To determine the pattern of glycaemic control and body composition in children and adolescents with type 1 diabetes mellitus (T1DM).

Methodology: This was a cross sectional descriptive study conducted in three centres in South-East Nigeria. Subjects were T1DM patients attending diabetic clinics at the hospitals who were consecutively recruited while controls were normal school children.

Body composition was determined using bio-electrical impedance analysis method.

Data was collected using a semi -structured proforma designed for the study and was subsequently analysed using SPSS version 22.0. The level of statistical significance was set at $p< 0.05$.

Results: A total of 108 children and adolescents comprising 54 diabetic patients and 54 controls (age and sex matched) were studied. The mean age of the subjects was 16.3 ± 3.5 years.

Majority of the patients had high HbA1c, with a mean and range values of 11.3 ± 2.4 and 7.0 – 13.0%, respectively. The body composition parameters among subjects including the body mass index, skeletal muscle percentage, visceral fat percentage and resting metabolic rate were lower than that of the controls.

Conclusion: A majority of the subjects had poor glycaemic control with overall lower measured body composition parameters. There is need to improve glycaemic control and maintain normal body composition in children and adolescents with T1DM in order to minimize the risks of diabetic complications in them.

Key words: *Body composition; Glycaemic control; Children; Adolescents*

INTRODUCTION

Type 1 diabetes mellitus (T1DM) is an autoimmune disorder arising from selective inflammatory destruction of pancreatic beta cells resulting in loss of insulin secretory reserve. It manifests with weight loss, ketoacidosis, acute onset and exogenous insulin dependency in children.[1,2]

With global pandemic rise in the prevalence of type 2 diabetes mellitus (T2DM), there has also been an increase in the burden of T1DM in children. In Nigeria, the actual burden of T1DM in children is not known. Some available hospital-based data report prevalence of type 1 diabetes as ranging from 0.1 to 2.3 per 1000.[3,4,5,6]

Usually, T1DM is known to impact negatively on childhood growth. The poor growth in addition to delayed pubertal growth spurt in diabetic children could be due to abnormalities in physiological bone growth and altered growth hormone-insulin like growth factor-insulin (GH-IGF-I) axis.[7] Metabolic derangements in diabetes grossly affect components of body composition particularly the fat mass.[8]

There has been rising prevalence of childhood overweight and obesity in the past 2 decades in those with type 2 diabetes mellitus (T2DM) as well as T1DM.[9] Patients with T1DM have been known to have lower body mass index compared to non-diabetic controls, however current research findings suggest otherwise.[9]

The current global trend of rising obesity prevalence has increased at a much higher rate in those with T1DM compared with the non- diabetic population.[9]

Also, there has been cases of "double diabetes mellitus" in which patients with T1DM equally manifest clinical signs of T2DM, mainly obesity and insulin resistance putting such individuals with T1DM at risk of having metabolic syndrome characterized by central obesity, hypertension, high density lipoprotein reduction, elevated serum triglycerides and high fasting glucose.[10] Metabolic syndrome equally increases the risk of cardiovascular disease in them by 1.7-folds.[11]

With the likelihood of increased adiposity and cardiovascular risk in individuals with T1DM, such patients in their early phase of presentation exhibit lower body mass index (BMI) and percentage body fat relative to normal population resulting from insulin deficiency which leads to catabolic state that is mainly lipolytic. However, the body composition is normalized in about 6weeks of insulin therapy as patients gain more fat than lean mass.[11,12,13]

Body composition in children with T1DM varies significantly during the course of the disease, and in most patients an excess accumulation of fat mass develops.[12,13] T1DM is generally associated with increased risk of diverse complications, with poor metabolic control leading to microangiopathy and diabetic nephropathy. Also uncontrolled or poorly controlled diabetes mellitus adversely affects bone and muscle (lean body) mass in addition to impairing their normal function.[14,15]

Assessment of body composition is now of increasing interest for routine monitoring of treatment efficacy, including weight loss interventions in many chronic childhood disease conditions including T1DM.[16]

Use of BMI is the most common method of determining adiposity, however BMI may not differentiate fat mass from fat free mass, and generally has a poor predictive index of body fat.[17]

Several laboratory methods have been employed to determine body composition indices including underwater weighing, anti-displacement plethysmography, deuterium dilution, dual energy x-ray absorptiometry (DXA), computerized tomography (CT), and magnetic resonance imaging (MRI).[18] DXA has been validated for measuring body composition in children. However, it is expensive with increased likelihood of patients' exposure to low density radiation in addition to the procedure being time consuming, hence limiting the use of DXA to field research mainly [16, 18]

Bio-electric impedance analysis (BIA) has been validated in clinical settings as a screening tool for measuring body composition with results comparable to the gold standard tools such as hydrodensitometry and DXA.[19,20] BIA has also been used clinically to determine body composition in children with sickle cell anaemia in our setting with promising results.[20,21]

BIA is simple to use, rapid, non-invasive, portable, cost- effective and free of risks to the patients.[22] It also differentiates fat free mass from fat mass by measuring the resistance of the body as a conductor to very small alternating current.[20]

Studies in body composition among paediatric and adolescent type 1 diabetic populations are scarce in sub-Saharan Africa.

Growing number of children with T1DM are now becoming overweight and obese, hence the International Society of Paediatric and Adolescence Diabetes (ISPAD) has recommended that carers of children with T1DM should ensure that they achieve and maintain appropriate BMI and waist circumference among others, to avoid developments of possible cardiovascular complications in them and further compound treatment outcomes and life expectancy. [23]

This study will help in establishing the baseline body composition among children with T1DM in our setting so that those with high body composition parameters including body fat, visceral fat and BMI among others could be recommended to undergo evaluation of their lipogram and appropriate measures taken to avoid the development of cardiovascular complications in them.

The aim of the current study was to determine the body composition of children and adolescents with T1DM using bio-electrical impedance analysis method in addition to their glycaemic control at three different centres in South-East Nigeria.

METHODOLOGY

Study design and setting
This was a cross sectional descriptive study. The study was conducted in the Endocrinology Units of the Department of Paediatrics, Alex Ekwueme Federal University Teaching Hospital Abakaliki Ebonyi State, University of Nigeria Teaching Hospital, Enugu and St. Charles Borromeo Hospital Onitsha Anambra State, Nigeria from 1st January to 30th April, 2019.

Ethical considerations
Study ethical approval was sought and obtained from the Human Research Ethics committee of the University of Nigeria Teaching Hospital, Ituku-Ozalla, Enugu(Approval Number-NHREC/05/01/2008B-FWA00002458-1RB00002323) while permission was obtained from the Ministry of Education, Enugu State of Nigeria to use the schools for the study of the controls. Further permissions to use the selected schools were obtained from the respective Head Teacher and Principal as the case may be.
Informed written consent was also obtained from each parent/guardian while assent was obtained from older children and adolescents among subjects and controls respectively.
The age of each control was confirmed from their respective class register and /or birth certificate.

Sampling method
Subjects comprised children and adolescents aged 0 to 20 years attending the Paediatric clinics and diagnosed with type 1 diabetes

mellitus (T1DM) based on a single random blood glucose of greater than or equal to 11.1mmol/l in conjunction with typical symptoms of diabetes (polydipsia, polyuria, and polyphagia) or random blood glucose of greater than or equal to 11.1mmol/l on two separate occasions with or without symptoms.[25]

Also, controls were normal school children who were age and sex matched and confirmed to be non- diabetic.[25]

The subjects were recruited consecutively upon their routine attendance to paediatric endocrinology clinics at the three study sites while age and sex matched normal children who served as controls were selected from two public primary and two co-educational secondary schools in Enugu urban using multi- stage sampling method.

A list of the public primary and secondary schools in the six densely populated areas of Enugu metropolis was drawn from where schools were selected by simple random sampling. There were about ten primary and secondary schools respectively in the 6 densely populated areas of the Enugu urban (Emene, Achara Layout, Uwani, Abakpa, Trans- Ekulu, and New Haven). Two primary and two secondary schools respectively were selected by simple random sampling method from the list of schools in these six densely populated zones of Enugu urban. Each primary school has classes 0ne to six while each secondary school has junior secondary class one to senior secondary class three. Each class has an average of 160 pupils/students as the case may be. In the selected schools, the children were stratified according to their classes and in each class, they were further stratified based on their sex. The controls were then selected by the use of systematic sampling method where the first child was selected by simple random sampling, and every other fifth child was equally selected. A total of ten children; 5 from each primary school were selected. Similarly, twenty-two children were selected from each of the two selected secondary schools giving a total of 44 students. In all, a total of 54 controls comprising normal primary and secondary schools' children were recruited and studied.

The social class of each child was determined using the criteria proposed by Oyedeji, in Ilesha, Nigeria with stratification into five different classes (social classes I to V).[26] In this method the social class of each child was determined using the occupational status and highest educational attainment of the two parents. In cases where one of the parents is late the social class of the child was determined with that of the living parent or guardian/s. The social class of each subject was further stratified into upper (social classes I and II), middle (social class III) and lower (social classes IV and V) classes.[26]

All subjects and controls were subjected to clinical examinations including measurement of their height to the nearest 0.1cm, using stadiometer following standard protocols while their weights were measured with a Tanita HD- 314 portable bathroom scale and has a maximum recordable weight of 110kg. At the beginning of each measurement day, accuracy of the weighing scales is checked by using a known standardized weight placed on the scale. Before each measurement, the scale is usually turned to "zero" to correct for zero error. The children were measured wearing a single layer of light/outdoor clothing. Weights were measured in kilograms to the nearest 100gram.

Blood pressure was measured using mercury in glass sphygmomanometer (Accoson®) with a cuff size that covered at least two-thirds of the child's right arm in a sitting position. Three different readings were taken consecutively and the average was taken as actual blood pressure.

The blood pressure percentile (for systolic and diastolic blood pressure) for each selected subject was read off from the fourth report on diagnosis, evaluation, and treatment of high blood pressure.

In children and adolescents, pre-hypertension was defined as a systolic and/or diastolic blood pressure greater than or equal to 90th percentile but <95th percentile for age, gender and height. For adolescents, pre-hypertension was considered if blood pressure was greater than or equal to 120/80mmHg but less than 95th centile.[27,28]

The various body composition parameters were determined using the BIA device (Omron BF 511: Medizin Technik, Mannheim, Germany). Parameters were measured with subjects barefoot and dressed in light underwear following manufacturer's instructions, by one of the researchers. [29]

Bio- impedance analysis device, Omron BF 511, uses eight electrodes in a tetrapolar arrangement and requires the subject to standard on a metal foot pads with bare feet, grasping a pair of electrodes fixed on a handle with arms extended in front of the chest.[29,30]

Data from each subject were documented in a semi-structured proforma designed for the study. Data were analysed using Statistical Package for Social Sciences (SPSS) version 22.0 (Chicago IL).
Comparisons between T1DM children and adolescents (subjects) and healthy controls (non- diabetics) for various anthropometric variables were done using student t- test and chi-square where applicable. The level of statistical significance was set $p < 0.05$.

RESULTS
A total of 108 subjects comprising 54 diabetics and 54 sex and age matched controls were recruited. Forty-eight of the diabetics were from FETHA, while four and two were from UNTH Enugu and St Charles Borromeo respectively. All the controls were recruited from two schools in Enugu.

Most of the subjects were males, 38(70.4%) with a male to female ratio of 2.4:1.
The mean age of the subjects and controls were 16.26 ± 3.50 and 16.15 ± 3.50years, respectively (p>0.05).
Majority of the subjects were older children and adolescents 48(88.9%) aged more than 10 years and were comparable with the controls.

Most of the mothers of study participants had at least secondary education 34(63.0%) while majority were of lower socio-economic class (social classes 4 and 5) accounting for 32(59.3%) for each of the subjects and controls (Table 1).

The mean age at diagnosis of T1DM in subjects was 13.59 ±3.39years and most presented ~~with~~ diabetic ketoacidosis, 40(74.1%).
There was good compliance to clinic attendance among subjects (those aged between 6 and 10years= average of 7times per year while those aged more than 10 years had average of 12 attendance per year), see Table 2.

Average mean daily injectable insulin dosing among subjects was 17.98 ± 56.12*iu* with majority on twice daily dosing, 46(85.2%) and receiving higher dosing in the mornings (mean morning dose: 49.73 ± 83.15*iu*) as well as practising self-administration of insulin injection, 52(96.3%)

Twenty-eight (51.9%) of the subjects occasionally missed their insulin injections.
Main reasons for missed insulin injections were due to financial constraints, 4 (100.0%) and out of stock of medication in the nearby pharmacy, 2(50.0).

A majority (no.=34, 63%) also routinely test for their blood glucose prior to administration of insulin injection and mostly two or more times per day 46(85.2%).
Among those who did not test their blood glucose before the administration of insulin, 8(100.0%), lack of strip, financial constraint

and fear of needle prick were the main reasons for not testing their blood glucose.

Table 1. Sociodemographic Characteristics of Subjects and Controls

	Subjects (n= 54)	Controls (n= 54)	Total (n= 108)
Mean Age (years)	16.26 ± 3.50	16.15 ± 3.50	16.26 ± 3.50
Sex			
Male	38(70.4)	38(70.4)	
Female	16(29.6)	16(29.6)	
Age (years)			
6 - < 10	6(11.1)	6(11.1)	
≥10	48(88.9)	48(88.9)	
Maternal Education			
Primary	20(37.0)	20(37.0)	
Secondary	16(29.6)	16(29.6)	
Tertiary	18(33.3)	18(33.3)	
Socio-economic Class			
Upper class	14(25.9)	14(25.9)	
Middle class	8(14.8)	8(14.8)	
Lower class	32(59.3)	32(59.3)	

Similarly, most of the subjects with T1DM, 38(70.4%) got the replenishment of their injection insulin stock through Federal Ministry of Health assisted support, in those attending Alex Ekwueme Federal University Teaching Hospital Abakaliki (Table 3).

In terms of subjects' glycaemic control – number of mild hypoglycaemia was (0 - 1time) in 46(85.2%) of the subjects, while 8(14.8%) had moderate (2-6times) hypoglycaemia.

Majority of the patients had high HbA1c, mean 11.26 ± 2.37 (7.0 – 13.0) %.

None of the subjects had hypertension as 52 (96.3%) had normal blood pressure while two (3.7%) had pre-hypertension (Table 4).

Similarly, all the controls, 54 (100%) had normal blood pressure. All the participants had normal renal function on serum creatinine and glomerular filtration rate assessment

The subjects and controls were sub-divided into two age brackets – younger (aged 0 to 9 years) and older (10-20years) respectively. The mean weight of the younger subjects was 24.40 ± 0.36kg while that of the controls was 25.63±2.23kg (p= 0.309).

Table 2. Clinical Characteristics of Subjects

Characteristics	Frequency (%)
Mean Age at diagnosis (years)	13.59 ± 3.39
Mode of first presentation (n= 54)	
DKA	40 (74.1)
Not in DKA but sick	14 (25.9%)
Yearly frequency of clinic visit (n= 54)	
6 - <10 years	14 (25.9)
≥ 10 years	40 (74.1)
Previous hospitalization (n= 54)	
Yes	36 (66.7)
No	18 (33.3)
No of hospitalizations (n = 54)	
1 – 2	38 (70.4)
3 – 4	12(22.2)
≥ 5	4(7.4)

Table 3. Injectable Insulin Usage Characteristics among subjects (n = 54)

Characteristics	**Freq (%)**
Type of Insulin used (n= 54)	
Humulin 70/30 (combined insulin isophane+ insulin regular)	36(66.7)
Regular Insulin + Intermediate (premixed)	6 (11.1)
Lautus (Insulin Glargine) + Actrapid (Regular insulin)	4 (7.4)
Regular Insulin + Isophane (intermediate acting insulin)	2 (3.7)
Mixed	6 (11.1)
Insulin dosing (Mean ± SD)	
Total daily dose	17.98 ± 56.12*iu*
Morning dose	49.73 ± 83.15*iu*
Evening dose	26.56 ± 42.47*iu*
Insulin daily dosing frequency	
Twice Daily	46(85.2)
Multiple Daily dosing (≥ 3)	8 (14.8)
Missed insulin medications (n=54)	
Yes	28(51.9)
No	26(48.1)
How frequently is medication missed? (n=28)	
Rarely	9 (32.1)
Occasionally	15(53.6)
Stopped Insulin for several days	4 (14.3)
Reasons for discontinuing insulin (n = 4)	
Financial	3 (75.0)
Out of stock in nearby pharmacy	2 (50.0)
Injects insulin by self (n = 54)	
Yes	52(96.3)
No	2 (3.7)
Routine testing of Blood Glucose before insulin dosing (n = 54):	
Always	34(63.0)
Sometimes	20(37.0)
Blood Glucose monitoring (n=54)	
2 times or more per day	46(85.2)
Once daily	4 (7.4)
Occasionally	4 (7.4)
Source of payment of insulin/strips used (n = 54)	
Out of pocket	12(22.2)
Government supported	38(70.4)
NHIS*	4 (7.4)
Reason for not testing Blood Glucose (n = 8)	
Lack of strips	8 (100)
Financial	8 (100)
Fear of needle pricking	4 (50)

*NHIS: National Health Insurance Scheme

However, the mean weight of the older subjects (48.84±8.73kg) was lower than that of the controls (65.69 ± 8.58kg) and the difference was statistically significant (p=0.000).

Also, the mean height of the older subjects (161.38±9.15cm) was lower than that of the controls (172.06±9.64cm) and the difference was statistically significant (p=0.024).

Table 4. Glycaemic and BP control among children and adolescents with type 1 diabetes mellitus

Characteristics	**Frequency (%)**
Number and severity of hypoglycaemia per week	
Mild (0 – 1 time)	46(85.2)
Moderate (2 – 6 times)	8 (14.8)
Classification of blood pressure (n=54)	
Normal	52 (96.3)
Pre-hypertension	2 (3.7)
Hypertension	0(0)
Mean DKA in the last 1 year (n= 18)	1.0 ± 0.00
HbA1C (Gylcosylated Haemoglobin)	
Range	7.0 – 13.0
Mean	11.26 ± 2.37
Blood pressure	
Systolic (mean)	100.3 ± 14.92
Diastolic (mean)	63.6 ± 13.810

The mean height of the younger controls (128.50±3.38cm) was higher than the age and sex matched subjects (mean height: 124.56±4.48cm). However, the difference was not statistically significant (*p*=0.309) while the mean height of the older subjects, 161.38±9.15cm was lower than that of the controls 172.06±9.64cm and the difference was statistically significant (*p*=0.024).

Similarly, the older subjects had lower mean body mass index (BMI 18.83± 2.07 Kg/m^2 compared to their counterparts in the controls group who had 22.00 ± 2.84kg/m^2 and the difference is statistically significant (*p*= 0.001) as shown in Table 5.

The mean skeletal muscle percentage of younger and older subjects respectively was low compared to the controls. There was statistically significant difference (*p*= 0.033) in the mean skeletal muscle percentage of the younger subjects aged 6 to <10years with T1DM as shown in Table 5.

The mean resting metabolic rate (RMR) in younger and older subjects were generally lower compared with the controls and the mean difference in older subjects and controls was statistically significant (*p*=0.000) as shown in Table 5.

Mean body fat percentage was lower in older subjects compared to counterparts in the control group, while among younger T1DM subjects even though they had higher mean body fat percentage than controls, the difference was not statistically significant (*p*=0.746).

The visceral fat percentage of subjects was generally low. In the younger T1DM subjects the visceral fat was not recordable. Similar findings were observed in the controls (Table 5). However, the older healthy controls who had recordable visceral fat percentage had higher mean visceral fat percentage of 4.08± 1.14 compared to 1.-73 ± 1.53 among the comparable subjects and the difference was statistically significant (*p*= 0.000).

Generally, T1DM subjects had lower measured body composition parameters compared with controls. Also, among the subjects the older ones aged ≥10 years showed lower body composition indices including weight, height, BMI, visceral fat percentage, skeletal muscle percentage, body fat percentage compared to their age and sex matched controls.

Table 5. Summary of Anthropometric Measurements in subjects and Controls

Characteristics	0 – 9 years of age Subjects (n=6)	Controls (n=6)	*p*-value	10 – 20 years of age Subjects (n=48)	Controls (n=48)	*p*-value
Height (cm)	124.56 ± 4.48	128.50 ± 3.38	0.309	161.38 ± 9.15	172.06 ± 9.64	0.024*
Weight (cm)	24.40 ± 0.36	25.63 ± 2.23	0.397	48.84 ± 8.73	65.69±8.58	0.000*
BMI (kg/m^2)	15.77 ± 1.16	15.50±0.76	0.755	18.83±2.07	22.00±2.84	0.001*
Skeletal Muscle (%)	29.07 ± 0.71	30.83±0.64	0.033*	41.01±5.71	41.82±4.92	0.576
Body fat (%)	16.2 ± 3.91	15.27±3.11	0.746	13.61±5.94	15.53±7.05	0.361
Visceral fat percent	0.000 (0.00-0.00)	0.00(0.00-0.00)	-	1.73±1.53	4.08±1.14	0.000*
Resting metabolic Rate (Kcal/kg)	1056.66 ± 10.97	1077.66±42.74	0.456	1338.04±171.17	1556.11±214.64	0.000*

DISCUSSION

Diabetes is becoming an increasing cause of morbidity and mortality globally, with about 250 million people living with diabetes globally and half a million are children under the age of 15years diagnosed with T1DM.[31]

In the present study about 54 children with T1DM are currently accessing care in two major teaching hospitals and one major missionary hospital providing healthcare services - in the southeast part of Nigeria.

There is paucity of paediatric data on child and adolescent diabetes in the sub- Saharan African (SSA). According to published studies, the prevalence of T1DM among school children was 0.33 per 1000 persons in Nigeria, and 0.95 per1000 in Sudan, while an incidence of 1.5 per 100,000 children and adolescents was reported in Tanzania. [32,33,34]

Plausible reasons for low prevalence of diabetes among African populations could possibly be due to delayed, under- and mis-diagnosis; and poorer prognosis in addition to genetic susceptibility which has also been documented among African Americans in the United States of America.[3,4]

The mean age at initial presentation/diagnosis of our patients was 13.59 ±3.39years. However, an earlier similar study in Abakaliki Nigeria, has reported a median age of 11.4years.[3] It is known that the prevalence of T1DM increases with age as was corroborated in the current study.

Care of children with T1DM in SSA has variously been reported to be sub-optimal and mostly attributable to high level of poverty among a majority of the population, lack of government support and non-functional health insurance schemes; in addition to high cost and poor availability of insulin, limited access to other consumables necessary for optimal diabetic care including syringes, blood glucose level monitoring devices, monitoring of Hb1Ac among others.[3,4,31,35,36,37]

Similar findings were observed in the current study with many patients not able to monitor their blood glucose and HbA1c adequately in addition to inadequate supplies of insulin formulations owing to high cost, storage concerns and out of stock "syndrome". Applications of these standards of care are key to good glycaemic control among the patients with T1DM.

In the present study, the mean Hb1Ac was 11.26± 2.37 with a range of 7.0- 13.0%.
However the ISPAD consensus guidelines has recommended at least once per year testing of glycosylated haemoglobin among individuals with T1DM with a treatment goal of HbA1c of <7.5%, [23] showing that majority of our patients still fall short of the desired treatment goal due to concerns related to inadequate dosing of insulin,

monitoring of blood glucose and inadequate nutrition as well as its supervision.

Most of the patients had normal blood pressure with only two having blood pressure in the pre-hypertensive range. Though the prevalence of arterial hypertension and pre-hypertension were higher in diabetics generally compared to healthy non-diabetics even when diabetic nephropathy symptoms are absent in them, [38]Sheyile et al [39] had corroborated the finding of normal arterial blood pressure in their cohort similar to the findings in the present study.

The T1DM subjects overall recorded lower measured body composition parameters including body mass index, visceral fat, skeletal muscle percentage and resting metabolic rate compared with controls except for body fat percentage in which the younger subjects aged 6 to9years had higher mean body fat than controls though the difference was not statistically significant. These findings corroborate a report in children and adolescents with type 1 diabetes who have sub-optimal body composition though with higher fat mass and lower bone mass.[40]

In variation to the fact that optimal glycaemic control helps to prevent associated diabetic complications as it acts on serum concentration of total cholesterol, low density lipoprotein and triglycerides; however, it supports greater weight gain and increase in percentage body fat than conventional treatment.[39]

Adequate insulin therapy with good glycaemic control is known to promote increased adiposity among children and adolescents with type 1 diabetes as they tend to have increased body mass index with resultant metabolic syndrome and cardiovascular complications.[13]

In the current study plausible reasons for the lower body composition parameters among subjects could be due to poor growth on presentation, low socio-economic background with many on government support for provision of insulin, glucometer and its strips monitoring of blood glucose as well as HbA1c which most of the time the supply is erratic and hence poor glycaemic control in them with resultant low body composition.

International society for Paediatric and Adolescent Diabetes (ISPAD) advocates multi-disciplinary team approach in diabetic care including efforts to prevent overweight and obesity in order to avoid the risk of development of metabolic syndrome.[23]All of the patients in the current study have recorded low body mass index owing to their inadequate insulin dosing with limited access to insulin and glucose monitoring equipment and consumables that enabled adequate glycaemic control in them.

In conclusion, majority of the subjects with T1DM had poor glycaemic control with overall lower measured body composition parameters including body mass index, visceral fat, skeletal muscle percentage and resting metabolic rate compared to controls except for body fat percentage in which the younger subjects had higher mean value than their age and sex matched controls.

There is need to improve glycaemic control and maintain normal body composition parameters in children and adolescents with T1DM in order to minimize the risks of diabetic complications in them.

REFERENCES

1. Laura A, Barker A, Schloot N, Hosszufalusi N, Ludvigsson J, Muthieu C, *et al*. Body mass index is an important driver of beta-cell in type 1 diabetes upon diagnosis in 10 to18years old children. *Eur J Endocrinol* 2015; 172:107-113.

2. Mazumder R, Sarkar D, Chowdhury BR, Chowdhury UR, Chowdhury S. Clinical assessment of obesity and insulin resistance in type 1 diabetes subjects

seen in a centre in Kolkata. *JAPI* 2009; 57:511-514.

3. Ibekwe MU, Ibekwe RC. Pattern of type 1 diabetes mellitus in Abakaliki, south-eastern, Nigeria. *Pediatric On Call J* 2011;8 [Serial online]. Available at: http://www.pediatricsoncall.com . date accessed: 25th August, 2019.

4. Ugege O, Ibitoye PK, Jiya NM. Childhood diabetes mellitus in Sokoto, North – Western Nigeria: A ten-year review. *Sahel Med J*2013; 16:97-101.

5. Opara PI, Anochie IC, Eke FU. Childhood diabetes mellitus in Port Harcourt: Any change in prevalence and outcome? *Port Harcourt Med J* 2008:21: 126-129.

6. Umar UI. Pattern of presentation of type 1 diabetic patients in Kano, Nigeria. *Niger J Basic Clin Sci* 2006; 3:85-88.

7. Parthasrathy L, Khadilkar V, Chiplonkar S, Khadilkar A. Longitudinal growth in children and adolescents with type 1 diabetes. *Indian Pediatr* 2016; 53:990-992.

8. Baltadjiev A, Baltadjiev G. Body composition of children suffering from diabetes type 1. *Biotechnology & Biotechnological Equipment* 2010;24: S354-S355.

9. De Keukelaere M, Fieuws S, Reynaert N, Vandoome E, Kerckhove KV, Asscherickx W, *et al*. Evolution of body mass index in children with type 1 diabetes mellitus. *Eur J Pediatr* 2018; 177:1861-1866.

10. Mottalib A, Kasetty M, Mar JY, Ashrafzadeh S, Hamdy O. Weight management in patients with type 1 diabetes and obesity. *Curr Diab Rep* 2017; 17:92.

11. Saki F, Setoodehnia Z, Javanmardi H, Ranjbar GO. Association between metabolic syndrome criteria and body composition components in children with type 1 diabetes mellitus. *Int J Pediatr* 2016; 10:3709-3717

12. Wiech P, Bazalinski D, Salacinska I, Binkowska-Bury M, Korczowski B, Mazur A, *et al*. Deceased bioelectrical impedance phase angle in hospitalized children and adolescents with newly diagnosed type 1 diabetes: a case – control study. *J Clin Med* 2018; 5:516.

13. Davis NL, Barsell JD, Evans WD, Warner JT, Gregory JW. Body composition in children with type1 diabetes in the first year after diagnosis: relationship to glycaemic control and cardiovascular risk. *Arch Dis Child* 2012; 97:312-315.

14. Wierbicka E, Swiercz A, Pludowski P, Jaworski M, Szalecki M. Skeletal status, body composition, and glycaemic control in adolescents with type 1 diabetes mellitus. J *Diabetes Res* 2018;8121634.

15. Maratova K, Souek O, Matyskova J, Hlavka Z, Petruzelkova L, Obermannova B, *et al*. Muscle functions and bone strength are impaired in adolescents with type 1 diabetes. Bone 2018; 106:22-27.

16. Wan CS, Ward LC, Halim J, Gow ML, Ho M, Brady JN, *et al.* Bio-electric impedance analysis to estimate body composition and change in adiposity in overweight and obese adolescents: comparison with dual energy x-ray absorptiometry. *BMC Pediatr* 2014; 14:249.

17. Wells JC, Williams JE, Chomtho S, Darch T, Grijalia- Eternod C, Kennedy K, *et al*. Body composition reference data for simple and reference techniques and a four- component model: a new UK reference child. *Am J Clin Nutr* 2012; 96:1316-1326.

18. Wang L, Hui S-C. Validity of four commercial bio-electrical impedance scales in measuring body fat among Chinese children and adolescents. *BioMed Research International* 2015; Article ID 614858,8pages.

19. Dube S, Viswanathan S, Dube M. Observational study of weight, body fat with segmental fat distribution, visceral fat and body mass index in type 2 diabetic patients. *International Journal of Research in Medical Sciences* 2016; 4:4806-4811.

20. Eke CB, Chukwu BF, Ikefuna AN, Ezenwosu UO, Emodi IJ. Bio-electric impedance analysis of body composition of children and adolescents with sickle cell anaemia in Enugu, Nigeria. *Pediatric Haematology and Oncology* 2015:1-11. DOI: 10.3109/0888001182015.101111.

21. Vanderjagt DJ, Okolo SN, Rabasa AI, Glew RN. Bioelectric impedance analysis of the body composition of Nigerian children with sickle cell disease. *J Trop Pediatr* 2000; 46:67-72.

22. Cornier MA, Despres JP, Davis N, Grossniklaus DA, Klein S, Lamarche B, *et al* assessing adiposity: a scientific statement from the American Heart Association. *Circulation* 2011; 124:1996-2019.

23. Smart CE, Annan F, Higgins LA, Jelleryd E, Lopez M, Acerini CL. ISPAD clinical practice consensus guidelines 2018: nutritional management in children and adolescents with diabetes. *Pediatr Diabetes* 2018;19(Suppl.27): 136-154.
24. 'National Bureau of Statistics. Demographic statistics bulletin 2017.Available at: http://www.nigeriastat.gov.ng/download/775.Accessed: 10th January, 2019.

25. American Diabetes Association. Diagnosis and classification of Diabetes Mellitus. *Diabetes Care* 2008; 31:55-60.

26. Oyedeji GA. Socio- economic and cultural backgrounds of hospitalized children in Ilesha. *Niger J Paediatr* 1985; 12:111-117.

27. Redwine KM, Daniels SR. Pre-hypertension in adolescents- risk and progression. *J Clin Hypertens* (Greenwich) 2012; 14:360-364.

28. Eke CB, Okafor HU, Ibe BC. Prevalence and correlates of microalbuminuria in children with sickle cell anaemia: experience in a tertiary health facility in Enugu, Nigeria. International Journal of Nephrology 2012, Article ID 240173, 7pages.

29. Bosy-Westphal A, Later W, Hitze B, Sato T, Kossei E, Gluer CC, *et al.* Accuracy of bio-electrical impedance consumer devices for measurement of body composition in comparison to whole body magnetic resonance imaging and dual x-ray absorptiometry. Obes Facts. 2008; 1:000-000. *Eur J Obes* Available at: http://www.fyslowebwinklelini/pdf/obesity%20facts%20-%20BF500.Pdf. Accessed: 20th December, 2018.

30. Omron HBF-516B. Available at: http://www.bathroom-scales-review.toptenreviews.com/omron-hbf-516b-review.html. Accessed: 18th November, 2018.

31. Reddy Y, Ganje Y, Pillay K. Characteristics of children presenting with newly diagnosed type 1 diabetes. *S Afr J Ch* 2013; 7:46-47.

32. Afoke AO, Ejeh NM, Nwonu EN, Okafor CO, Udeh NJ, Ludvigasson J. Prevalence and clinical picture of IDDM in Nigeria Igbo schoolchildren. *Diabetes Care* 1992; 15:1310-1312.

33. Elamin A, Omer MI, Hofwander Y, Tuvemo T. Prevalence of IDDM in schoolchildren in Khartoum, Sudan. *Diabetes Care* 1989; 12:430-432.

34. Swai AB, Lutale JL, Mc Larty DG. Prospective study of incidence of juvenile diabetes mellitus over 10years in Dar es Salaam, Tanzania. *BMJ* 1993;306: 1570-1572.
35. Ngwiri T, Were F, Predien B, Ngugi P, Iughetti L. Glycemic control in Kenyan children and adolescents with type 1 diabetes. *Int J Endocrinol* 2015; 2015:761759.

36. International Diabetes Federation, M. J. C. Report on the international insulin

and diabetes supplies survey on cost and availability 2006. 2006; p.1-49.

37. Beran DA, McCabeb A, Yudkina J. Access to medicines versus access to treatment: the case of type 1 diabetes. *Bulletin of the World Health Organization* 2008; 86:648- 649.

38. Pietzak I, Mianowska B, Gadzicka A, Nilynarski W, Szalkowska A. Blood pressure in children and adolescents with type 1 diabetes mellitus- The influence of body mass index and fat mass. *Pediatric Endocrinology, Diabetes and Metabolism* 2009;15:240-245.

39. Sheyile AS, Neilda SF. Relationship between anthropometric and biochemical profiles in children and adolescents with type 1 diabetes. *Revista Paulistadeb Pediatria* 2012; 30:65-71.

40. Khadilkar V, Parthasarathy L, Khadilkar A, Chiplonkar S. Body composition in Indian children and adolescents with type 1 diabetes. *Int J Pediatr Endocrinol* 2015;(Suppl.1): 18.