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Fasting blood sugar test versus HbA_{1C} in assessment of impaired fasting glucose in obese children

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A – Study Design, **B** – Data Collection, **C** – Statistical Analysis, **D** – Data Interpretation, **E** – Manuscript Preparation, **F** – Literature Search, **G** – Funds Collection

Summary **Background.** The available information on risk factors for childhood obesity is scarce compared to that for adults, and the progression of impaired fasting glucose (IFG) to type 2 diabetes in obese children has not been systematically investigated. However, the transition from prediabetes to type 2 diabetes is more rapid in children and adolescents than in adults.
Objectives. The objectives were to assess the prevalence of IFG in obese children using their fasting blood glucose (FBG) levels and to test the validity of the HbA_{1c} level as a measure of IFG.
Material and methods. This cross-sectional study included 412 obese children 6 to 18 years of age from two primary healthcare centers in Baghdad, with a BMI ≥ the 95th percentile according to their gender and age. Data (age, weight, height, BMI, FBG, HbA_{1c} and family history) was collected over two interviews three days apart.
Results. IFG was found in 8.9% of boys and 6.3% of girls, and a significant association was found between gender and IFG ($p < 0.001$). The HbA_{1c} level of the boys and girls in the cohort with IFG was inconclusive, as the results bordered on normal values.
Conclusions. Obesity is a risk factor for IFG, and fasting blood sugar is the test of choice for the early detection of type 2 diabetes. The HbA_{1c} level was not a valid measure of IFG in this study. Larger samples may be needed to detect reliable results for HbA_{1c} as a valid measure of IFG.
Key words: blood glucose, fasting, prediabetic state, pediatric obesity, type 2 diabetes mellitus, glycated hemoglobin A.

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Background

Obesity is defined as an excess of body fat and an increase in adipose tissue [1]. Adults diagnosed with obesity are at greater risk for developing back pain, diabetes and cardiovascular disease than those who are not obese, but the data on obesity in children is scarce in comparison to that on adults [2, 3]. Some studies on obese children have reported that they are less likely to be affected by abdominal fat [4, 5]. The body mass index (BMI) of many Asian populations (e.g. Chinese) and Latino groups has been reported to be higher than that of Caucasians [1, 6, 7].

The natural history of impaired fasting glucose (IFG) is such that half of all cases remain in their abnormal glycemic state, 25% have normal results in the following 3–5 years of an abnormal result, and the remaining 25% progress to overt diabetes [8]. The increase in the prevalence of type 2 diabetes and impaired glycemic control seems to be associated with the increase in childhood obesity [9, 10]. The American Diabetes Association has defined diabetic states based on glycemic function, ranging from normoglycemia to diabetes: a fasting blood glucose level (FBG) < 100 mg/dl = normal fasting glucose; FBG 100–125 mg/dl = impaired fasting glucose (IFG) or prediabetes; and FBG ≥ 126 mg/dl on two or more blood samples = diagnosis of diabetes [11, 12]. Nutritional therapy is considered the main tool for helping patients lose 5–10% of their body weight, and studies have found that regular exercise and some medications may prevent the development of diabetes in people with IFG. Many individuals with IFG may be normoglycemic during the day and may have a normal HbA_{1c} level. These results may be abnormal only when an oral glucose tolerance test is administered [13].

One of the earliest references to prediabetes in 1965 by the World Health Organization (WHO) was not as an identifiable state but as a term used in retrospect during case reviews. Hence, prediabetes could not be identified until diabetes was diagnosed, and the WHO also recommended using it (prediabetes) in research but not clinical settings. Thus, prediabetes was undiagnosed for the benefit of the patient, even though the WHO had already stated in 1965 that increased levels of insulin and some vascular changes could be found in the blood during the prediabetic stage [14].

The progression of IFG to type 2 diabetes in the pediatric population with obesity has not been systematically investigated. However, the transition from the prediabetes state of IFG to type 2 diabetes has been found to be more rapid in children and adolescents compared to adults [15].

Objectives

The study's objectives were to assess the prevalence of IFG in obese children using their fasting blood sugar levels and to examine the validity of the HbA_{1c} level as a measure of IFG.

Material and methods

This study of 412 obese children 6 to 18 years of age from two primary healthcare centers in Baghdad was conducted in 2018 using a cross-sectional design. Patients were excluded from the study if they were diagnosed with diabetes or used metformin or any other hypoglycemic drugs, and those with secondary obesity or an endocrine disorder were excluded from the study.

During the first visit, we measured the child's fasting blood sugar (FBS), height, weight and BMI using the definition of the Centers for Disease Control (CDC) for BMI from the 2002–2020 BMI chart for boys and girls. Only obese children with a BMI greater than or equal to the 95th percentile according to gender and age were included in the analysis. The parents of the children were asked whether there was a family history of diabetes.

During the second visit, which took place three days later, a second FBS was measured. The participants were categorized by gender and age, and plasma glucose monitoring was performed using the FBS from two occasions three days apart. The HbA_{1c} level was measured post-classification of participants into three diabetes states based on their glycemic function (normoglycemia, prediabetes and diabetes) during the second visit to assess the validity of the HbA_{1c} level as a measure of IFG.

Statistical analysis

The data was analyzed using OpenEpi: Open Source Epidemiologic Statistics for Public Health, Version 301, online at http://www.openepi.com. Descriptive statistics are expressed as numbers and percentages or means and standard deviations. The chi-square test was used to analyze categorical variables, and the level of significance chosen for this study was $p < 0.05$.

Ethical considerations

Verbal consent was obtained from each participant's parent prior to the first interview. All procedures were carried out in accordance with the Declaration of Helsinki. Permission to carry out the study was obtained from the two primary healthcare centers in Baghdad.

Results

The study sample consisted of 412 children, including 226 (58%) boys and 186 (42%) girls. The results are presented in Tables 1, 2 and 3. Table 1 shows the three staging classifications of the participants by glycemic regulation/diagnosis and of those with a positive family history of diabetes. The chi-square statistic for the analysis was 52.275, which was significant ($p < 0.001$).

Table 1. Diabetes classifications of all participants and those with a positive family history of diabetes

Characteristic	Normoglycemia *n* (%)	Prediabetes *n* (%)	Diabetes *n* (%)
Total (412)	341 (82.7%)	63 (15%)	8 (1.9%)
Positive family history	22 (5.3%)	9 (2.2%)	10 (2.4%)

Table 2. Diabetes classifications and characteristics of the boys in this study (*n* = 226)

Characteristic	Normoglycemia mean ± SD or *n* (%)	Prediabetes mean ± SD or *n* (%)	Diabetes mean ± SD or *n* (%)
Age	13 ± 2.2	13 ± 1.3	12 ± 1.4
Boy	186 (84.5%)	37 (16.3)	3 (1.3%)
Weight	28 ± 2.2	34 ± 0.5	48 ± 1.3
Height	120 ± 3.1	138 ± 3.4	161 ± 3.7
Body mass index	22	24 ± 1.2	28 ± 1.7
Fasting blood sugar	89 ± 3	105 ± 1.4	133 ± 2
HbA_{1c}	4.4 ± 1.2	5.3 ± 0.7	7 ± 0.9

Table 2 shows the diabetes classifications and demographic and physical characteristics of the boys in this study. Table 3 shows the diabetes classifications and demographic and physical characteristics of the girls in this study.

Table 3. Diabetes classifications and characteristics of the girls in this study (*n* = 186)

Characteristic	Normoglycemia mean ± SD or *n* (%)	Prediabetes mean ± SD or *n* (%)	Diabetes mean ± SD or *n* (%)
Age	12 ± 1.8	11 ± 1.5	14 ± 2.4
Girl	155 (83%)	26 (14%)	5 (2%)
Weight	26 ± 1.2	29 ± 0.8	50 ± 0.2
Height	119 ± 1.8	133 ± 2	153 ± 1.3
Body mass index	21 ± 1.4	26 ± 0.7	30 ± 1.1
Fasting blood sugar	79 ± 1.3	102 ± 0.2	131 ± 2
HbA_{1c}	4.3 ±1·1	5.1 ± 1.3	6.8 ± 0.9

Discussion

The prevalence of type 2 diabetes has shown a large increase in recent decades, and the age of onset of type 2 diabetes has shifted toward children and teens. Obesity is now considered a major risk factor for type 2 diabetes, and the prevalence of obesity has increased among children and adolescents in the past two decades with a concomitant increase in insulin resistance and type 2 diabetes [16].

The change in the prevalence of obesity in our community is an indicator of the trend in our society toward an obesogenic diet and lifestyle [17]. FBS is still considered the most reliable test for screening diabetes, for the early detection of IFG and for the assessment of the HbA_{1c} level for possible use as a reliable detector of IFG in obese children [18].

The prevalence of IFG among all the children with obesity in our Baghdad sample was 15%, which is considered high in comparison to the IFG of 12–19-year-old adolescents in the United States, which has been reported to be 12.7% [19]. The prevalence of IFG was found to be 3.7% among obese Caucasian children [20] and 5.7% among obese German children according to the American Diabetes Association, and it was 1.1% according to the WHO [21].

In this study, IFG was found in 8.9% of boys and 6.3% of girls, with a significant association between gender and IFG ($p < 0.001$). The HbA_{1c} level of the boys and girls in the cohort with IFG was found to be inconclusive, as the results approached normal levels.

The use of HbA_{1c} for the diagnosis of impaired glycemic control in the pediatric population remains controversial [22, 23]. We should acknowledge that the number of participants enrolled in this study was small and that we did not conduct an oral glucose tolerance test to screen for impaired glucose tolerance. Although the results were close to being conclusive for participants classified as diabetic, their numbers were small, including only three (0.7%) boys and five (1.2%) girls [24]. This variation in HbA_{1c} levels among Mediterranean and Southeast Asian populations may be partially explained by hemoglobinopathies, which are prevalent in these populations and could have interfered with our interpretation of the HbA_{1c} results [25].

Conclusions

Obesity is considered a risk factor for the development of IFG, and the FBS is the test of choice for its early detection. The

HbA_{1c} level was not found to be a valid measure of IFG for the children in this study, although a larger sample might yield results that are more reliable.

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