Evaluation of Management Outcome of Adolescent Type-1 Diabetes Patients in Selected Clinics in Calabar, Nigeria

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Abstract
Diabetes mellitus (DM), is a group of metabolic diseases in which there are high blood sugar levels resulting from defects in insulin absorption over a prolonged period. This research was carried out to evaluate the management outcome in Type-1 diabetes adolescents in Calabar, Nigeria. Nineteen (19) diabetic adolescent patients attending selected clinics in Calabar and another 19 age-and-sex matched healthy adolescents were recruited for this research. Glycaemic control was assessed using fasting blood glucose (FBG) levels and Glycated haemoglobin concentration (HbA1c%). Anthropometric parameters (height, weight, BMI) in diabetic and control subjects were equally measured. Blood pressure in diabetic and control subjects were equally measured. Mean age of diabetic male and female were not statistically significant compared with male and female control groups. Average age of onset of illness in diabetic males and females were also not significant, and the same result was observed in duration of illness. Findings revealed that baseline fasting blood glucose (FBG) and glycated haemoglobin (HbA1c%) values of the diabetic adolescents were significantly (P<0.001) higher than values in control group. There was a significant (P<0.01) decrees in anthropometric parameters of diabetics compared with controls. Significant negative correlation was observed between father’s educational status and FBG (r=-0.546*) and negative correlation in glycated haemoglobin (HbA1c%) (r=-0.464*) levels in diabetic group. Glycated haemoglobin appeared to be a very dependable marker for diagnosis of diabetes mellitus in adolescents. Adolescent female diabetics have better management outcome compared to males. Combined therapy and insulin therapy resulted in improved glycaemic control and general wellbeing.

1 Introduction
Diabetes mellitus (DM) is a common metabolic disorder affecting greater than 300 million people world-wide1. The disease describes a metabolic disorder of multiple aetiologies, characterized by chronic hyperglycaemia with disturbance of carbohydrate, fat and protein metabolism, resulting from defects in insulin secretion and action, or either of them. Insulin plays a crucial synergistic and integrative role in the conservation of body fuel and relative or absolute lack of insulin results in biochemical derangement of energy homeostasis with its attendant clinical manifestation2. Diabetes is regarded as a syndrome being made up of diverse symptoms culminating in anatomical and biochemical abnormalities with hyperglycaemia accompanying glycosuria as a common factor to the syndrome. The disease which has been recognized over 2000 years ago affects people at various stages of social and economic development. The prevalence is much higher in certain tribes and geographical locations3. Seasonal variations have also been observed by some researchers4,5.

There are two main types of diabetes, usually categorised as Type-I or insulin dependent (IDDM) or Type 2 DM and non-insulin dependent (NIDDM). Type-I DM, which is the most
severe type accounts for almost all diabetes mellitus in children. Type 1 diabetes is caused by auto immune destruction of the pancreas. Patients with Type 1 DM have severe and usually permanent insulin deficiency and require insulin for survival and prevention of life threatening episodes of ketoacidosis. Type 2 DM is less common in children but account for about 90% of all diabetes mellitus cases. Individual with Type 2 DM are not dependent on insulin for survival but they may require insulin to achieve adequate glycaemic control. Type 2 DM is more common in people older than 35 years and most commonly result from insulin resistance with inability of the pancreas to maintain adequate compensatory hyperinsulinaemia.

The signs and symptoms of diabetes mellitus (DM) includes polyuria, polydipsia, polyphagia, weight loss, ketoacidosis, ketonuria, hyperosmolarity, hepatomegaly, tiredness, leg cramps, shocks, coma, frequent infections. Complications of DM include arteriosclerosis, capillary glomerulosclerosis, neuropathy, nephropathy, lower limb gangrene, micro and macro angiopathy and retinopathy. These complications are responsible for greater morbidity and mortality in diabetics and arise in chronic diabetic state. Hyperglycaemia, the most frequent sign of DM, is considered the aetiological source of most if not all diabetic complications as well as anthropometric derangements. Good glycaemic control has clearly been shown in several clinical studies to reduce the risk of development of acute and chronic complications and to slow the progression of already established complications.

Good glycaemic control can be achieved by use of insulin and oral hypoglycaemic agents in combination with appropriate diet, exercise, life style changes and in some reported cases herbal agents have been used. However, insulin remains the main agent of choice for childhood diabetes. Insulin accelerates the rate of glucose transport from the extracellular fluid to the interior of the cells thereby reducing their concentration in blood. Thus insulin play a central role in intermediary metabolism and derangement in the functioning of insulin has far reaching effects beyond glycosuria, hyperglycaemia or ketoacidosis, but also include other signs and symptoms of diabetes. In addition coma or death may result from hyperosmolarity induced by hyperglycaemia and or ketoacidosis. Today due to better understanding, routine monitoring of children with diabetes and treatment with insulin and other health promoting practices, there has been a reduction in death rate, and delay in development of severe complications, such that affected children can now attain their full life potentials.

Despite World Health Organization (WHO) report that Type I diabetes mellitus is rare in most Africans, Americans, Indians and Asian population while higher rates are seen in some Northern European countries including Finland and Sweden, it appears the global rate of reported childhood cases is still on the increase even in developing countries. Moreover type 2 diabetes which was thought to be rare in children is becoming a problem and if nothing is done, it will soon become an epidemic even in Nigerian children.

Adolescence refers to the passage from childhood to adulthood. Early adolescence age 10 – 14 years, middle adolescence age 15 – 17 years, while late adolescence comprise those 18 – 21 years old. Adolescents present many challenges to health care provider because their physical symptoms often are related to psychosocial rather than biologic disorders. Nonetheless, adolescents frequently have chronic medical illnesses and psychosocial problems. Nonadherence to medical regimens is common. Limit testing, resistance to authority figures, and request for confidentiality can complicate clinical care.

Adolescence is an age –range of rapid biological changes accompanied by increasing physical, cognitive and emotional maturity. During this age bracket, children struggle to find their own identity separate from their families. Thus parent-child conflict has been associated with poorer diabetes outcome in several studies. Many of the diabetes-related tasks can interfere with the adolescent's drive for independence and peer acceptance.

Certain characteristics of the child/adolescents and their parents predict an increased risk for difficulties with diabetes. Adolescence is an age –range of rapid biological changes accompanied by increasing physical, cognitive and emotional maturity. During this age bracket, children struggle to find their own identity separate from their families. Findings in the child include the presence of other health problems (e.g. asthma, eating disorders), poor school attendance, learning disabilities, and emotional and behavioural disorders, including risk-taking behaviours resulting in delinquent behaviour and depression. Likewise certain family characteristics have been identified as risk factors for poor diabetic control and repeat hospitalization. These include single parenthood, chronic physical or mental health problems in a parent or other close family members (including substance abuse), a recent major life change for the parent (e.g. loss of a job or a death in the family), health/cultural/religious beliefs that make it difficult for the family to follow diabetes treatment plans.

Additional barriers may be found in a family with intimate experience with diabetes as a parent with diabetes may be committed to outdated treatment ideas or information more pertinent to adult diabetes care. Knowledge of the acute and chronic complication of diabetes may result in anxiety and/or depression, impairing the ability to learn the tools needed to succeed in diabetes management and hindering the care of the child with diabetes.
The onset of puberty causes insulin resistance and psychosocial challenges to achieving optimal metabolic control.

In addition to the hormonal changes of adolescent that causes insulin resistance, adolescent rebellion/ experimentation results in reduced adherence to the treatment regimen. Adolescence is a period marked by feelings of ambivalence, impulsiveness, and mood swings; the struggle to separate from parents; and the need to be accepted by peers may adversely affect diabetes treatment. Adolescents typically engage in experimentation and risk-taking behaviours that may adversely affect self-care and clinical outcomes. Metabolic/glycaemic control thus tends to deteriorate in adolescence.

Good glycaemic control over the course of the disease has been shown to reduce the risk of development and progression to complications. Thus, good glycaemic control should form the main goal of any management protocol for children with diabetes.

2 Materials and Methods

2.1 Materials

Materials used in this study were: Glucometer, Accu-check Advantage II, Roche Diagnostic, Germany; Accu-check Advantage II, Test strips; Bathroom weighing scale (Hanson, England); Stethoscope – Lithman; sterile gloves; tourniquet; DIALAB Glycated haemoglobin kit, Germany; meter rule; mercurial sphygmomanometer, China; methylated spirits; cotton wool; 5mls syringes and needles; sample bottles (Fluoride Oxalate bottles, EDTA bottles); Antisera A, Anti-B and Anti-AB (Human Polyclonal Immucorinc, Norcross); white porcelain tile; 0.9% normal saline; Anti-Rh (anti-D) serum; centrifuge; water bath.

2.2 Subjects

This study was carried out in two groups of adolescents after ethical approval by Ethics Committee University of Calabar Teaching Hospital, Calabar (UCTH). The first group of subjects considered test group involved in the study is the test group comprised of 19 confirmed male and female adolescent diabetics drawn from the Endocrinology Unit of the Paediatric Department of the University of Calabar Teaching Hospital, Faith Foundation Clinic and Union Medical and Children Centre. The second group of subjects which is the control group comprised 19 adolescent males and females with no clinical symptoms of diabetes or any other endocrine condition. Both groups were made of adolescents from various parts of the country who reside in Calabar.

2.3 Method of sampling

This was a prospective study involving confirmed adolescent diabetic children aged between 13 and 19 years, receiving treatment between February 2012 and January 2013 in the above mentioned clinics with no other chronic illness and who also gave consent following detailed explanation of extent and purpose of the study to subjects, their parents/guardians. The subjects were randomly selected within the limit of the desired age bracket. Both test and control groups were age and sex matched.

The selection criteria for diabetics were based on blood glucose level above 7.0Mmol/L. Parameters measured include height, weight, BMI, blood pressure, blood groups, fasting blood glucose and glycated haemoglobin levels. The subjects were monitored quarterly for one year.

2.4 Sample collection

Blood samples for investigation were collected during subject clinic visits. After an overnight fast, fasting venous blood samples were collected aseptically from the subjects via venepuncture for fasting plasma glucose determination. 4mls of the blood was emptied into EDTA bottles and about 2mls fixed into fluoride oxalate bottles. Blood sample in EDTA bottle was used for blood grouping and glycosylated haemoglobin while that in fluoride oxalate bottles was used for fasting blood sugar estimation. Blood grouping was done according to method described by Dacie and Lewis.

2.5 Estimation of glucose

This was done using the glucose oxidase method of Barharm and Trinder. The blood samples in fluoride-oxalate bottles were centrifuged at 2000rpm for 5 minutes, minutes and plasma was collected. Three test tubes were used and 0.01ml of subjects’ blood was put into one test tube, 0.01ml of glucose standard into another and 0.01ml of distilled water into the third tube. Into each of the tubes 1ml of glucose reagent was added and incubated at 37 °C for 10 minutes. The absorbance of standard and subjects was read against the blank at a wave length of 660 nm. The intensity of the colour change is proportional to the concentration of the glucose in the sample blood. Blood glucose estimation was also carried out with glucometer (Accucheck advantage II Roche diagnostic GmbH Germany) and Accucheck advantage II test strips) where sugar strip was inserted into a one stop glucometer, glucometer and a drop of blood werewas placed on the sample spot. The meter automatically issued a result in mmol/L after 45 seconds. The glucometer is a glucose oxidase based instrument used for blood glucose measurement.

2.6 Glycated haemoglobin analysis

This was analysed using ion exchange chromatography as described in the DIALAB Glycated haemoglobin Kit obtained from Giesel shaft, Germany. No special preparation was necessary for this assay.

2.7 Height and weight

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Anthropometric measurements were taken according to the methods described by Paynter and Parkin.

### 2.7.1 Height

Height was measured with subjects standing using an erect meter rule placed against a perpendicular wall. The subjects stood erect, barefooted, heels together against the bottom of the wall with the buttocks, shoulder and head touching the wall and the chin raised. They were told to look straight ahead, take a deep breath and make themselves as tall as they could. A wooden head piece was then made to rest on the head of the subject and held firmly to the wall at right angles and the subject was asked to move away from under the head piece. The height was read from under the head piece on the calibrated meter rule placed against the perpendicular wall to the nearest 0.1 cm.

### 2.7.2 Weight

Weight was taken using a standard scale, bathroom type (Hanson made in England), which has an inbuilt calibrated scale in kilograms. It was ensured that the pointer was at zero mark before measurement was taken for each subject. The subjects were asked to remove shoes and made to stand squarely and gently on the scale, straight and looking forward. The kilogram weight was recorded after reading from the pointer lens. Errors due to parallax were avoided by placing the scale on a flat but solid surface and the reading taken vertically.

### 2.8 Body mass index (BMI)

Body weight and height for both subjects measured were used to calculate body mass index. Body mass index was calculated using the equation:

\[
\text{Body mass index} = \frac{\text{Weight (kg)}}{\text{Height (m)} \times \text{Height (m)}}
\]

### 2.9 Blood pressure

All subjects had their blood pressure measured in the morning in the sitting position from the arm after five minutes rest using a mercury sphygmomanometer with cuff of appropriate sizes. The appropriate cuff was that which had a bladder length of 80% and a width that was at least 40% of the subjects arm circumference. Phases I and V Korotkoffs sounds were used as systolic and diastolic values respectively. Two measurements were taken from each subject to the nearest 2mmHg at five minutes interval at each clinic visit and the mean calculated and used for analysis. Elevated blood pressure was defined as systolic and/or diastolic blood pressure > 95th percentile for age and sex as recommended by the fourth report on the diagnosis, evaluation and treatment of high blood pressure in children and adolescents.

### 2.10 Statistical analysis

Data were presented as mean ± SEM. Analysis of data for statistical significant was done using the unpaired students t-test, Pearson’s correlation and regression analysis. The analysis was done with the aid of computer software, SPSS 17.0 for windows. P value of less than 0.05 was accepted as statistical significant.

### 3 Results

The results obtained from this study on the various parameters measured are presented below:

#### 3.1 Comparison of the average age (years) of control and diabetic subjects

The mean ages of control males and females were 15.79±0.55 years and 15.80±0.97 years, respectively. While the mean age of diabetic males and females were 15.27±0.60 years and 15.75±0.70 years, respectively. There were no significant differences in the mean age of the male and female control or diabetic subjects as shown in (Fig.1).

![Fig. 1: Comparison of the mean ages of diabetic and control male and female subjects. Values are mean ±SEM](image)

#### 3.2 Comparison of the average age (years) of onset and duration (years) of diabetes

Age distribution results showed that all our subjects were of adolescent age range 13 – 19 years. The mean age of onset of diabetes in males 13.09±0.49 (years) and females 13.75±0.56 (years) was not significantly different. The average duration of illness in the diabetic males 2.18±0.35 (years) and females 2.06±0.33 years was also not significantly different. This is presented in Table 1.

<table>
<thead>
<tr>
<th>Groups</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age of onset</td>
<td>13.09 ±0.49</td>
<td>13.75 ±0.56&lt;sup&gt;NS&lt;/sup&gt;</td>
</tr>
<tr>
<td>Duration in illness</td>
<td>2.18 ±0.35</td>
<td>2.06 ±0.33&lt;sup&gt;NS&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>NS</sup> = Not statistically significant
3.3 Comparison of anthropometric parameters and blood pressure between control and diabetic subjects

In the table 2 the mean heights (m) of control males and females were 1.53 ±0.03 m and 1.58 ±0.03 m, respectively. Their weight (kg) were 63.92 ±3.25 kg and 69.60 ±3.27 kg, respectively, their systolic blood pressure (mmHg) were 117.90 ±1.18 mmHg and 118.00 ±2.00 mmHg while their diastolic blood pressure (mmHg) were 76.43±1.38 mmHg and 80.00±0.00 mmHg. No significant statistical differences were observed in mean height, weight, SBP and DBP between control males and females. Between diabetic male and female subjects SBP and DBP was not statistically different. Similarly SBP and DBP were not statistically different between diabetic and control groups.

Table 2: Anthropometric and blood pressure parameters in control and diabetic male and female subjects

<table>
<thead>
<tr>
<th>Groups</th>
<th>Height (m)</th>
<th>Weight (kg)</th>
<th>SBP (mmHg)</th>
<th>DBP (mmHg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control males</td>
<td>1.53±0.06</td>
<td>63.93±3.25</td>
<td>117.9±1.18</td>
<td>76.43±1.38</td>
</tr>
<tr>
<td>Control females</td>
<td>1.58±0.3</td>
<td>69.60±3.27</td>
<td>118.0±2.00</td>
<td>80.00±0.00</td>
</tr>
<tr>
<td>Diabetic males</td>
<td>1.45±0.03*</td>
<td>43.91±3.16***</td>
<td>116.36±1.52</td>
<td>74.55±2.67</td>
</tr>
<tr>
<td>Diabetic females</td>
<td>1.45±0.03*</td>
<td>45.5±3.16***</td>
<td>113.80±2.63</td>
<td>75.00±2.67</td>
</tr>
</tbody>
</table>

* P<0.05, ***P<0.001 vs control

However, mean body weight for the male and female diabetic subjects 43.91 ±3.16 kg and 45.5 ±3.16 kg were significantly (P<0.001) lower compared to the control male and female counterparts as represented in Fig. 2. Mean height of diabetic male and female subjects 1.45 ±0.03 m and 1.45 ±0.03 m was significantly lower (P<0.05) compared with control subjects which is represented by Figure 3.

3.4 Comparison of body mass index (BMI) of diabetic and control subjects

Figure 4 shows the mean BMI values for diabetic males and females. The mean BMI values were 20.75±0.82 and 21.70±0.89 kg/m², respectively BMI of diabetic subjects was significantly (P<0.001) lower compared with values obtained for control males and females which were 27.09±0.80 and 27.92±0.84 kg/m², respectively.

3.5 Comparison of fasting blood glucose levels in control and diabetic subjects

Figure 5 represents the fasting blood glucose record which was significantly (P<0.001) higher in the diabetic males (6.93 ±0.59 mmol/L and females 7.59 mmol/L) compared with the control male 4.3±0.6 mmol/L and female 3.68 ±0.2 mmol/L.

3.6 Comparison of HbAic% of diabetic and control male and female subjects

HbAic of diabetic males 7.93 ±0.56 and females 8.39 ±0.57 were significantly (P<0.001) higher compared with values for respective control males 5.36 ±0.11 and females 5.18 ±0.37 subjects as shown in Figure 6.

3.7 Self-blood glucose monitoring

Evaluation of self-monitoring of blood glucose per day in the patients showed significant number 15(78.9%) measured their
blood glucose 2 times per day while two patients (10.5%) were only able to measure once daily and 3 times respectively as presented in Table 3.

Table 2 shows that polyuria, polydipsia and polyphagia were the predominant presenting features in 100% of our patients. While 57.9% of the patients presented with weight loss, 47.4% were dehydrated, vomiting and abdominal pains were the features in 15.8% and 31.6% of patients. The remaining patient (5.3%) was admitted in a state of coma while two patients (10.5%) presented with ketoacidosis.

Table 3: Frequency of blood glucose self-monitoring per day

<table>
<thead>
<tr>
<th>Frequency/day</th>
<th>No. of subjects</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – once</td>
<td>2</td>
<td>10.53</td>
</tr>
<tr>
<td>2 – twice</td>
<td>15</td>
<td>78.9</td>
</tr>
<tr>
<td>3 – thrice</td>
<td>2</td>
<td>10.53</td>
</tr>
<tr>
<td>Four times</td>
<td>-</td>
<td>0</td>
</tr>
</tbody>
</table>

3.9 Duration of symptom before presentation

As represented in Table 4 significant number of patients 11(57.9%) presented to the clinic within 3 – 6 weeks of symptoms. Those that presented within 1 – 4 weeks were 5(26.3%). Two (10.53%) patients presented within 9 – 12 weeks period and the extremely late presentation was by one patient after 6 months.

Table 4: Duration of symptoms before presentation

<table>
<thead>
<tr>
<th>Duration</th>
<th>Adolescent diabetics N = 19</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weeks – months</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 – 2 weeks</td>
<td>5</td>
<td>26.3%</td>
</tr>
<tr>
<td>3 – 6 weeks</td>
<td>11</td>
<td>57.9%</td>
</tr>
<tr>
<td>9 – 12 weeks</td>
<td>2</td>
<td>10.53%</td>
</tr>
<tr>
<td>&gt; 6 months</td>
<td>1</td>
<td>5.3%</td>
</tr>
</tbody>
</table>

3.10 Frequency distribution of diabetic children relatives who were also diabetic

There was no significant relationship between the incidence of diabetes in children and their families. Among the diabetic children which were 19 (100%), only 2 fathers (10.53%), 3 mother (15.79%) and 1 sibling (5.26%) had diabetes. This is represented in table 5.

3.11 Class performance of control and diabetic subjects

In table 6 class performances of control and diabetic subject are represented. The class performance ratings of the diabetic males and females were significantly lower (P<0.05) compared with the control subjects. The mean rating of the control males
and females was 2.21 ±0.16 and 2.00 ±0.32 respectively. While in the diabetic group it was 1.73±0.14 and 1.25 ±0.16 respectively.

Table 5: Relations of diabetic children who are also diabetic

<table>
<thead>
<tr>
<th>Diabetic relations</th>
<th>Frequency</th>
<th>%age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Father</td>
<td>2</td>
<td>10.53</td>
</tr>
<tr>
<td>Mother</td>
<td>3</td>
<td>15.79</td>
</tr>
<tr>
<td>Siblings</td>
<td>1</td>
<td>5.26</td>
</tr>
</tbody>
</table>

Table 6: Ranking/rating of class performance in diabetic and control subjects

<table>
<thead>
<tr>
<th>Groups</th>
<th>Control</th>
<th>Diabetic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>2.21±0.16</td>
<td>1.73±0.14*</td>
</tr>
<tr>
<td>Female</td>
<td>2.00±0.32</td>
<td>1.25±0.16*</td>
</tr>
</tbody>
</table>

*P<0.05 vs control

Table 7 showed that all the control subjects in this study belonged to O⁺ve blood group while in the diabetic group 16 subjects had O⁺ve, 2 subjects had A⁺ve and 1 subject was B⁺ve.

Table 7: Blood group distribution in diabetic and control subjects

<table>
<thead>
<tr>
<th>Groups</th>
<th>O⁺ve</th>
<th>A⁺ve</th>
<th>B⁺ve</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>19(100%)</td>
<td>0(0.0)</td>
<td>0(0.0)</td>
</tr>
<tr>
<td>Diabetics</td>
<td>16(84.21%)</td>
<td>2(10.53%)</td>
<td>1(5.3%)</td>
</tr>
</tbody>
</table>

4 Discussions

Diabetes mellitus is characterized by high blood glucose level and poor insulin performance. In Nigeria, diabetes mellitus is the most common chronic physical health condition in children. It is a disease entity that is still an enigma most especially in the developing countries where adolescent/childhood, diabetes is poorly understood and managed 50, with cumulative prevalence rate (CPR) of type 1 diabetes mellitus reported to range from 0.038% to 0.025% for boys and girls respectively between the ages of 5 – 17 years51.

4.1 Anthropometric parameters

The mean body weight of diabetic males and females were significantly lower compared to the control males and females. This supports the classical presentation of type 1 DM which includes polyuria, polydipsia, polyphagia and weight loss 45. Baron and Knerr had reported that glucosuria causes a substantial loss of calories for every gram of glucose excreted, and that this loss when coupled with loss of muscle and adipose tissues, results in severe weight loss in spite of increased appetite 46,47. There was no sex barrier or differences in the degree of weight loss in both male and female diabetics probably because both are being affected by the increased metabolic demand associated with diabetes. Thus, the observed weight loss could have resulted from the persistent catabolic state as well as the loss of ingested calories including micronutrients through glycosuria and ketonuria 48,49. Even the greater body fat of female than males at this stage cannot compensate for the weight loss 50. The mean height of diabetic male and female adolescents was significantly lower compared to the control males and females respectively. However, there was no significant difference in height of male and female diabetics, though one would have expected the mean height in females to be higher than the male due to the fact that females grow faster than males during adolescence. From 11 – 13 years of age the average boy shorter than the average girl because the peak height velocity (PHV) occurs later in the male pubertal sequence in contrast to the relatively early female growth spurt. PHV occurs 18 – 24 months earlier in the female than in the male 51. Poor nutrition, poor glycaemic control and the documented anthropometric derangement associated with diabetes mellitus could lead to the significant lowered anthropometric values observed 52. Poor growth is a long term complication,53 has reported that during adolescence anthropometry provides tools for monitoring and evaluating the hormone-mediated changes in growth and reproductive maturation. Therefore, impaired linear growth or poor weight gain should raise suspicion of the co-existence or development of a co-morbidity 54.

4.2 Age of onset and duration of illness

Average age of onset in male and female diabetics subjects were not significantly different, though some research work has reported early onset in females due to the effect of puberty. Results from this study corresponded positively with a study in Jos that placed mean age of onset at 12±4.3 years 55. This is however different from the following results obtained from North America, Spain, Saudi Arabia, and Iran which got a mean age of 7 years 56.

Although some studies have suggested that type 1 DM in children and adolescent present at a relatively older age in Nigeria, youngest children in researches in Benin and Jos were 5 years old respectively. An earlier study had reported that type 1 DM in Nigerian Africans rarely occurs in patients younger than 10 years which is in support of the findings of this study57. Differences in age of onset might be related to racial variation.

Duration of illness in years was not significant between both sexes in this study and was similar to results of various studies including 53. The importance of age of onset is that the earlier the age of onset, the more difficult to manage and the longer the individual will be exposed to hyperglycaemia with it consequences. The longer the duration of ill health, the greater
the increased risks of complications. It has also been shown that increased vascular complications in type 1 DM is related to disease duration and low density lipoprotein cholesterol levels.

4.3 Duration of symptoms before presentation

The study showed that majority of the patients delayed for more than 3 weeks before presentation to hospital following symptoms. Similar late presentations have been reported by almost all research works on childhood DM especially in developing countries. Mean duration of illness before presentation was 2.3±1.2 weeks. Others have reported 6±4.9 weeks and 7 weeks. Reasons for this late presentation include lack of knowledge and awareness of symptoms and signs of type 1 DM amongst the children and their parents making it difficult for them to explain what is wrong with the child when symptoms are demonstrated. Poverty, poor health seeking behaviour and misdiagnosis are other contributory factors to late presentation.

4.4 Clinical features at presentation

The major observed clinical features in diabetic subjects were polyuria, polydipsia and polyphagia which are classical symptom of DM. Other features included weight loss, dehydration, abdominal pains, vomiting DKA and coma in descending order (Table 4).

Differences in prevalence of DKA in this study and other reported research values could be due to the fact that DKA was the presenting symptoms in most of these studies, also due to the fairly though not optimal glycaemic control in our subjects who were already undergoing treatment before this research.

4.5 Blood pressure

The systolic and diastolic pressures of both diabetic male and female subjects were not significantly different compared to the control, despite the strong correlation of DM with hypertension due to its effect on lipid metabolism and hence effects on blood pressure. Adolescents are at greater risk than younger children for the development of microvascular complication from diabetes. Puberty increases the risk for hyperglycaemia, partly as a result of decreased insulin sensitivity secondary to increased growth hormone levels, thus placing the adolescent especially those with long duration, at increased risk for cardiovascular disease. Postural hypotension was even discovered to be common in young persons with type 1 DM with higher frequency in those with long standing disease. Our result could be explained due to the short duration of illness as most chronic complications set in after 3 – 5 years. Moreover for blood pressure abnormality there are other determinants apart from DM which include age, sex, height, weight BMI, level of physical activity, psychological stress, salt intake, oral contraceptives, environment, race, parental socio-economic status and coexistence with other diseases.

4.6 Body mass index (BMI)

Though the initial BMI of diabetic male and females were within normal values, they were still significantly lowered compared to the BMI values of the control whose BMI appeared to represent pre-obese values. This result in a way seems to support the rising incidence of childhood obesity amongst our children and hence requires attention. It also may indicate that apparently the diabetic subjects could have been obsessed or pre-obessed prior to onset of diabetes.

4.7 Fasting blood sugar in diabetic and control

Baseline fasting blood sugar levels in diabetic male and female subjects were significantly higher compared with the control male and female adolescents in this study. This is in keeping with the results from several studies that have also found hyperglycaemia as the hall mark of diabetes mellitus. Fasting blood glucose values in this study approximately > 7mMols/L for males and > 8mMols/L in females were far lower than values in studies by Ibekwe and Ibekwe which was 16.33mMol/L. This may be due to the fact that patients in this study were already undergoing treatment prior to this study.

4.8 Glycated haemoglobin in diabetic and control male and female subjects

Prior to this study HbA1c% was not assessed in these adolescent. Similarly reports from various researches within the country also showed irregular HbA1c% evaluation due to cost of the investigation and also the fact that many patients were not knowledgeable about the investigation and its values in the management of DM. HbA1c in adolescent diabetics in this study showed greater values than the control. This result is similar to findings by. Also in many other studies the mean HbA1c has been above 10.5% with some studies having the mean HbA1c as high as 12.5%. The only study with a reported mean HbA1c of 7.5% is from non-sub-Saharan Africa. These higher HbA1c% values in adolescent diabetics indicate that the management has not been as good as expected and means greater risk of diabetic complications. This poor glycaemic control could be due to several reasons, including poor knowledge, unavailability and unaffordability of required drugs and equipment, poor attitudes and poor compliance to treatment protocols as has been suggested. Moreover, there is evidence that adolescent with diabetes especially girls have a higher incidence of eating disorders and that eating disorders are associated with poor glycaemic control. Reports have also shown that suboptimal diabetes control is frequently seen during adolescence and prevalent in sub Saharan Africa which is in line with finding of this research.

4.9 Self-blood glucose monitoring

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Self-blood glucose monitoring reported in this study indicated that most patients were able to check their blood glucose level twice a day. This is in contrast with results from Ikweke and Ikweke’s study where only 3% of their subjects were able to measure their sugar levels.[69]. But Ogbera and Kuku had 61% of their patient measuring twice a day a report similar to this study.[69]. Twice a day glucose monitoring especially in adolescent is not adequate but due to poverty, poor attitude to health, inconvenience, ignorance and time, most of the subjects could only assess twice.[63]. Result of this is poor glycaemic control as have been previously reported. Low purchasing power of parents in buying glucometer, test strips and other requirements for self-care could account for the inadequate blood glucose monitoring as observed in this study.

4.10 ABO/rhesus blood groups

Results on investigations to identify possible association between ABO and Rhesus blood groups and diabetes mellitus have been variable, inconsistent and different from one region to the other. Findings have shown blood groups O and A to be more in diabetics and O+ more in non-diabetics with no significant difference in blood groups B and AB distribution amongst diabetics and non-diabetics [64], while results by Addul et al showed higher percentage of AB in diabetic patients with blood group A and B less common but 0 group had same distribution among both groups. Though some studies have demonstrated no significant difference in blood groups distribution in diabetics and non-diabetics, Henry and Poonking recently found increased frequency of blood group B in diabetics [64].

In this study, O+ blood group was predominant in both groups with few A+ and B+ subjects in the diabetic group. Thus while some have identified an association between blood groups and diabetes, others have found no association. Study has shown that early onset of type 1 DM in patients with O and A blood groups, especially in males. Another study identified an ABO locus which influences pepsinogen secretion a marker linked to insulin gene on chromosome 1, 14 and 15 [65].

These conflicting findings can be explained by the fact that racial and geographical factors have a role in genetic expression of disease. The small sample size of this study cannot permit any logical conclusion about any blood group being more susceptible to diabetes mellitus. Similarly most of the studies had small sample perhaps larger scale studies and a meta-analysis of works done in this area may provide logical conclusion.

4.11 Gender Distribution distribution

Gender distribution of subjects in this study showed male (11)/female (8) ratio of 0.6: 0.4 respectively for diabetics and male (14)/female (5) ratio of 0.7:0.3 respectively for the control group. Studies among Ethiopian and Nigerian type 1 diabetes patients found a two-three fold higher incidence of type 1 diabetes in males compared to females 4, 17 [10]. This is in support of our result which showed more affected males than females. Female preponderance has also been reported in other series from some parts of Nigeria, Sudan and Ethiopia [16].

However, some other instances there is no differences in the incidence of type 1 diabetes in males and females as seen in reports from Tunisia [66]. In adolescent females the role of puberty is a major reason of high prevalence of female diabetics. Moreover, for adults diabetics according to up to 50% of women affected by gestational diabetes mellitus end up with diabetes which may account for more affected females as reported by ADA, 2004. Irregular menstrual cycle is also a maker for risk of type-2 diabetes mellitus [67].

Even though studies have shown that type-1 diabetes is the only major organ specific autoimmune disorder not to show a strong female bias [10], there seems to be conflicting reports regarding the gender ratios of patients with type-1 diabetes. It has therefore been suggested that more search for type 1 susceptibility gene should continue, perhaps with time it will be clearer whether any gender is more susceptible [68].

4.12 Hospitalization

Hospital admission is indicative of deterioration in health and the advent of disease complications. Only 4 out of the control subjects were hospitalized at one point or another for malaria, gastroenteritis and lower respiratory tract infection. However, due to increased susceptibility of diabetics to infection, in addition to potential for rapid clinical deterioration expected in untreated/poorly treated children with type 1 diabetes, all the diabetic subjects in this study have been hospitalized at least more than 4 times for various ailments. Malaria was the major illness for which most of the patients in this study were admitted to the hospital. While several other studies have reported DKA as major indication hospitalization, other indications for hospitalization included upper respiratory tract infection (URTIs), gastroenteritis, DKA, urinary tract infection and uncontrolled hyperglycaemia. Duration of hospital stay for most of our patients varied from two weeks to 6 weeks following admission. However, few patients stayed between 6 weeks and above due to very poor glycaemic control and slow recovery rate. Studies have shown poor metabolic control to be associated with a number of psychological problems including anxiety, depression and poor esteem. Recurrent ill health has also been associated with poor glycaemic control and increased hospitalization. Hospital admission outcome for the adolescent diabetics in this study showed 89.47% discharged cases but unfortunately two patients died during the course of this study. In similar studies in Abakiliki hospital outcome was also good with one death. These deaths could have been avoided with intensive diabetes management which has been shown to
reduce hospitalization, emergency room visits, prevent the progression of diabetic complications and reduce overall cost.\(^7\)

**4.13 Diagnosis/treatment modalities**

In this study adolescent type 1 diabetes was diagnosed using symptoms plus fasting blood glucose >7mmol/L recorded on two occasions or random blood glucose >11.1mmol/L and HbA\(_{1c}\) of >7\%. DKA was diagnosed using FBG >14mmol/L, serum bicarbonate <15mmol/L, ketonuria and DKA signs which included dehydration, acetone breath and Kussmaul respiration. Treatment modalities for adolescent diabetics in the selected clinic included insulin alone, insulin and diet, insulin, diet and exercise (combination therapy).

Commonly used insulin in our subject was human insulin (premixed). Insulin analogues were very expensive and out of reach to these patients. Insulin dosing regimen was poor ranged from twice in most subject to three times daily for very few patients. Reason for this low dosing is that despite the middle and high socioeconomic class of the parents, the availability/affordability of insulin was poor. Therefore, people in these families use less than prescribed amount so that their supply last longer which can account for the inadequate use as observed in this study. Other factors associated with poor adherence to insulin prescription are inconvenience, needle pain/phobia complexity of regimen and insulin side effects. Average daily insulin dosage was 1.4µ/kg/day with a range of 0.8 – 2.4 units/kg/day subcutaneously. All the subjects had self-injection. Insulin syringes which were readily accessible were mainly used by patients in this study. However, insulin pens are more convenient to use but unfortunately were not readily available/accessible to most patients. Thus, only 2(10.5\%) of the patients in this study used insulin pens. Meanwhile subcutaneous insulin infusion pumps as means of insulin administration for optimum glycaemic control is absent in this environment.

**4.14 Treatment modalities and fasting blood glucose**

Fasting blood glucose levels showed better glycaemic control for patients on diet and insulin, followed by those on combination therapy with poor result observed on those on insulin alone. While insulin treatment is life-saving and lifelong, chronic under treatment with insulin with resultant long standing poor diabetic controls often leads to poor growth and weight loss and a delay in pubertal and skeletal maturation while over treatment with insulin can lead to excess weight gain, hypoglycaemia and even death. Exercise offers many health promoting benefits for people with or without diabetes. Benefits of exercise in type I diabetes include a greater sense of well-being, help with weight control, improved physical fitness; improved cardiovascular fitness, with lower pulse and blood pressure and improved lipid profile. On the other hand, medical nutrition therapy plays a major role on the management of diabetes in children/adolescents which is why consultation with registered dietician with experience in paediatric nutrition and diabetes is recommended. Several studies have demonstrated that strict adherence to diet and intensive insulin therapy in patients with type 1 DM improves glycaemic control which is supported by our result. However, combination of the above treatment modalities with the benefits of exercise gives the best glycaemic control.\(^7\) This was not the case with the finding of this study. Reason may be that most of them may not actually be having monitored exercise as they claim or there may not have been strict adherence to diet and insulin regimen because self-discipline and adherence to management protocols are necessary if the disease is to be well managed.

**4.15 Mode of treatment versus HbA\(_{1c}\)% levels**

The results of HbA\(_{1c}\)% obtained from the various treatment modalities showed better values of HbA\(_{1c}\)% obtained in patients on diet and insulin, followed by those on combination therapy and unacceptable values seen in those on insulin alone. This result is in line with previous reports that showed that abnormal HbA\(_{1c}\)% result are obtained when the blood glucose levels have been above normal over a period of weeks to months. Ideal HbA\(_{1c}\)% depends on patient’s general health and whether or not patient is using insulin. Low level of HbA\(_{1c}\) can lead to increased risk of hypoglycaemia and high level to increased risk of long term micro-vascular complications. HbA\(_{1c}\)% above 7\% as observed in our subjects indicates that diabetes control may not be as good as it should be and means greater risk for complications.\(^2\) Those on insulin + diet and combination therapy had HbA\(_{1c}\)% value nearly close to 7\% indicating better control with these treatment modalities.

**4.16 Mode of treatment and body mass index (BMI)**

Adolescent diabetics in this study all had body mass indices within the normal range with improvements following treatment. Those on combination therapy had slightly higher BMI values than those on diet and insulin while those on insulin had the lowest BMI. This is not surprising because chronic under-treatment with insulin with resultant long standing poor diabetic control often leads to poor growth, weight loss and delay in pubertal skeletal maturation while over treatment with insulin leads to excess weight gain. The expected normal weight gain and normal linear growth upon initiation of appropriate treatment may have contributed to the observed improved BMI in some of the diabetics following treatment. The improvement in BMI of the diabetic subjects shows treatment modalities have to an extent been good and means lower risk of complications which may also in addition to short duration of illness explain why none of them has developed chronic complication. Moreover normal linear growth and appropriate weight gain are indices of health in general and reasonable marker of metabolic control. Thus
impaired linear growth or poor weight gain should raise suspicion of coexistence or development of co-morbidity.

4.17 Academic performance

Bearing in mind that school problems such as school phobia, truancy and under achievement which will eventually lead to academic failure is common during adolescence period, when such children are saddled with a chronic ill health like DM with further psychological complications, absenteeism from school due to ill health and frequent hospitalizations then poor academic performance may become inevitable.

In this study (Table 7), academic performance was better in control groups than in diabetic group. This result can be explained by the effect of recurrent severe hypoglycaemia and hyperglycaemia which has been related to decrease memory and learning capacity. It is however difficult to draw a strong conclusion due to short duration of ill health, small sample size and the fact that the assessment of academic achievement was based on verbal information which could be deceptive.

Academic performance was also slightly lower in early onset diabetes (EOD) compared to late onset diabetes (LOD) in children in their study.

5 Summary

Mean age of diabetic males and females were not statistically significant as compared to male and female control group. Result showed lower body weight, height and BMI in diabetic subjects compared to controls. More adolescent males were affected with DM than females. Average age of onset of illness in diabetic males and females were not significant, and the same result was observed in duration of illness.

No blood pressure abnormalities were observed in both groups. ABO/Rhesus blood group showed predominance of O− in both groups.

The major presenting clinical features were polyuria, polydipsia, polyphagia and weight loss. Almost all the patients presented late to hospital. Hospitalization of diabetic patients was mainly due to malaria group. Majority of the diabetic patients had prolonged hospital stay with encouraging discharge rate. Acceptable FBG level, HbA1C%, body weight and BMI were seen in those on diet + insulin followed by those on combination therapy while those on insulin alone had unacceptable values. Self-blood glucose monitoring was inadequate. Daily insulin dosing was also inadequate in these patients. Hence the suboptimal result. Two deaths occurred amongst the diabetic group in the course of this study due to ketoacidosis.

6 Conclusion

Education correlates positively with glycaemic control, anthropometric parameters and general wellbeing of the diabetic subjects especially those who received diet and insulin therapy. Adolescent female diabetics have better management outcome compared to males.

Combined therapy and insulin therapy resulted in improved glycaemic control and general wellbeing.

There is need for improved awareness to the general public that diabetes mellitus in children/adolescents is not as rare as previously thought and prevalence is increasing. Also, diabetes mellitus in children does not present exactly the same way as diabetes mellitus in adults to help reduce high misdiagnosis rates.

Evaluation of height, weight, BMI and nutrition plan at least every year.

Patients with disease duration longer than 3 – 5 years should have annual clinical examination for retinopathy, nephropathy, cholesterol level estimation, and periodic assessment of blood pressure.

Glycosylated haemoglobin should be measured four times a year and blood glucose levels at least twice a day. Additional test if there is hypoglycaemia in the night during period of intercurrent illness and when FBGL is >300mg/dl (16.7mmol/L) urine ketones should be tested.

Combination therapy should be encouraged in the management of diabetes. And being a multi-faceted disease, it requires multidisciplinary, multi-sectorial and multidimensional approach to be effectively managed and controlled.

7 Conflict of interests

There is no conflict of interest among the authors regarding the publication of this article.

8 Author’s contributions

This work was carried out in collaboration between all authors. Authors Nwangwa JN and Seriki SA were involved in concept and design of research. Author Nyoro IK was involved in data Analysis and interpretation. Author Lelei S participated in manuscript creation involving critical writing and revising of the content. All authors read and approved the final version of this manuscript.

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