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Impaired fasting glucose and impaired glucose tolerance in rural population of Bangladesh

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Abstract

The prevalence of type 2 diabetes is rapidly rising all over the world at an alarming rate. Over the past 30 years, the increase in prevalence is rising exponentially in South Asian region, data suggest a three fold increase (from 2.0 to 7.0%) in the urbanizing population of Bangladesh within 5 years. However, the prevalence of various degrees of glucose intolerance i.e. type 2 diabetes, impaired glucose tolerance and impaired fasting glucose considered vital for prevention are still unknown in this population. The objective of the study was to estimate the prevalence of impaired fasting glucose (IFG) and impaired glucose tolerance (IGT) and type 2 diabetes (T2DM) with their demographic and anthropometric characteristics in a reasonable large sample compare to other studies conducted in Bangladesh. A random sample of 5000 rural population aged $\geq$ 20 years was included in this cross sectional study. Fasting blood glucose (FBG) level was measured from 3981 individuals and 2-hr blood glucose (BG) was done on 3954 subjects, excluding known diabetic cases (n= 27). Height, weight, waist and hip circumference including blood pressure and demographic information was also collected. The prevalence of impaired fasting glucose (IFG), impaired glucose tolerance (IGT) and newly detected type 2 diabetes (T2DM) were 1.3%, 2.0% and 7.0% respectively. IFG, IGT, IFG+IGT were more prevalent in females than males. Age, body mass index (BMI), waist circumference (WC) and waist to hip ratio (WHR) were higher in glucose–intolerant subjects than in normal glucose tolerant (NGT) group. FBG and 2-hr BG values were correlated in NGT and DM subjects. Our data suggest that estimation of FBG value identifies more people with diabetes compared to 2-hr BG estimation. These findings need to be further examined in other settings with urban and rural populations for the justification of FBG for screening of diabetes in Bangladeshi population for development of intervention strategy for the prevention and management of abnormal glucose tolerance. The significance of IFG as a precursor of diabetes and CVD will become evident only from longitudinal studies in different ethnic groups.

Introduction

The prevalence of type 2 diabetes is anticipated to increase drastically during the forthcoming decades in both developed and developing countries[1]. However, the prevalence of different stages of glucose intolerance, i.e. type 2 diabetes mellitus (T2DM), impaired fasting glucose (IFG) and impaired glucose tolerance (IGT) differ distinctly between countries and populations. It has been suggested that disproportion of prevalence in the stages of glucose intolerance is related to diet, genetic susceptibility of an individual, and population age structure, stage of economic development, and level of urbanization of a country[2]. Bangladesh is a developing country with happening of recent rapid urbanization, rural to urban migration, and increase employment with some degree of economic development[3]. At the same time, the county has experienced demographic transition with slow but gradual increase in the proportion of older population[4].

There are some population-based studies conducted in urban and rural areas of Bangladesh to estimate the prevalence of diabetes mellitus. These studies were conducted in different time points and have revealed a growing trend of diabetes prevalence ranging from 2.2 to 8.1%, both in rural and urban communities[5-7]. A high prevalence of diabetes and chronic heart disease (CHD) has also been reported among Bangladeshis settled in UK compare to native population[8]. Some other recent studies showed a high prevalence of diabetes, IGT and IFG in native Indians, Asian in Europe and in the USA[9-11]. The IFG or IGT is now considered as pre-diabetes and is suggested as a strong risk factor for cardiovascular diseases (CVD)[12].

In Bangladesh, studies related to diabetes and IGT in urban areas showed different prevalence[6,13]. The results may have been influenced by different sample sizes and different cut-off values of glucose threshold for diagnosing of abnormal glucose tolerance. To the best of our knowledge a very few studies has yet been conducted in the Bangladeshi population to estimate the prevalence of glucose intolerance i.e. (IFG, IGT and T2DM,) following American Diabetes Association (ADA) or World Health Organization (WHO) criteria[14,15]. Some studies have suggested that the groups with IFG and IGT differ phenotypically any of the criteria[9,10]. It is likely that the characteristics of subjects with different categories of glucose intolerance may vary in different populations[11,12].

Evidence suggests that risk factors for diabetes and CVD different within various regions in Pakistan, India and Bangladesh[16]. In this milieu, the purpose of the present study was to estimate the prevalence of different categories of glucose intolerance specially IFG, IGT and Type-2 DM following new WHO-1999 criteria, among the rural population of Bangladesh[15] and to identify the demographic and anthropometric characteristics of the sample population of these categories.

Materials and Methods

This analysis was carried out with the data collected from a population-based cross- sectional survey conducted in a rural community - 40 km north to the Dhaka city in 2004. The details of the study population were described elsewhere[17]. In brief, the rural population was selected from a community 35 miles north of Dhaka city called 'Chandra, under Gazipur district. Ten villages were randomly selected from five areas with a population of approximately 20000 aged $\geq$ 20 years. All individuals were given an identification number including a household number. Among those, 5,000 populations (both males and females) were selected following a simple random procedure. Of these, 3981 subjects were participated to the study and investigated their fasting blood glucose (FBG). Two hour after BG was performed on 3954 individuals excluding known diabetic cases (n=27).

Weight, height, waist and hip circumferences were measured for the study participants in standing position wearing light cloths and no shoes. The weight was taken to the nearest 0.1 kg by a modern digital bathroom scale and the height was taken to the nearest 0.1 cm. Body Mass Index (BMI) was calculated as a ratio of weight in (kg) to height in meter squared. Waist circumference was measured at the minimum circumference between the lower border of ribs and iliac crest on the mid axillary line. Hip circumference was measured at the greatest protrusions of the buttocks just below the iliac crest. The waist hip ratio (WHR) was calculated as waist/hip circumference.

To reduce the variations in blood pressure (BP), the subjects were ensured rest and relaxation for at least 5 minutes by keeping them in sitting position before recording BP. The pressure was measured on the right arm using normal cuff for adults fitted with a standard mercury sphygmomanometer placing the stethoscope bell lightly over the pulsatile brachial artery. Blood pressure was recorded to the nearest 2mm Hg from the top of the mercury meniscus. Systolic blood pressure (SBP) was recorded at the first appearance of sound, and diastolic blood pressure (DBP) was measured at phase V, i.e. the disappearance of the sound.

Fasting capillary blood glucose was measured from all individuals (n=3,981) using HEMOCUE glucose analyzer. The machine was calibrated every day with standard glucose solution to minimize the measuring error. After estimation of FBG, all participants except the known diabetic cases (n=3954) went through 2-hr BG.

Statistical analysis

The prevalence of Diabetes, IFG and IGT was determined by simple percentages.Values are reported as mean ±SD. Group comparisons were made using *t*-test and χ^2 test , Pearson's correlation test was used to calculate the correlation between the variables studied. A p-value of < 0.05 was considered statistically significant. All p-values presented are two tailed. We used Stata version 7.0 (Stata Corp. 2001; Stata Statistical Software Release 7.0,College Station, TX, USA) for statistical calculations.

Ethic

Verbal consent was secured from each individual prior to inclusion in the study, as most of the participants were illiterate. They were also verbally informed of their wright to withdraw from the study at any stage or to restrict their data from the analysis. The protocol was approved by both the Norwegian and Bangladeshi ethical committee for medical research**.**

Results

The prevalence of IFG, IGT, IFG +IGT and diabetes were 1.3%, 2.0%, 4.3% and 7.0% respectively. IFG, IGT, IFG+IGT were more prevalent in females than males, however the difference is significant only in IFG+IGT (5.0% in females and 3.1% in males; p <0.001) group. No significant sex difference was found in diabetes or other groups. Increased BMI was observed among IGT, IFG+IGT and DM groups, and increased waist circumference was observed in IGT and DM groups (Table-I).

The mean age of the subjects increased with increasing degree of glucose intolerance in both sex. BMI, WHR and waist circumference were higher in glucose intolerant groups than in the NGT group, while the highest mean values were found in diabetes group for both sex. WHR was significantly higher in males in all groups compare to females. Waist circumference was also significantly higher in males in IFG and DM groups compare to females (Table- II).

The subjects with FBG value of (5.6-6.0) mmol/l, 23.2% belongs to NGT, 74.1% belongs to IGT and 2.6% are diabetic following 2hr BG values. Among the 258 diabetic subjects having FBG of ≥6.1 mmol/l, 128 (49.6%) had 2h BG ≥11.1 mmol/l and (114) 44.6% had 2hr BG level (7.8-11.0) mmol/l. Among the total 266 diabetes subjects, 128 subjects had 2-h BG values of ≥ 11.1 mmol/l. and the remaining 130 subjects satisfied the FBG criterion of ≥ 6.1 mmol/l only (Table-III).

Mean FBG and corresponding 2h BG values in categories of glucose tolerance in men and women. A gender differences was present in the values of NGT and DM subjects. Data for total group were used for correlation analysis The corresponding correlation (Pearson) values and significance levels between FBG and 2h BG values for NGT and DM for males, females and total subjects are (r=0.13, p<0.000; r=0.20, p <0.000; r=0.18, p=<0.000) and (r=0.78, p<0.001; r=0.85, p <0.000; r=0.81, p < 0.001) respectively (Table –IV).

Table I: Prevalence of different categories of glucose tolerance and percent of sample with increased BMI, waist circumference and WHR and by sex

	NGT		IFG		IGT		IFG+IGT		DM	
	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)
Total	3,387	(85.4)	53	(1.3)	79	(2.0)	169	(4.3)	279	(7.0)
Male	1,383	(86.9)	17	(1.1)	23	(1.4)	50	(3.1)***	119	(7.5)
Female	2,004	(84.2)	36	(1.5)	56	(2.4)	119	(5.0)***	160	(6.7)
% with increased										
BMI	321	(9.5)	5	(9.4)	11	(14.1)	26	(15.2)	60	(21.5)
Waist circumference	481	(14.2)	7	(13.2)	23	(29.1)	41	(24.0)	79	(28.3)
WHR	1,950	(57.5)	33	(62.2)	55	(69.6)	113	(66.8)	203	(72.7)

***IFG+IGT men vs. women χ^2= 6.4, *P* < 0.0001

NGT (FBG value: ≤5.5 mmol/L and 2-hr BG: ≤7.7 mmol/L); IFG (FBG value: 5.6-6.0 mmol/L and 2-hr BG :≤7.7 mmol/L)
IGT (FBG value :≤5.5 mmol/L and 2-hr BG :7.8-11.0 mmol/L); IFG+IGT (FBG value :5.6-6.0 mmol/L and 2-hr BG : 7.8-11.0 mmol/L)
DM (FBG value :≥ 6.1 mmol/L or 2-hr BG : ≥ 11.0 mmol/L)

Table II: Mean ± SD of age, BMI, Waist, WHR by different categories of glucose tolerance, males and females

	NGT		Isolated IFG		Isolated IGT		IFG+IGT		DM	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Age in years*										
Male	37.9*	±14.6	37.2	±14.9	44.6	±17.3	43.9	±16.9	49.2**	±16.1
Female	34.9*	±12.9	41.3	±19.7	40.4	±17.0	41.2	±15.3	42.6**	±14.8
BMI(kg/m^2) *										
Male	20.4*	±2.9	20.8	±2.6	20.7	±3.0	20.7	±3.2	22.1	±4.2
Female	20.7*	±3.3	20.0	±3.7	20.6	±3.6	21.0	±4.3	21.3	±4.6
Waist (cm) *										
Male	73.8**	±8.5	76.6*	±9.2	75.2	±11.7	75.9	±9.7	79.6*	±11.6
Female	72.0**	±9.1	70.0*	±9.5	72.9	±10.6	73.9	±11.4	75.3*	±10.4
WHR*										
Male	0.88**	±0.06	0.89	±0.05	0.88*	±0.09	0.89**	±0.07	0.92**	±0.07
Female	0.83**	±0.06	0.83	±0.05	0.85*	±0.07	0.85**	±0.06	0.86**	±0.07

*Values are mean ±2SD; Male vs. Female comparison was done by Pearson χ^2 test Singnigacnt relationship was seen asteriks mark with p value * p <0.05, ** p <0.001

Table III: Distribution of subjects according to FBG and 2-h BG categories

	2-h Blood glucose (mmol/l)							
FBG (mmol/l)	NGT (≤7.7)		IGT (7.8-11.00)		DM (≥11.1)		Total	
	No.	%	No.	%	No.	%	No.	%
NGT (0.0-5.5)	3,387	97.7	79	2.3	2	0.1	3,468	87.7
IFG (5.6-6.0)	53	23.2	169	74.1	6	2.6	228	5.7
DM (≥ 6.1)	16	6.2	114	44.6	128	49.6	258	6.7
Total	3,456	87.4	362	9.2	136	3.4	3,954	100

Table IV: Mean values of FBG and corresponding 2-h BG for difference categories of glucose tolerance, male and female

Mean value (mmol/l)	NGT		IFG		IGT		IFG+IGT		DM	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
FBG	4.4**	4.5**	5.7	5.7	4.7*	5.0*	5.8**	5.7**	8.1**	8.0**
2h BG	4.9***	5.4***	5.0**	6.1**	8.5	8.3	8.5	8.5	12.4**	12.6**
N	1,383	2,004	17	36	23	56	50	119	114	152

*p=<0.05; **p=<0.01; ***p=<0.001

Note: P values indicates significance difference in mean values of FBG and 2h BG by gender among different groups of glucose tolerance

Discussion

Our data showed that the prevalence of IGT was significantly higher than IFG. Prevalence of IGT was slightly higher in female but no such sex difference was observed for IFG cases. Female subjects showed significant higher prevalence of IFG+IGT whereas prevalence of diabetes did not vary between male and female subjects. However, earlier data showed higher prevalence of diabetes among female subjects[19]. Prevalence of IFG and IGT was found to vary in terms of its ascendancy across studies. IGT was found to be more prevalent compared to IFG in Mauritius[20] in USA[21] and in Pima Indians[22]. However, studies conducted in the Netherlands [23], Finland[24], India[9] and among Asian Indians in US [11] did not find any difference in the prevalence of IFG and IGT. Our results showed similar levels of IFG and IGT in men; however, IGT was higher in women compared to IFG, and this finding is consistent with previous studies in Bangladesh[7,13]. Sex difference in the prevalence of IGT has been reported in other countries[25] .Prevalence of IGT was found to be similar for both sexes in an urban Indian study[26]. Some other studies showed higher prevalence of IFG among men and higher prevalence of IGT among women[21, 27].

Adverse anthropometric features are more prevalent among subjects having impaired glucose regulation i.e. IFG, IGT,IFG+IGT and DM. Our data suggests that IGT and DM were more common among older participants. Similar finding on IFG was also observed in Asians Americans[11]. Contrary to this finding, a report from Austria showed that age related increase in FBG was particularly seen in subjects with IFG[28]. The diverse finding in our study and that from India compared to the studies conducted elsewhere may suggest ethnic differences.

Our data showed that the prevalence of diabetes (FBG $\geq$ 6.1 mmol/l) was 6.7% while this was 3.4% following 2-hr BG values. This finding is an agreement with an Indian study where the prevalence of diabetes was 5.2% following FBG and 4.3% according to 2-hr BG threshold[29]. Furthermore, our data showed that the agreement between the two procedures (FBG and 2-h BG) for the identification of diabetic cases was around 50%. Concern was expressed previously that the IFG might not identify the same subjects as for the IGT category [29]. However, prevalence of glucose intolerance by either procedure was similar [by FBG (IFG + DM) was 12.4% or 2-h BG (IGT + DM)] was 12.6%].

In conclusion, the prevalence of glucose intolerance varied significantly depending on the procedures adopted namely FBG or 2-h BG estimates. However, concern should be raised to attempt the larger number of subjects with glucose intolerance to prevent the escalating prevalence of diabetes for medical and economical consequences. The significance of IFG and IGT as a forerunner of diabetes and CVD will become evident only from longitudinal studies in different ethnic groups.Our findings need to be further verified in other settings for the development of intervention strategy for the prevention and early management of abnormal glucose tolerance

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References

1. Wild H, Roglic G, Green A, Sicree R, King H. Global Prevalence of Diabetes, Estimates for the year 2000 and projections for 2030. Diabetes care 2004; 27: 1047-1053.
2. Diabetes Atlas, third edition 2007. International Diabetes Federation, 2007.
3. Laskar S I. Urbanization in Bangladesh: some contemporary observations. Bangladesh Dev Stud 1996; 24(1-2): 207-216.
4. Bangladesh Bureau of statistics. Statistical Pocket Book of Bangladesh 2004. Statistical Division, Ministry of Planning, Government of the Peoples Republic of Bangladesh, 2004.

5. Hussain A, Rahim M A, Azad khan A K, Ali S M K. Type 2 diabetes in rural and urban population: diverse prevalence and associated risk factors in Bangladesh. Diabet Med 2005; 22:931-937.

6. Sayeed M A, Hussain M Z, Banu A, Ali S MK, Rumi MAK, Azad khan AK. Effect of socioeconomic risk factor on differences between rural and urban in the prevalence of diabetes in Bangladesh. Diabetes Care 1997; 20: 551-555.

7. Sayeed MA, Mahtab H, Khanum PA, Latif Z A, Ali SMK, Banu A et al. Diabetes and Impaired fasting glycaemia in rural population of Bangladesh. Diabetes Care 2003; 26:1034-1039.

8. McKeigue P M, Bela S, Marmot MG: Relation of central obesity and insulin resistance with high diabetes prevalence and cardiovascular risk in South Asians. Lancet 1991; 337: 382-386.

9. Ramachandran A, Snehalatha C, Satyavani K, Vijay V. Impaired fasting glucose and impaired glucose tolerance in urban population in India. Diabetic Medicine 2003; 20: 220-224.

10. Qiao Q, Nakagami T, Tuomilehto J, Borch-Johnsen K, Balkau B, Iwamoto Y et al. The DECODA Study Group on behalf of the International Diabetes Epidemiology Group. Comparison of the fasting and the 2-h glucose criteria for diabetes in different Asian cohorts. Diabetologia 2000; 43: 1470-1475.

11. Marguerite J, Neely M C, Edward J. Type 2 diabetes prevalence in Asian Americans. Diabetes Care 2004; 27:66-69.

12. Larsson H, Berglund G, Lindgarde F, Ahren B. Comparison of ADA and WHO criteria for diagnosis of diabetes and glucose intolerance. Diabetologia 1998; 41: 1124-1125.

13. Sayeed M A, Hossain M Z, Banu A , Rumi M A K, Azad khan A K. Prevalence of diabetes in a suburban population of Bangladesh.Diab Res Cli Pract 1997; 34: 149-155.

14. Expert Committee on diagnosis and classification of diabetes mellitus. Report of the expert committee on diagnosis and classification of diabetes mellitus. Diabetes Care 1997; 20:1183-1197.

15. World Health Organization: Definition, Diagnosis and Classification of Diabetes Mellitus and its Complications; Part 1. Diagnosis and Classification of Diabetes Mellitus Geneva, Department of Non-communicable Disease Surveillance, WHO, 1999.

16. Barnett A H, Dixon A N, Bellary S, Hanif M W, Hare J P O, Raymond N T, Kumar S. Type 2 diabetes and cardiovascular risk in UK south Asian community. Diabetologia 2006; 49: 2234-2246.

17. Rahim MA, Hussain A, Azad Khan A K, Sayeed M A, Ali S M K, Vaaler S. Rising prevalence of type 2 diabetes in rural Bangladesh: A population based study. Diab Res Clin Pract 2007; 77:300-305.

18. World Health Organization. WHO Recommendation. Obesity preventing and managing the Global Epidemic, Geneva. World Health Org 2000; (Tec,Rep,Ser,no.894).

19. Hussain, A, Stein V, Sayeed MA, Hajera M, Ali SMK, Azad khan A K. Type 2 diabetes and impaired fasting blood glucose in rural Bangladesh: a population-based study. Euro J Public Health 17(3):291-296, 2007

20. Shaw J, Zimmet P, Courten M. Impaired fasting glucose or impaired glucose tolerance. What best predicts future diabetes in Mauritius? Diabetes Care 1999; 22: 399-402.

21. Harris M I, Goldstein D E, Flegal K M, Little R R, Cowie C C, Wiedmeyer H-M et al. Prevalence of diabetes, impaired fasting glucose and impaired glucose tolerance in U.S adults. The third National Health and Nutrition Examination 1988-1994. Diabetes Care 1998; 21: 518-524.

22. Gabir M M , Hanson R L , Dabelea D, Imperatore G, Roumain J , Bennett P H et al. The 1997 American Diabetes Association and 1999World Health Organization criteria for hyperglycemia in the diagnosis and prediction of diabetes. Diabetes Care 2000; 23: 1108-1112.

23. de Vegt F, Nijpels G, Dekker J M, Bouter L M, Stehouwer C D, Heine R J. The 1997 American Diabetes Association criteria versus the 1985 World Health Organization criteria for the diagnosis of abnormal glucose tolerance. Poor agreement in the Hoorn study. Diabetes Care 1998; 21: 1686-1690.

24. Yliharsila H, Lindstrom J, Eriksson J G, Jousilahti P, Valle TT, Sundvall J, Tuomilehto J. Prevalence of diabetes and impaired glucose regulation in 45-to 640 year old individuals in three of Finland. Diabetic Medicine 2005; 22: 88-91.

25. Ministry of Health. Ministry of Health Clinical practice Guidelines 4/99. Diabetes Mellitus. Singapore: Ministry of Health 1999, 123pp.

26. Ramachandran A, Snehalatha C, Kapur A, Vijay V, Mohan V, Das AK et al. High prevalence of diabetes and impaired glucose tolerance in India. National Urban Diabetes Survey (INUDS). Diabetologia 2001; 44: 1094-1101.

27. Tripathy D C M, Almgren P, Isomaa B, Taskinen M, Tuomi T, Groop L. Insulin secretion and insulin sensitivity in relation to glucose tolerance: lessons from the Botnia Study. Diabetes 2000; 49: 975-980.

28. Botas P, Delgado E, Castano G, Diaz de Grenut C, Prieto J, Diaz- Cadorniga FJ. Comparison of the diagnostic criteria for diabetes mellitus, WHO-1985, ADA- 1997 and WHO- 1999 in the adult population of Austria’s (Spain). Diabetic Medicine 2003; 20:904-908.

29. Ramachandran A, Snehalatha C, Latha E, Vijay V. Evaluation of the use of fasting plasma glucose as a new diagnostic criteria for diabetes in Asian Indian population. Diabetes Care 1998; 21: 666-667.