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# Predictors of Glucose Control in Children and Adolescents with Type 1 Diabetes: Results of a Cross-Sectional Study in Khartoum, Sudan

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**Keywords:** Diabetes mellitus; Glycemic control; Children; Adolescents; Sudan

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**Abstract**

**BACKGROUND:** Type 1 diabetes mellitus (T1DM) is a rapidly growing problem in Sudan as well as other African countries. Children and adolescents with type 1 diabetes have previously been found to have poor glycemic control. Strict glycemic control reduces the incidence and progression of chronic complications.

**AIM:** This study aimed to identify the factors associated with glycemic control among children and adolescents.

**METHODS:** The study was a health-centre based descriptive cross-sectional study. Data on socioeconomic, demographic, disease history, and diabetes-specific variables was obtained. Glycemic control was assessed by measuring glycosylated haemoglobin (HbA1C). Linear regression analysis was done to determine factors associated with glycemic control.

**RESULTS:** One hundred Sudanese children with T1DM aged from (1-18) years were recruited for the study (63 % females). Most of the study children (80%) had high random blood glucose levels. Less than half (40%) suffered from the presence of glucose in their urine and one-quarter of them have urine ketones. Also, Glycosylated haemoglobin (HbA1c) level of the study children showed that more than three-quarters (76%) had poor glycemic control. It was found that there is no relationship between nutritional status and glycemic control. However, there is a relationship between socioeconomic status and glycemic control (P = 0.025)

**CONCLUSION:** To improve metabolic control, more frequent BGM should be encouraged among children and adolescents with T1DM. Emphasis needs to be put on providing families with children with diabetes with the medical, financial and social support for better control of their diabetes.

## Introduction

Type 1 diabetes mellitus (T1DM) is one of the most significant and serious chronic diseases targeting children and adolescents worldwide. It is an autoimmune disease with a strong genetic component [1] [2]. While it may target any age group, it tends to develop during childhood [3].

More than half a million children (542,000) worldwide have T1DM and the number of newly diagnosed cases each year is 86,000 [4]. Prevalence of cases in children under 15 is expected to rise by 70% in the coming years until 2020 [5] [6].

Type 1 Diabetes is a major health problem in Sudan and other African countries and is a leading cause of morbidity and mortality [7]. The incidence was found to range between 4.4/100,000 in Algeria to 20/100,000 in Morocco [8]. The prevalence of T1DM among Sudanese young people is increasing. Old studies showed an increase in incidence from 9.5/100,000 in 1991 to 10.3/100,000 in 1995 [9]. In Sudan, T1DM prevalence is 10.1 per 100,000 children, and the overall annual increase is estimated to be around 3% [10].

Diabetic children are expected, with proper nutrition and care, to acquire normal nutritional status [11] [12]. However, several studies describe growth impairment and poor nutritional status to be well-

known complications of T1DM [13] [14]. It is also associated with poor glycemic control [13].

A previous study in children with T1DM in Sudan found the glycemic control to be poor in 86% of the patients, where the pre-meal blood glucose level was 9 mmol/l or higher [15]. It has been well documented and supported by the Diabetes Control and Complication Trial (DCCT) that strict glycemic control could reduce the long-term complications of T1DM [16]. The general recommendations, as evidenced by the DCCT, are to maintain the glycosylated haemoglobin (HbA1c) below 7 %. Nevertheless, to protect children from hypoglycemia, the American Diabetes Association (ADA) provides recommendations for children and adolescents which vary. A level of < 8% is recommended for children between 6 and 12 years, and a level of < 7.5% for those > 12 years [17]. In Sudan, a high prevalence of chronic complications has been described, and they are associated with poor glycemic control, low quality of life, and particularly with morbidity [15].

A study carried out on children and adolescents aged 5 to 18 years in Khartoum showed acute complications of diabetes, as evidenced by ketone bodies in urine, reported in 46% of the children, and hypoglycemia that needed special attention had occurred in 37% of the patients [18]. There was no correlation between the parents' incomes and glycemic control, nor was there is a difference in diabetes control between children attending private and public clinics. Hypoglycemia requiring special attention had occurred in 37% of the patients, and 57% had been admitted at least once to the hospital within the last year; the main causes of admission being diabetic ketosis (72%), hypoglycemia (6%), malaria (11%) or other medical disorders or surgical interventions (9%) [18].

Various risk factors and challenges have been described that are associated with glycemic control. Some of these include socio-demographic variables, such as the age of the child, socioeconomic status, and family structure [19] [20]. Other diabetes-related factors, such as duration of diabetes, adherence and caregiver involvement in the child's care, have also been significantly associated with glycemic control [21] [22]. There was a negative correlation between the mother's educational level and the fasting blood glucose level of children with diabetes. Most of these studies were done in Europe and North America, and very little data exists about risk factors in low resource settings in sub-Saharan Africa.

This study aimed to identify the factors associated with glycemic control in children and adolescents with T1DM in Khartoum. This will help to plan and implement effective intervention programs that focus on improving diabetes control in children and adolescents and to prevent chronic complications.

## Methods

This study was a Health-center based descriptive cross-sectional study. We recruited 100 Sudanese children with T1DM aged from (1-18) years attending Sudan Childhood Diabetes Centre in Khartoum after obtaining consent from parents.

The study subjects were diagnosed with T1DM for at least 1 year with or without complications, attended the centre during the study period from October 2017 to March 2018. We excluded any child with T1DM whose age was below or above the age group (1-18) years and those diagnosed with T1DM for less than one year.

The study was approved by the Ahfad University for Women Research Ethics Committee. Additional clearance was obtained from the Sudan Childhood Diabetes Centre, who enabled the data collected from the patients. Informed consent was taken from respondent families before the enrolment of participants in the study. Privacy and confidentiality were maintained throughout the study period by excluding personal identifiers during data collection.

Primary data was collected using a pretested questionnaire that was initially developed in English and then translated into Arabic using a cross-translation technique. The questionnaire includes questions about demographics and disease history of the study subjects, food intake using a standard food frequency questionnaire, and nutritional habits. Biochemical data (blood and urine test results) were obtained from the patients' records. Anthropometric measurements, including weight and height, were measured using standard procedures.

All analyses were performed using IBM SPSS Statistics version 14, and the results were presented in the form of tables of frequencies and percentages. Chi-square test was used to test the relationship between nutritional status, socioeconomic status, and glycemic control. The nutritional status was assessed using the BMI-for-age (Z-score) Child Growth Reference 0-2, 2-5 and 5-19 years [23]. In the abstract, you mentioned using linear regression analysis.

## Results

A total of 100 children and adolescents aged up to 18 years with T1DM were recruited for the study. The mean age was $12.5 \pm 2.7$ years (median: 12.5, range: 7-18 years). The majority of the children (89%) were in the age group (7-18) years, and the females were more (63%) than males (37%). Over half of the

study subjects (58%) were in basic school, and one quarter (26%) at secondary school (Table 1).

**Table 1: Child Characteristics (n = 100)**

| Parameters | Description | Frequency | Percentage |
|---|---|---|---|
| Gender | Female | 63 | 63 |
| | Male | 37 | 37 |
| Age | 1-3 | 3 | 3 |
| | 4-6 | 8 | 8 |
| | 7-9 | 15 | 15 |
| | 10-12 | 27 | 27 |
| | 13-15 | 29 | 29 |
| | 16-18 | 18 | 18 |
| Child's Education | No Schooling | 10 | 10 |
| | Pre-school | 5 | 5 |
| | Basic Education | 58 | 58 |
| | Secondary | 26 | 26 |
| | University | 1 | 1 |
| | Total | 100 | 100 |
| Child's Position | 1st child | 26 | 26 |
| | 2nd child | 18 | 18 |
| | 3rd child | 21 | 21 |
| | 4th child | 19 | 19 |
| | Above | 16 | 16 |
| | Total | 100 | 100 |

The family demographics are shown in Table 2. Most of the children's families (77%) have incomes less than 1500 (SDG) per month. While child's birth order in the family shows that one-quarter of the children (26%) were the first child, about half (53%) of the children were coming from family members of 6-8 (Table 2).

**Table 2: Family demographics (n = 100)**

| Parameters | Description | Frequency | Percentage (%) |
|---|---|---|---|
| Mother's Age | 20-30 | 13 | 13 |
| | Above 30 | 87 | 87 |
| Mother's Education | Illiterate | 8 | 8 |
| | Primary | 24 | 24 |
| | Middle | 12 | 12 |
| | Secondary | 32 | 32 |
| | University | 16 | 16 |
| | Postgraduate | 8 | 8 |
| Mother's Occupation | Housewife | 80 | 80 |
| | Worker | 2 | 2 |
| | Employee | 8 | 8 |
| | Self-employed | 10 | 10 |
| Father's Education | Illiterate | 9 | 9 |
| | Primary | 20 | 20 |
| | Middle | 12 | 12 |
| | Secondary | 28 | 28 |
| | University | 25 | 25 |
| | Postgraduate | 6 | 6 |
| Father's Occupation | Retired | 3 | 3 |
| | Unemployed | 11 | 11 |
| | Worker | 10 | 10 |
| | Employee | 16 | 16 |
| | Self-employed | 60 | 60 |
| Origin | North Sudan | 27 | 27 |
| | East Sudan | 13 | 13 |
| | West Sudan | 17 | 17 |
| | Center of Sudan | 40 | 40 |
| | Outside Sudan | 3 | 3 |
| Residence | Omdurman | 20 | 20 |
| | Khartoum | 40 | 40 |
| | Bahri | 28 | 28 |
| | Aljazira Villages | 12 | 12 |
| Family Members | 3-5 | 29 | 29 |
| | 6-8 | 53 | 53 |
| | 9-11 | 18 | 18 |
| | Above 11 | 0 | 0 |
| Income/Month(SDG) | Less than 1500 | 77 | 77 |
| | 1500 - 2500 | 19 | 19 |
| | More than 2500 | 4 | 4 |

Most of the children had normal weight (70%). About 88% were using insulin mixtures, while none of them was using insulin pumps. Most of the children (80%) had had a history of hospital admission with DKA. Of the 71% of the children who reported a regular Self-Monitoring Blood Glucose (SMBG), 31% do it on a daily basis. Seventy-nine percent of those who didn't do regular SMBG claimed the cost of tests to be the main obstacle. Twenty one percent of the children have other family members with diabetes, where one-third of them (33.3%) were their mothers (Table 3).

**Table 3: Nutritional status and diabetes history (n = 100)**

| Parameters | Description | Frequency | Percentage (%) |
|---|---|---|---|
| Nutritional Status | Overweight | 10 | 10 |
| | Obesity | 3 | 3 |
| | Sever thinness | 4 | 4 |
| | Thinness | 13 | 13 |
| | Normal | 70 | 70 |
| Insulin Regimen | Basal/bolus | 12 | 12 |
| | Mixtures | 88 | 88 |
| | Insulin pump | 0 | 0 |
| | Total | 100 | 100 |
| History of DKA | Yes | 80 | 80 |
| | No | 20 | 20 |
| | Total | 100 | 100 |
| Regular SMBG | Yes | 71 | 71 |
| | No | 29 | 29 |
| If yes, frequency (n=71) | On a daily basis | 22 | 31 |
| | Three times a week | 4 | 5.6 |
| | Twice a week | 41 | 57.7 |
| | Once a week | 2 | 2.8 |
| | Once a month | 2 | 2.8 |
| | Total | 71 | 100 |
| If no, the reason (n=29) | Cost of test | 23 | 79.3 |
| | Damaged device | 3 | 10.3 |
| | Doesn't know the importance of the test | 3 | 10.3 |

Most of the study children (80%) had high random blood glucose levels. Less than half of them (40%) suffered from the presence of glucose in their urine and one-quarter of them had urine ketones. Also, Glycosylated haemoglobin (HbA1c) level of the children showed that more than three-quarters of them (76%) had poor glycemic control and less than one quarter (24%) have a good glycemic control (Table 4).

**Table 4: Biochemical Data (n = 100)**

| Parameters | Description | Frequency | Percentage (%) |
|---|---|---|---|
| Random blood glucose level | Normal | 20 | 20 |
| | High | 80 | 80 |
| | Total | 100 | 100 |
| Urine glucose level | Normal | 60 | 60 |
| | Present | 40 | 40 |
| | Total | 100 | 100 |
| Urine ketones level | Normal | 75 | 75 |
| | Present | 25 | 25 |
| | Total | 100 | 100 |
| Glycosylated haemoglobin (HbA1c) level | Good control | 24 | 24 |
| | Poor control | 76 | 76 |
| | Total | 100 | 100 |

It was found that there is no relationship between nutritional status and glycemic control, while there is a relationship between socioeconomic status and glycemic control (P = 0.025) (data not shown).

## Discussion

In this cross-sectional study, most of the children (80%) had a history of hospital admission

with DKA. Similar results have been recently reported in Sudan as (81%) of the children diagnosed with T1DM were presented to hospitals with DKA [18]. According to WHO, the highest rates of DKA are found in low- and middle-income countries and therefore, our findings might be associated with the cost of test that, resulting in a low frequency of SMBG [24]. Among the children who reported a regular SMBG, only one third of them performed the test on daily basis. The cost of the test was given as the main factor for the majority (79.3%) for not following a regular SMBG. The finding of the association between the SMBG and the cost is of great importance, as it will affect the control of diabetes. A massive study of 26723 children with T1DM and similar age to our study's children found that increasing the SMBG frequency was significantly associated with better metabolic control and reduced frequency of DKA. Only (21%) of the children have other family members with diabetes, where one-third of them (33.3%) were the children' mothers. This might prove that T1DM is a form of the disease that has no known aetiology and low role of heredity associated with it [25].

Diabetic complications were reported among our study children, where (11%) of the children have eye problems and (2%) had kidney problems. Another study in Sudan has revealed the association between T1DM in children with poor glycemic control, the high prevalence of complications, low quality of life, and particularly with morbidity. Regardless of the importance of consistent glycemic control for protection from chronic diabetes complications that has been well documented, adhering to a diabetes regimen is particularly difficult for young children. This has ultimately led to more frequent hospitalisations and medical complications among children [26]. In the current study, (8%) of the children had celiac disease, and only (2%) had thyroid problems. This might be in adherence with the reported figures in the Krause's food & the nutrition care process whereby celiac disease affects 1-16% of patients compared with 0.3-1% in the general population, and autoimmune thyroid disease occurs in 17-30% of people with T1DM [27].

The management of diabetes in childhood has implications for later development of complications which have been linked to poor glycemic control and the duration of the disease [28]. Children with T1DM should be targeted to achieve an HbA1c ≤ 7.0% to reduce the risks of diabetic complications [29]. In the current study, the biochemical data of the children revealed poor results. Their Glycosylated haemoglobin (HbA1c) levels show that most of them (76%) had poor glycemic control. Also, the majority of the children (80%) had high random blood glucose levels, more than one-third (40%) suffered from the presence of glucose in urine and a quarter (25%) had urine ketones. Similar results of poor glycemic control were reported in Sudan among children with T1DM [18]. Other studies have been conducted in Africa and have also documented poor glycemic control among children with T1DM [30] [31]. Regardless of the poor glycemic control of the children, no significant effect was detected on their growth. Most children have a normal weight, and no significant association was found between their nutritional status and glycemic control (P = 0.168). This result contrasts with the findings of other studies where children with poor metabolic control were reported to have a significantly lower growth velocity than those with adequate metabolic control [32].

The major finding of our study is the significant association between the children's socioeconomic status and their glycemic control (P = 0.025). In contrast to our study, Eliadarous, 2017 was not able to detect any correlation between the parents' incomes and glycemic control of diabetic children in Sudan [18]. Several reasons may stand behind the poor glycemic control of those children, such as high illiteracy rates amongst both mothers and fathers. Besides the direct effect of illiteracy on good health care, illiteracy may also affect the father's income capacity to provide for the family including health care and hence, hamper good financial support to children with diabetes. Nevertheless, this poor glycemic control increases the children's risk of diabetic complications and reduces the quality of their lives.

In conclusion, we found that the metabolic control of our diabetic children is very poor. No significant correlation was found between the children nutritional status and glycemic control (P = 0.168) and most of the study subjects had normal weight. However, a significant association was revealed between their socioeconomic status and glycemic control (P = 0.025).

To improve metabolic control, more frequent BGM should be encouraged among children and adolescents with T1DM. Emphasis needs to be put on providing families with diabetic children with the medical, financial and social support for better control of their diabetes. The Sudanese healthcare should emphasise continuous educational programs for parents and caregivers on the important practices that aim for metabolic control and proper management. Close follow up of the children is needed as this group is the most vulnerable to develop complications.

Further research is needed to evaluate the effectiveness of teaching children and adolescents with T1DM and their family members about the glycemic index of foods consumed in the context of different insulin treatment regimens.

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