

# Prevalence of high normal FBS and prediabetes among adolescents in Birjand, East of Iran, 2012

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## ABSTRACT

**Background and Objectives:** To determine the prevalence of impaired fasting glucose in adolescents in Birjand city in eastern Iran. **Materials and Methods:** This cross-sectional study was done on 2653 students aged 11–18 years selected through multi-stage stratified and random sampling. Fasting blood glucose (FBS) of these students was measured applying the enzymatic process. The obtained data were analyzed by means of SPSS software (V: 15) and statistical tests T and X2. **Results:** The mean age of individual was  $14.5 \pm 2$  years. Mean FBS of the whole population was  $89.8 \pm 9.8$  mg/dl, but it was significantly higher among boys than girls ( $P < 0.001$ ). Out of the whole subjects (92.4%), 1,328 (95.1%) of the girls and 1,122 (89.3%) of the boys, FBS was less than 100 mg/dl among whom 64.4% had FBS above 86 mg/dl. In 200 subjects (7.5%) of whole population, FBS was 100–125 mg/dl; with that of the boys was 2.3 times than the girls revealing a prediabetes condition: OR = 2.3(CI: 1.7-3.2). Among the students, 3 (0.1%) had an FBS > 126 mg/dl. Mean blood glucose was significant regarding age and sex. **Conclusions:** High prevalence of high FBS (within normal range) among adolescents is warning and requires special attention of health officials. Screening of children and adolescents in order to identify those at risk and plan for intervening is urgent to prevent type-2 diabetes epidemic and following cardiovascular complications in the Society.

**Key words:** Adolescents, Birjand, fasting blood sugar, Ira, prediabetes, prevalence

## INTRODUCTION

Prevalence of both type-1 and type-2 diabetes in children and adolescents is rapidly increasing worldwide.<sup>[1-4]</sup> Type-2 diabetes is often asymptomatic in its early stages<sup>[2,5]</sup> and, thus, it remains unidentified.<sup>[6]</sup> The risk of such a condition

is the same or higher than the previously diagnosed ones.<sup>[6-8]</sup> The individuals with impaired fasting glucose (IFG) and/or impaired glucose tolerance (IGT) are called prediabetes, which is an intermediate and reversible condition before getting type-2 diabetes.<sup>[9,10]</sup> The prediabetic condition itself is also associated with cardiovascular risk.<sup>[11]</sup> Identifying and appropriate management of the adolescents susceptible to the abnormal carbohydrate metabolism can have an effective role in preventing or delaying their development of type-2 diabetes in later life and reduce their long-term mortality and morbidity.<sup>[9]</sup> The American Diabetes Association (ADA) and the American Academy of Pediatrics have confirmed the screening of children for diabetes, and given the high prevalence of prediabetes in children there is also interest in screening for prediabetes in the pediatric population.<sup>[2]</sup> There were no data available on the prevalence of T2DM (type-2 diabetes mellitus) and prediabetes for adolescents in Birjand. The authors, therefore, performed a, cross-sectional and descriptive – analytical study on secondary and high school

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students aged 11–18 years to ascertain the prevalence of T2DM and prediabetes in adolescents in Birjand.

## MATERIALS AND METHODS

This cross-sectional study was conducted on 2,653 students aged 11–18 years. Samples were chosen through multistage stratified and random sampling. At first, Birjand was divided into five regions based on socioeconomic levels. Afterward, secondary and high schools were identified in each region. The number of students in all schools was taken from the city health center. For each sex, seven secondary and seven high schools were chosen considering the distribution of the schools in different districts of the city. Total of 2,800 students were chosen based on a procedure as a subsample was selected from different classes of each school with respect to the population of school and its ratio to the total number of students in that class. After obtaining verbal consent from the selected students, a questionnaire (containing demographic information, age, sex, known diseases, and drugs) along with a consent form was sent to each one's parents. The parents were demanded to fill out the questionnaire and the consent form that show their children having not any chronic disease or endocrine disorder such as diabetes or not being on treatment of corticosteroids, and then return completed forms to the school.

In this step 2,690 questionnaires were completed and returned. Thirty-seven incompletely filled questionnaires were excluded. Finally, 2,653 students were referred to a diagnostic clinic and a 12-h fasting blood sugar sample was taken from each for testing. The obtained samples were immediately centrifuged, and applying enzymatic procedure using German Rosh kits, their respective sugar levels were determined. The standard by which impairment in FBS would be approved was that of ADA, that is,  $FBS \geq 100$  mg/dl but  $<125 < 126$ mg/dl.  $FBS < 100$  mg/dl was considered as a normal range.<sup>[12]</sup> In this study, the authors were considered fasting plasma glucose level of 86 to 99 mg/dl as high normal FBS. Statistical analysis was performed by means of SPSS software (v: 15) and comparison of qualitative variables was made using X<sup>2</sup>. Prevalence was mentioned in percentage and  $\alpha \leq 0.05$  as taken as the significant level.

## RESULTS

The secondary and high school students studied were 2,653, out of which 47.4% were boys. The mean age was  $14.5 \pm 2$  years. Mean blood glucose by age and sex is presented in Table 1. Mean FBS of the whole population was  $89.8 \pm 9.8$  mg/dl, but it was  $92 \pm 11.3$  mg/dl in boys and  $87 \pm 7.7$  mg/dl in girls, the difference being statistically significant ( $t = 11.36, P < 0.001$ ). As shown in Table 2, in 2,450 cases (92.4%), including 1,328 (95.1%) of girls and 1,122 (89.3%) of boys, mean age was  $14.05 \pm 1.96$  years and FBS was  $<100$  mg/dl (mean:  $88.5 \pm 6.6$ ). FBS of 1,580 individuals (64.4%) was 86–99 mg/dl. In 200 subjects (7.5%) of the whole population, including 67 (4.8%) of girls and 133 (10.6%) of boys (mean age  $13.9 \pm 1.9$  years), FBS was  $\geq 100$  mg/dl (mean:  $104.2 \pm 3.5$ ).

The difference was statistically significant ( $X^2 = 32.24, df = 1, P < 0.001$ ); that of the boys was 2.3 times than the girls had  $FBS \geq 100$  mg/dl. OR = 2.3(CI: 1.7–3.2). Among the students, 3 (0.1%) had an  $FBS \leq 126$  mg/dl. As illustrated in Figure 1, Mean blood glucose at different ages was significantly different ( $f = 19.03, P < 0.001$ ). Data were normally distributed according to Kolmogorov–Smirnov test. According to the Totti test, the difference between ages 11, 12, and 13 years with 15, 16, and 17 years was significant, respectively. 11 with 15: Mean difference = 4.6,  $P < 0.001$ , 11 with 16: Mean difference = 4.8,  $P < 0.001$ , 11 with 16: Mean difference = 4.6,  $P < 0.001$ , 12 with 15: Mean difference = 5,  $P < 0.001$ , 12 with 16: Mean difference = 5.2,  $P < 0.001$ , 12 with 17: Mean difference = 5,  $P < 0.001$ , 13 with 15: Mean difference = 4.6,  $P < 0.001$ , 13 with 16: Mean difference = 4.8,  $P < 0.001$  and 13 with 17: Mean difference = 4.6,  $P < 0.001$ . Mean blood glucose level was more in boys than in girls at all ages except at age 11 [Table 1].

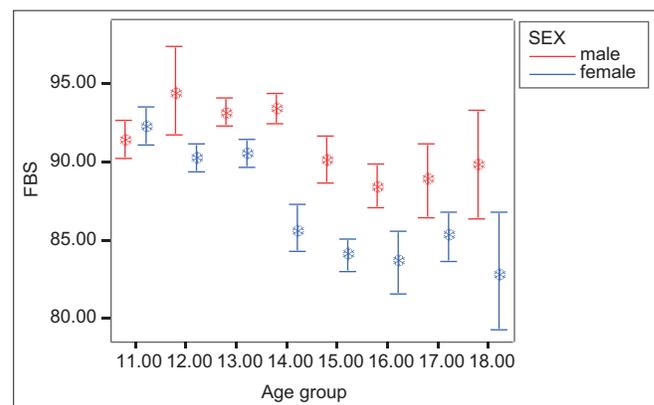
## DISCUSSION

This article was conducted in Birjand, the east Iranian provincial capital of South Khorasan which is a poor province, to estimate prevalence of prediabetes cases in adolescents. As seen in the present study, in the majority of the cases (92.4%) – based on ADA criteria – FBS was within the normal range, which is in accord with many of previous studies.<sup>[12,13]</sup> In a prospective study by Nguyen *et al.*, blood

**Table 1: Mean FBS accounting for age and sex**

Age	Boy		Girl		t	P
	Mean	SD	Mean	SD		
11	91.46	5.96	92.34	7.24	-1.03	0.31
12	94.62	21.60	90.32	7.13	2.93	0.003
13	93.21	7.37	90.59	6.78	4.07	<0.001
14	93.47	6.75	86.58	7.91	9.36	<0.001
15	90.75	6.93	84.07	6.99	8.79	<0.001
16	88.98	6.96	85.10	6.93	5.21	<0.001
17	89.76	7.91	85.80	7.44	4.04	<0.001
18	89.88	8.34	85.05	6.69	2.64	0.01
Total	92.07	11.30	87.83	7.70	11.36	<0.001

SD=Standard deviation



**Figure 1: Comparison of mean FBS accounting for Age and sex**

**Table 2: Distribution of blood glucose by age and sex in our subjects**

Age	Boy (N=1257; 47.4%) (mg/dl)						Girl (N=1396; 52.6%) (mg/dl)					
	FBS<100		100≤FBS,≤125		FBS≥126		FBS<100		100≤FBS≤125		FBS≥126	
	N	%	N	%	N	%	N	%	N	%	N	%
11	102	93.6	7	6.4	0	0	121	87.7	17	12.3	0	0
12	191	84.9	33	14.7	1	0.4	225	92.2	18	7.4	1	0.4
13	230	86.8	34	12.8	1	0.4	216	94.7	12	5.3	0	0
14	157	84.9	28	15.1	0	0	216	96.4	8	3.6	0	0
15	154	93.3	11	6.7	0	0	171	99.4	1	0.6	0	0
16	176	95.7	8	4.3	0	0	164	98.8	2	1.2	0	0
17	90	90.9	9	9.1	0	0	148	94.9	8	5.1	0	0
18	20	87	3	13	0	0	67	98.4	1	1.6	0	0
Total	1122	89.3	133	10.6	2	0.2	1328	95.1	67	4.8	1	0.1
P value	0.004						0.001					

FBS=Fasting blood glucose

glucose level was mostly within normal range and its mean was 84.6 mg/dl.<sup>[12]</sup> Although impairment in FBS, which leads to diabetes, is not of high prevalence in this study, 64.4% of those with normo glycaemic state (59.6% of total) had an FBS between 86–99 mg/dl.

FBS in many of the total population (59.6%) was in the upper limit of normal range; a condition which must be paid special attention to since it covers those being at risk. Different studies have shown that high FBS, within the normal range, is a risk factor for type-2 diabetes.<sup>[14-16]</sup> Tirosh *et al.* found that FBS greater than (87 mg/dl) significantly increased diabetes risk among young men with FPG level <100mg/dl.<sup>[17]</sup> The prospective study by Nichols *et al.* revealed that people with FBS (90 to 94 mg/dl), even after controlling for a large number of known risk factors, are significantly at the risk of developing diabetes (49% greater risk); compared with individuals, with FBS less than 85 mg/dl.<sup>[18]</sup> Their results demonstrate that the increased risk of diabetes extends well below the ADA's current maximum limit of normal plasma glucose of 99 mg/dl.<sup>[18]</sup> Nguyen *et al.* also found that children with FBS level of 86–99 mg/dl, even after controlling of other cardio metabolic factors, are significantly (i.e. more than two times) at the risk of a prediabetic condition and diabetes during adulthood; compared with children with FBS less than 86 mg/dl.<sup>[12]</sup> The mechanism by which higher normal FBS increases the risk of diabetes is unknown.<sup>[14]</sup> Hypothetical mechanisms include increased hepatic insulin resistance, impaired early insulin response, and decrease in noninsulin-dependent glucose clearance. The main factor of prediabetes and diabetes is progressive beta-cell failure.<sup>[14]</sup> The presence of islet cell autoantibodies during prediabetic period damages to the beta cells.<sup>[19]</sup>

In our study, similar to other studies,<sup>[13,15]</sup> mean FBS of boys was higher so that they were in more serious risk for getting a prediabetic condition. The underlying mechanism of this problem is not yet known.<sup>[15]</sup> Central obesity is a risk factor to insulin resistance and to diabetes II. Puberty is associated with drastic changes in size, shape, and composition of the body. While girls had higher total body fat percentage during

puberty, boys suffered more increase in their central obesity.<sup>[15]</sup> In a study conducted in gorgan city located in northern Iran by Mehrkash it was found that, FBS was also significantly higher in boys than in girls.<sup>[20]</sup> In Romero study on Mexican pediatric population, mean FBS was slightly higher in girls and slightly lower in the boys. He holds that estrogenic activity in girls is one of the determining factors.<sup>[21]</sup>

Low prevalence of FBS > 126 (0.1%) in this study was similar to Guerrero.<sup>[21]</sup> Of our population, 7.5% were prediabetics, which is not too high compared to other studies, but it is alarming. In the study by Li *et al.* conducted on U.S. adolescents aged 12–19 years, 16.1% were prediabetic.<sup>[9]</sup> Prevalence of prediabetes in Mysore city in India was 3.7%.<sup>[22]</sup> In the study of Lee *et al.*, on overweight or obese children, aged 10–17 years, 39% cases were prediabetes.<sup>[2]</sup> The difference in the prevalence of prediabetes in different communities is due to differences in the prevalence of obesity and Cardio metabolic risk factors which is caused lifestyle and diet plus ethnic and cultural differences.

Our results show that mean blood glucose varies according to age [Table 1]. Mean blood glucose at all ages except at 11 years of age was higher in boys between the age range of 11 and 12 years, the trend was a rising one but in girls it was declining. After 12, increasing or decreasing in blood glucose was similar in both sexes, but it occurred sooner in girls. This is justifiable because puberty occurs earlier in girls [Figure 1]. Possibly, the variation in blood glucose level at different ages and in both sexes corresponds with pre–post puberty hormonal changes. During puberty, rapid and dynamic changes occur in various metabolic systems, such as hormonal regulations, variations in body fat and its distribution, and insulin resistance increasing. Insulin sensitivity is highest before the beginning of puberty (Tanner stage 1), approaching near prepubertal levels at the end of maturation (Tanner stage 5).<sup>[23]</sup>

Although this study shows that the population of adolescents with FBS impairment is not high, the relatively high percentage of adolescents with high normal FBS can be predictive of following risk for developing prediabetes and diabetes during

youth, middle age, and old age. Early identification and appropriate management of them can effectively prevent or delay their development of type-2 diabetes in later life. Our data highlights the importance of coordinated individual, school- and community-based lifestyle intervention measures aiming at all age groups. Intervention programmers are requisite to prevent a type-2 diabetes epidemic in society. In order to study the final outcome of children's FBS impairment, prospective researches are required. The results of this study can be used as a basis of following studies.

The positive aspects of this study include a large population sample, representative sampling methodology, and the use of standardized data collection protocols. One of the limitations of this study was that, given the large population of children, Re-testing of blood glucose for a definitive diagnosis of patients with diabetes was not possible.

## CONCLUSION

High prevalence of high normal FBS among adolescents requires special medical attention. Screening of all school children is ideal, but given the high cost of general screening it is recommended that measurement of fasting plasma glucose in individuals with risk factors such as obesity should be done, to prevent outbreaks of diabetes and its cardiovascular complications. Great efforts may be needed to intervene against the fundamental causes of FBS impairment such as overweight, physical inactivity, and unhealthy diet in pediatric primary care centers and through public health services.

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