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RESEARCH ARTICLE

Growth status of Adolescents with Diabetic Type 1 and its associated factors

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ABSTRACT

Background: childhood and adolescent growth is a good indicator of general health, and attaining normal growth speed is one of the goals of treating diabetic children. Diabetes mellitus type 1 (T1DM) is well known to negatively affect growth. The aim of this study is to assess the growth parameter of diabetic adolescents and related factors.

Methods: The study was conducted at Shaheed Layla Qasim Diabetic Center in Erbil City during June 2022. 160 diabetic adolescent cases were enrolled as samples for the study. Growth was assessed by taking weight and height then plotted on Centers for Disease Control (CDC) growth charts, and a blood sample to was taken to determine glycemic control (HbA1C%).

Results: 160 children participated with mean age of 13.96 ± 1.8. Mean HbA1C was 9.9 ± 2.18 %. 73.8% had poor glycemic control. 33.8% of adolescents were stunted (stature-for-age) and 56.3% of them were underweight (BMI-for-age). There was a significant association between stunting and age group also underweight (BMI-for-age) with age and gender.

Conclusion: one-third of diabetic adolescents were of short stature, and most of them were underweight.

Keywords: adolescent, type 1 diabetes mellitus, glycated hemoglobin, growth.

INTRODUCTION

Diabetes mellitus is an increasingly common chronic disease worldwide.[1] The Middle East and North Africa (MENA) region, comprising 19 countries (including Iraq), has more than 39 million people with diabetes, and there are 425 million worldwide; by 2045 this number will increase to 67 million.[2] The incidence rates of T1DM differ powerfully in different countries of the world. The highest was recorded in northern Europe (36.5/100,000 per year in Finland) and the lowest in China (0.1/100,000 per year) and South America (Venezuela 0.1/100,000 per year). [3]

The total population of Iraq is over 32 million, with diabetes prevalence of 9.1% in 2011, 10.7% in 2021and expected to reach 10.4% by 2030; in 2017 the number of diabetic cases in Iraq was 1,411.5.[2] The estimated national prevalence of T1DM increased from 7.8 per 100,000 children (aged under 15) in 1995 to 14.2 in 2000, and 24.7 in 2014. [4]. The average annual incidence rate of T1DM was 7.4 per 100,000, which takes place in the intermediate group. [5]

In 2021 the total number of registered diabetes patients at Layla Qasim Centre in Erbil was 44,626, of which 36,515 were from Erbil, 6,964 were refugees and 1,147 were in the pediatric age group.[6] Health assessment for this age cohort depends on growth, which is a good indicator of health, thus attaining normal growth rate is one of the goals of treating diabetic children.[7] Adolescence is a transitional period of growth and development between puberty and adulthood.[8] Peak growth in the adolescent body occurs during the puberty phase. Although the growth phases before and after puberty is important, puberty is a critical stage for rising growth, particularly for T1DM. After puberty there is a notably decline in growth and development rate until maturity. [9]

Type 1 diabetic as a chronic disease in childhood is a factor affecting the onset of male and female puberty itself, including age at menarche.[10] Some researchers found that children with T1DM are shorter and have lower height velocity compared to their healthy peers. Children diagnosed at a younger age with improper metabolic control are at higher risk of long-term growth failure. Modern care, especially in terms of insulin delivery, might improve metabolic control in children with T1DM with early diagnosis, helping prevent abnormality in growth hormones, leading to normal growth and final height equivalent to healthy peers. [11,15]

However, it remains controversial whether linear growth is impaired in diabetic children. Several investigators have documented that metabolic control in patients with T1DM is an important factor in final adult height, although growth in such children is normal and many others have not been found to be affected by hemoglobin A1c levels (HbA1c). [16] However, various investigators have shown that reduced height growth is related to disease duration rather than the level of metabolic control. A study found that adolescent girls diagnosed with poor metabolic control in T1DM were overweight, whereas diabetic boys were no different from normal controls. [17]

The study aims to investigate growth status of adolescents with T1DM and related factors such as age, diagnosis age, duration of disease, and glycemic control in Erbil City in the Kurdistan Region of Iraq.

METHODS

This quantitative descriptive study was conducted at Shaheed Layla Qasim Diabetic Center in Erbil City throughout June 2022. Shaheed Layla Qasim Diabetic Center is the principal diabetic center in Erbil, established in 2007 to provide services for all diabetic patients. The researcher obtained a list of pediatric T1DM patients from the Registration Unit of the Center. Through the list, I called all patients who met our inclusion criteria (diabetic adolescents aged 12-18 years old who desired to participate in the study), invited them to participate in the study and patients with congenital anomalies and congenital dwarfs excluded from the study and.

Total number of pediatric age group who recorded in the center was 1,147 cases and about 500 cases were in adolescent stage periods, finally 160 adolescents from total 500 cases were accepted to participate in the study.

Demographic data were filled through using questionnaire interview consisting of birth date, gender, residential area, family history of diabetes, age at diagnosis, and duration of disease.

The anthropometric measurement was taken by using a wall-mounted scale to measure standing height, without shoes, with heel and back in contact with the wall. The head was held looking straight forward, and patients were weighed without shoes using a calibrated electronic scale. Body Mass Index (BMI) was then calculated by weight / [height (m)]^2, then the weight, height, and BMI data were plotted to the CDC (Centers for Disease Control and Prevention) growth charts for patients

aged 2-20 years (weight-for-age, stature or height-for-age, and BMI-for-age).

The CDC growth reference charts use the 5th and the 95th percentiles as the outermost percentile cutoff values indicating abnormal growth (CDC growth charts are available at http://www.cdc.gov/growthcharts/clinical_charts.htm). According to CDC growth charts, patient scores can be categorized into the following cohorts:

CDC Growth Charts 5th and 95th percentile		
BMI-for-age	≥ 95th	Obesity
BMI-for-age	≥ 85th and < 95th	Overweight
BMI-for-age	< 5th	Underweight
Stature-for-age	< 5th	Short stature

Blood samples were taken by the researcher using scientific techniques to measure Hemoglobin A1c (HbA1c) to determine metabolic control, after which samples were sent to a bio lab using a COBAS INTEGRA® 400 plus machine.

Data were analyzed using the statistical package for social sciences (SPSS) version 22. Frequency and percentages were used for categorical data, and the chi-square test was used to find out the association between variables, with P-value < 0.05 being considered as statistically significant.

RESULTS

Table 1: Demographic characteristics of diabetic adolescents

Most of the 160 participants were in early adolescence (n=98, 61.3%, $\bar{x}\pm$SD 13.9 ± 1.8 years). Just over half of them were female (n=82, 51.3%). The majority (60%) lived in urban areas, and had a family history of diabetes (n=86, 53.8%).

Table 1: Demographic characteristics of diabetic adolescents

Items	**Frequency n= 160**	**Percent**
1. Categorize of age		
Early adolescence (11-14) Middle adolescence (15-17) Late adolescence (>17)	98 50 12	61.3 31.3 7.5
$\bar{x}\pm$SD	13.9 ± 1.8 years	
2. Gender		
Male Female	78 82	48.8 51.3
3. Residential area		
Urban suburban rural	96 50 14	60.0 31.3 8.8
4. Family history		
Yes No	86 74	53.8 46.3
5. Age at diagnosis		
7-9 10-12 13-15	24 90 46	15.0 56.3 28.8
$\bar{x}\pm$SD	11.2 ± 1.9 years	
6. Duration of diabetes		
1-3 years 4-6 years	112 48	70.0 30.0
$\bar{x}\pm$SD	2.7 ±1.6 years	
7. Metabolic or glycemic control (HbA1c %)		
Controlled (< 8%) Uncontrolled (> 8%)	42 118	26.3 73.8
$\bar{x}\pm$SD	9.9 ± 2.1%	

Regarding age at diagnosis, 90 (56.3%) were diagnosed at 10-12 years old ($\bar{x}$±SD 11.2 ± 1.9 years), and 112 (70%) had 1-3 years illness duration ($\bar{x}$±SD 2.7 ±1.6 years).

With respect to metabolic control (HBA1C %), 118 (73.8%) were at an uncontrolled level ($\bar{x}$±SD 9.9 ± 2.1%).

Table 2: Assessment growth parameters of samples through using CDC growth charts

Short stature-for-age was reported for 54 (33.8%), while the rest of the participants were in the normal range (n=106, 66.3%). In terms of BMI-for-age, 90 (56.3%) were underweight, 60 (37.5%) were normal weight, and a negligible number (n=10, 6.3%) were overweight.

Table 2: Assessment growth parameters of samples using CDC growth charts

Items	Frequency	Percent
1. Stature-for-age		
Short stature	54	33.8
Normal stature	106	66.3
2. BMI-for-age		
Underweight	90	56.3
Normal weight	60	37.5
Overweight	10	6.3

Table 3a and 3b: Association between growth parameters (stature-for-age) and some variables

The only significant association was between age group and stature-for-age (p-value 0.018). It seems that more short stature-for-age was noted among those in the early stage of adolescence, while the greatest prevalence of normal stature was found in mid-adolescence, and other variables (including gender, age at diagnosis, duration of diabetes, and metabolic control) had no association with stature-for-age.

Table 3a: Association between growth parameters (stature-for-age) with age and gender

Variables	Stature-for-Age		Total	P-value Chi-square
	Short	Normal		
1. Age group				
Early adolescence	44 (44.9%)	54 (55.1%)	98 (100%)	0.018
Middle adolescence	6 (12.0%	44 (88.0%)	50 (100%)	
Late adolescence	4 (33.3%	8 (66.7%)	12 (100%)	
Total	54 (33.8%	106 (66.3%)	160 (100%)	
2. Gender				
Male	26 (33.3%	52 (66.7%)	78 (100%)	0.939
Female	28 (34.1%	54 (65.9%)	82 (100%)	
Total	54 (33.8%	106 (66.3%)	160 (100%)	

Table 3b: Association between growth parameters (stature-for-age) with age at diagnosis, duration of diabetes and glycemic control

Variables	Stature-for-Age		Total	P-value Chi-square
	Short	Normal		
3. Age at diagnosis				
7-9	12 (50.0%)	12 (50.0%)	24 (100%)	0.363
10-12	30 (33.3%)	60 (66.7%)	90 (100%)	
13-15	12 (26.1%)	34 (73.9%)	46 (100%)	
Total	54 (33.8%)	106 (66.3%)	160 (100%)	
4. Duration of diabetes				
1-3 years	38 (33.9%)	74 (66.1%)	112 (100%)	0.959
4-6 years	16 (33.3%)	32 (66.7%)	48 (100%)	
Total	54 (33.8%)	106 (66.3%)	160 (100%)	
5. Metabolic or glycemic control				
Controlled	16 (38.1%)	26 (61.9%)	42 (100%)	0.624
Uncontrolled	38 (32.2%)	80 (67.8%)	118 (100%)	
Total	54 (33.8%)	106 (66.3%)	160 (100%)	

Table 4a and 4b: Association between growth parameters (BMI-for-age) and some variables

There was a high, significant association between age group and BMI-for-age (p-value < 0.01; 0.004), indicating that increasing age was associated with reduced underweight incidence. There was also a significant association of gender with BMI-for-age (p-value < 0.05; 0.032). It was shown that underweight more common among females. Other studied factors (age at diagnosis, duration of diabetes, and metabolic control) were not significantly associated with BMI-for-age.

Table 4a: Association between growth parameters (BMI-for-age) with age and gender

Variables	BMI-for-age			Total	P-value Chi-square
	Underweight	Normal weight	Overweight		
1. Age group					
Early adolescence	66 (67.3%)	32 (32.7%)	0 (0..0%)	98 (100%)	0.004
Middle adolescence	20 (40.0%)	20 (40.0%)	10 (20.0%)	50 (100%)	
Late adolescence	4 (33.3%)	8 (66.7%)	0 (0.0%)	12 (100%)	
Total	90 (56.3%)	60 (37.5%)	10 (6.3%)	160 (100%)	
2. Gender					
Male	36 (46.2%)	32 (41.0%)	10 (12.8%)	78 (100%)	0.032
Female	54 (65.9%)	28 (34.1%)	0 (0.0%)	82 (100%)	
Total	90 (56.3%)	60 (37.5%)	10 (6.3%)	160 (100%)	

Table 4b: Association between growth parameters (BMI-for-age) with age at diagnosis, duration of diabetes and glycemic control

Variables	BMI-for-age			Total	P-value Chi-square
	Underweight	Normal weight	Overweight		
3. Age at diagnosis/years					
7-9	12 (50.0%)	10 (41.7%)	2 (8.3%)	24 (100%)	0.480
10-12	52 (57.8%)	36 (40.0%)	2 (2.2%)	90 (100%)	
13-15	26 (56.5%)	14 (30.4%)	6 (13.0%)	46 (100%)	
Total	90 (56.3%)	60 (37.5%)	10 (6.3%)	160 (100%)	
4. Duration of diabetes					
1-3 years	68 (60.7%)	38 (33.9%)	6 (5.4%)	112 (100%)	0. 464
4-6 years	22 (45.8%)	22 (45.8%)	4 (8.3%)	48 (100%)	
Total	90 (56.3%)	60 (37.5%)	10 (6.3%)	160 (100%)	
5. Metabolic or glycemic control					
Controlled	20 (47.6%)	18 (42.9%)	4 (9.5%)	42 (100%)	0.582
Uncontrolled	70 (59.3%)	42 (35.6%)	6 (5.1%)	118 (100%)	
Total	90 (56.3%)	60 (37.5%)	10 (6.3%)	160 (100%)	

DISCUSSION

T1DM and other chronic diseases are well known to adversely affect growth, which is a good indicator to determine the health of child and adolescent patients. In this study, we noticed that over half of participants had a family history of diabetes. This affirms the relatively high prevalence of family history in DM patients in Iraq. An investigation in Dhi-Qar City in Iraq found that 47.6% of diabetic cases had a positive family history, while a lower percentage of 40% was reported in Kenya.[18, 19]

The mean age at diagnosis for adolescents with T1DM is 11.2 ± 1.9 years, but many studies have reported lower ages, including 9.9 ± 4.4 years in Kenya;[19] and 8.9 ± 3.5 and 8.1±3.8 years in Izmir and Diyarbakir (respectively) in Turkey.[20, 21] In Iraq, specifically Basrah, the mean age of the first diagnosis of T1DM was 15.3 ± 9 years.[5]

Glycaemia was uncontrolled in 73.8% of cases (Hba1c > 8%), and the mean Hba1c level was 9.9%. Similar results were reported by a recent study carried out in Rwanda in 2018, finding HbA1c of 9.7% and poor glycemic control among 72% of participants;[22] 72% poor glycemic control was also reported in Kenya[19] and Iraq.[4] In Pune (India), HbA1C was 9.1 ± 2.0%,[23] while according to [18] reported that all cases' HbA1C level was high (>8%).

We observed that a third of samples were of relatively short stature (stunted), slightly more than reported by Hussein et at. [24] in Capital of Iraq in 2023 that 38.09% were short stature among children and adolescents with type 1diabetic and Kayirangwa,[22] who concluded that 30.9% were stunted. Parthasarathy et al.'s study of longitudinal growth in children and adolescents with T1DM in Western India found that children with T1DM are shorter, and have lower height velocity in comparison with healthy children.[13] Similarly, Khadikar et al.[23] concluded that 27.1% of diabetic children were stunted, but much lower prevalence of stunted growth of 15% was reported by AL-Rubaee,[18] and of 13.1% by Abed et al.[25] These different results could be due to the wider age cohorts considered, as we studied only adolescents.

In the study we reported that more than half of diabetic adolescents were within underweight (BMI-for-age); the same result was reported by Zurita et al.[26] about pediatric patients with T1DM, whom they noted had growth and growth failure associated factors manifest in half of participants having impaired growth. A lower rate of 33.1% of diabetic children were underweight in the study of Kayirangwa[22], and descending BMI-for-age scores of 19.4%[18] and 13.2%[23] were reported by other studies.

Our study showed that there was only a significant association between stature and age group. Most stunting was observed in early adolescence, and this decreased with increasing age. This affirms the results of previous studies indicating increased stunting among the youngest age group with increasing age reducing stunting in Iraq[18, 25] and Libya.[27]

There was not a significant association between stunting and gender, a conclusion also reached by Al-Rubaee [18] and Kayirangwa,[22] who found that there was no statistically significant difference

between males and females in height-for-age z-score. We observed that there was no significant association between stature and duration of disease, consistent with previous studies;[25, 27] and a study in southwest Iran on the relationship between growth and metabolic control in T1DM pediatric patients.[28] No firm relationship between stature and age at diagnosis has been decisively indicated by recent studies, but the greatest correlation between short stature and T1DM is among children diagnosed < 9 years old.[14, 22, 23] Abed et al. they stated that the duration of diabetes had a significant relationship with growth parameters.[25]

Glycemic control was not an important factor for stature-for-age in our study, affirming previous works that used HbA1c as an indicator for this.[22, 23, 28] We observed a significant association between BMI-for-age and gender, with more underweight among females, consistent with Al-Rubaee,[18] while the opposite result was reached in Hong Kong by Wong et al. in a study devoted to sex-related growth differences among diabetic children in Hong Kong, which found that girls were likely to become overweight.[29]

Other factors such as age at diagnosis, duration of disease, and glycemic control had no statistically significant association with BMI-for-age in this study and other recent works. Grbavac et al. concluded that there was no statistically significant difference in the value of BMI-standard deviation score between groups with better and poorer metabolic control,[30] and Luna et al. indicated that the degree of metabolic control in children with T1DM did not play an important role in the relative anomalies in growth.[31] Finally, Chiarelli et al. stated that:

"impaired pubertal growth is supported by abnormal serum concentration of insulin-like growth factors I (IGF-I) and insulin-like growth factor binding proteins IGFBPs. IGF-I levels were reported to be reduced in both girls and boys with type 1 diabetes mellitus (T1DM). Alterations in the growth hormone insulin-like growth factors I (GH–IGF-I) axis represented by low IGF-I and IGFBP-3 levels play an important role in the pathogenesis of pubertal growth failure in diabetes and have been demonstrated to be related to insulin deficiency".[12]

CONCLUSION

The investigators concluded that most participants were in early adolescence and over half of them were diagnosed at 10-12 years old. Almost three-quarters of cases exhibited uncontrolled metabolic levels (in terms of HbA1c %). Finally, one-third of diabetic adolescents were of short stature, and most of them were underweight.

ABBREVIATIONS

MENA	Middle East and North Africa
T1DM	Type 1 diabetes mellitus
BMI	Body mass index
CDC	Centers for Disease Control and Prevention
HbA1C	Hemoglobin A1C
SPSS	Statistical package for social sciences
$\bar{x}\pm SD$	Mean and standard deviation
IGF-I	Insulin-like growth factors I
IGFBPs	Insulin-like growth factor binding proteins
GH–IGF-I	Growth hormone insulin-like growth factors I

DECLARATIONS

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Authors' contributions

KJ contributed to the conception and design of the study, data collection, data analysis, and preparation of the manuscript.

Ethics approval and consent to participate

Ethical approval was obtained to carrying out the study from Ethical Committee Hawler Medical University/College of Nursing, then an official permission letter was issued from the College of Nursing to Hawler Medical University, then from the latter to the Directorate of Health at the Ministry of Health in Erbil City, and finally the Directorate issued instructions to Shaheed Layla Qasim Diabetic Center. Written, informed consent was obtained from the participants and their parents prior to their participation.

Consent for publication

Not applicable.

Competing interests

The author declares that they have no conflicting interests related to this manuscript.

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