RESEARCH PAPER

Prevalence of Prediabetes in School-Going Children

D NARAYANAPPA, HS RAJANI, KB MAHENDRAPPA AND AK PRABHAKAR

From the Department of Pediatrics, JSS Medical College, JSS University, Mysore, India.
Correspondence to: Dr D Narayanappa, Prof and Head Pediatrics, 534, Sinchana,15th Main, 5th Cross, Saraswathipuram, Mysore 570009, India. sinchabhi@yahoo.com
Received: October 21, 2009; Initial review: November 23, 2009; Accepted: March 29, 2010.

Objective: To study the prevalence of prediabetes among school children in Mysore city.

Design: Cross sectional study.

Settings: Children aged 5-10 years from three schools in Mysore city were included. Study was done over a period of 1 year during 2006-2007.

Participants: 726 children (59.8% males).

Main Outcome: Prevalence of prediabetes. Prediabetes was defined as fasting blood sugar level between 100-125 mg/dL.

Results: The prevalence of prediabetes was 3.7%. No statistically significant association was observed with major risk factors of diabetes.

Conclusions: Efforts must be made to recognize type 2 diabetes in the asymptomatic prediabetes state.

Key words: *Children, India, Prevalence, Prediabetes, School.*

Published online 2010 August 1. PII: S097475590900753-1

Diabetes mellitus is one of the leading chronic diseases of childhood and adolescence. Diabetes affects quality of life, has a major impact on their families and has significant public health impact [1]. Although type 1 diabetes is the most common form in children, type 2 diabetes mellitus (T2DM) poses a major health problem globally, especially in many developing countries [2]. In India, type 2 diabetes is reaching epidemic proportions [3-6] and is also being reported in children of Indian origin living in other countries [7]. The primary driver of the epidemic of diabetes is the rapid epidemiological transition associated with changes in dietary patterns and decreased physical activity as evident from the higher prevalence of diabetes in the urban population [8].

Type 2 diabetes mellitus in children is probably under-diagnosed because it can exist without symptoms. The clinical manifestations of T2DM are preceded by an asymptomatic prodromal period called preclinical or prediabetes [9]. Early identification of children with prediabetes aids in appropriate management thereby reducing both the incidence of diabetes, and related cardiovascular and microvascular complications. The data on prevalence of diabetes in school-going children is scanty. To the best of our knowledge, there are hardly any studies providing prevalence of prediabetes among school children in our country. The present study was planned to study the prevalence of prediabetes in apparently healthy school-going children.

METHODS

This school-based cross-sectional study was conducted in Mysore city between September 2006 and June 2007 on 726 children between 5 to 10 years age, from three schools in Mysore city. The schools were selected by using purposive sampling procedure keeping in view the operational feasibility. A proforma to collect appropriate data was devised and pre tested. Information regarding

age was obtained from school records and was recorded in completed years. History of consumption of fast food and soft drinks at least once in a week was taken as fast food consumption. History of playing outdoor games for one hour per day thrice in a week was considered as sports. History of diabetes in any one of the parent was considered as positive family history. Anthropometric measurements were taken by medical graduates under supervision of co-investigators. Their techniques were corrected and retested until desired level of intra-observer and inter-observer variability was reached (coefficient of variation for all measurements <5%). A written informed consent was obtained from the head of the institutions and parents before data collection. Ethical clearance was obtained from institutional ethical committee.

Digital weighing machines (calibrated to 0.5 kg accuracy) and calibrated stadiometers were used. Height (to the nearest mm) and weight (to the nearest 100 g) were measured using standard techniques. Body mass index (BMI) was calculated using the formula weight in kg divided by height in m^2. Agarwal charts of BMI for age and sex were used as reference standards. Children with BMI above 95th percentile were considered as obese, those above 85th percentile and below the 95th percentile as overweight [10]. Fasting blood sugar, as recommended by American Diabetes Association was used as the biochemical test for screening [9]. A blood sample was drawn after overnight fasting and plasma glucose was estimated using glucose oxidase method.

Prediabetes was defined as fasting blood sugar level between 100 mg/dL to 125 mg/dL. Fasting blood sugar more than 126 mg/dL was considered diabetes and less than 100 mg/dL was considered normal [12,13]. The results were analyzed statistically using chi square and *P* value <0.05 was considered as significant.

RESULTS

A total of 726 children (59.8% boys) in the age group of 5-10 years participated in the study. The prevalence of prediabetes in different age groups is shown in ***Table* I**. No statistically significant association was observed with age or sex. Prevalence of prediabetes was 3.9% in boys and 3.4% in girls. Only 4 children had fasting blood sugar higher than 126 mg/dL, with prevalence of diabetes 0.6%. The average fasting blood sugar was 76.6 mg/dL with standard deviation 15.9 mg/dL. There was no clear trend with age. Prevalence of overweight and obesity was 11% and 5%, respectively. No statistical significant association was observed with BMI and prediabetes. Prediabetes was not associated with known major risk factors related with diabetes (***Table* II**).

TABLE I AGE AND SEX DISTRIBUTION OF CHILDREN AND PREDIABETES PREVALENCE

Age (y)	Sex		Total	Prediabetes
	Male	Female		(%)
5	60	44	104	3 (2.9)
6	65	43	108	2 (1.9)
7	70	60	130	8 (6.2)
8	73	42	115	9 (7.8)
9	70	42	111	2 (1.8)
10	96	62	158	3 (1.9)
Total	434	292	726	27

Number in paranthesis indicate percentage.

DISCUSSION

India leads the world with largest number of diabetic subjects, earning the dubious distinction of being termed the ''diabetes capital of the world''**.** The International Diabetes Federation (IDF) estimates the total number of diabetic subjects to be around 40.9 million in India and this is further set to rise to 69.9 million by the year 2025 [13,14]. Diabetes develops at a younger age in Indians, that is at least a decade or two earlier than in the Western population [3].

In our study, the prevalence of diabetes was 0.6%. In a study done by Asha Bai, *et al*. [16] in 1982 on 3515 children aged 5-15 years with oral glucose tolerance test, no cases of diabetes were found. In a population based study of physician diagnosed diabetes in US youth <20 years, the prevalence of undiagnosed type 2 diabetes was 0.4 % [19]. In Taiwan, in children aged 6-18 years, the

TABLE II ASSOCIATION BETWEEN PREDIABETES AND RISK FACTORS

Risk factors	Classification	No.	Prediabetics	Prevalence (%)
Sex	Male	434	17	3.9
	Female	292	10	3.4
Birthweight groups(g)	<2000	17	0	0
	2000-2500	102	6	5.9
	>2500	607	21	3.5
Sports	Yes	636	24	3.8
	No	90	3	3.3
Fast food	No	368	9	2.5
	Yes	358	18	5.0
Soft drinks	No	184	6	3.3
	Yes	542	21	3.9
BMI	Normal	607	23	3.8
	Overweight and obese	119	4	3.4
History of diabetes in parents	Yes	49	0	0
	No	677	27	4.0

P value >0.05 for all factors studied.

rate of newly diagnosed diabetes in screening programme was 0.9 and 1.53% in boys and girls, respectively [19].

The prevalence of prediabetes in our study was 3.7%. There are hardly any population based studies done in children aged 5-10 years to compare the data from this study. According to the National Urban Diabetes Survey done in adults above 20 years, the prevalence of impaired glucose tolerance was 16.8% in Chennai, 14.9% in Bengaluru, 29.8% in Hyderabad, 10% in Kolkatta, 10.8% in Mumbai and 8.6% in New Delhi [13]. The Amrita Diabetes and Endocrine Population Survey done in Kerala showed that 11.2 % of the subjects had either impaired fasting glucose or impaired glucose tolerance [13]. Prevalence of prediabetes was 19.2% in 280 overweight Japanese children [3].

There are very few publications on the natural history of type 2 diabetes in children. Several case series suggests that children also have an asymptomatic phase similar to adults, during which the disease can be diagnosed [10]. The rate of progression is influenced by various factors like high BMI, hypercholesterolemia, high blood pressure, positive family history etc. In adults, the likely duration of diabetes prior to clinical diagnosis has been estimated as 4-7 years. The duration of 'asymptomatic' diabetes in children has not been estimated [10]. Several studies have confirmed that lifestyle modification and treatment with pharmacological agents like metformin can prevent or delay the onset of diabetes in patients with impaired fasting glucose [10]. Several studies have shown that these prediabetic states are also high risk stages for cardiovascular disease [13,15,16].

The prevalence of overweight and obesity in our study was 11% and 5%, respectively in concordance with other school based data in India, which demonstrated prevalence of obesity in the range of 5.6% to 24% among children and adolescents [20-23]. A positive association between overweight and obesity and risk of type 2 diabetes has been established repeatedly in many cross-sectional and prospective studies [7]. Increasing prevalence of type 2 diabetes among children in India and other countries has been attributed to epidemic of obesity and overweight among children [7]. In our study no association was found between prediabetes/diabetes with overweight or obesity. This can be explained by

WHAT THIS STUDY ADDS ?

- Prevalence of prediabetes and diabetes in 5-10 year old school children in Mysore city was 3.7% and 0.6%, respectively.

the fact that insulin resistance is a common feature even in nonobese Asian–Indian subjects [3,7]. It was also not possible to establish any association with known major risk factors related with type 2 diabetes.

The present study has certain limitations for generalizability. The data utilized in the study was drawn from a research project which is basically a study on the changes in blood pressure over a period of time in school going children. The lipid profile and blood sugar estimation was carried out as a part of the study. The sample size was calculated based on the main study. Hence sample size for estimation of prevalence of prediabetes and for studying the association of risk factors may not be adequate. Classification of diabetes was also not feasible in this study. This study has brought out important points for further studies with sufficiently larger samples to confirm the epidemiological consistency of the observations made in this study.

Prevalence of type 2 diabetes and prediabetes in Indian children is not known at present. Efforts must be made to recognize type 2 diabetes in the asymptomatic prediabetes state. Early identification of at-risk individuals using simple screening tools and appropriate lifestyle intervention would greatly help in preventing or postponing both the onset of diabetes and its related cardiovascular and micro-vascular complications thereby reducing the burden on the community and the nation as a whole.

Acknowledgments: We acknowledge the assistance provided by co-investigators Dr Sudarshan Murthy KA, Professor and HOD, Department of Medicine, JSS Medical college, Dr Renuka, Associate Professor, Depart-ment of Community Medicine, Senior research fellows: Dr Ravikumar, Dr Purushottam V, Dr Purushottam DR and Medical Social Workers: Smt Sharada and Smt Prakruti; and, CFTRI for providing *Annapoorna* software for nutritional assessment.

Contributors: DN, HSR, KBM, AKP participated in study design, acquisition of data, analysis, interpretation of data. DN, HSR, AKP participated in manuscript preparation and critical review. DN will be the guarantor of this study. The final manuscript was approved by all authors.

Funding: ICMR.

Competing interests: None stated.

REFERENCES

1. Allen PJ, Vessey JA. Primary care of the child with a chronic condition. 4th ed. St Louis, MO: Mosby: 2004.
2. Jones KL. World diabetes day 2008: Focussing on the children. Indian J Med Res. 2008;128:567-9.
3. Ramachandran A, Snehalatha C, Satyavani K, Sivasanakri S, Vijay V. Type 2 diabetes in Asian Indian urban children. Diabetes Care. 2003; 26:1022-5.
4. Ramachandran A, Snehalatha C, Dharmaj D, Vishwanathan M. Prevalence of glucose intolerance in Asian Indians : Urban-Rural Difference and significance of upper body adiposity. Diabetes Care. 1992;15:1348-5.
5. Ramachandran A, Snehalatha C, Latha E, Vijay V, Vishwanathan M. Rising prevalence of NIDDM in urban population in India. Diabetologia. 1997; 40:232-7.
6. 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 (NUDS). Diabetologia. 2001;44:1094-1101.
7. Ramachandran A. Diabetes and obesity. The Indian angle. Indian J Med Res. 2004;120:437-9.
8. Venkatnarayan KM, Campagna A, Imperatore G. Type 2 diabetes in children. A problem lurking in India. Indian Pediatr. 2001;38;701-4.
9. Agwu JC. Screening for type 2 diabetes mellitus in children and adolescents. Br J Diabetes Vasc Dis (Indian edition). 2009;3:S4-9.
10. Khadlikar VV, Khadlikar AV, Choudhury P, Agarwal KN, Ugra D, Shah NK. IAP growth monitoring guidelines for children from birth to 18 years. Indian Pediatr. 2007;44; 187-96.
11. American Diabetes Association. Diagnosis and classification of diabetes mellitus. Diabetes Care. 2009;32: S62-7.
12. American Diabetes Association. Standards of medical care in diabetes-2009. Diabetes Care. 2009;32:S13-S61.
13. Mohan V, Sandeep R, Shah DB, Varghese C. Epidemiology of type 2 diabetes: Indian scenario. Indian J Med Res. 2007;125:217-30.
14. Sicree R, Shaw J, Zimmet P. Diabetes and impaired glucose tolerance. In: Gan D, editor. Diabetes Atlas. International Diabetes Federation. 3rd ed. Belgium: International Diabetes Federation. 2006.p.15-103.
15. Novoa FJ, Boronat M, Saavedra P, Diaz-Cremades JM, Varillas VF, La Roche F, *et al*. Differences in

cardiovascular risk factors, insulin resistance, and insulin secretion in individuals with normal glucose tolerance and in subjects with impaired glucose regulation: the Telde Study. Diabetes Care. 2005;28:2388-93.
16. Petersen JL, McGuire DK. Impaired glucose tolerance and impaired fasting glucose - a review of diagnosis, clinical implications and management. Diabetes Vasc Dis Res. 2005;2:9-15.
17. Asha Bai PV, Krishnaswami CV, Chellamariappan. M, Vijaikumar G, Subramanian JR, Srivatsa A, *et al*. Prevalence of diabetes in south India. Indian Pediatr. 1995; 32;1173-6.
18. Liese DA, Agostino RB, Hamman RF, Kilgo PD, Lawrence JM, Liu LL, *et al*. The burden of diabetes mellitus among US youth; prevalence estimates from the search for diabetes in youth study. Pediatrics. 2006;118; 1510-8.
19. Wei JN, Sung FC, Lin CC, Lin RS, Chiang CC, Chueng LM. National surveillance for diabetes mellitus in Taiwanese children. JAMA. 2003:290:1345-50.
20. Greydanus DE, Bhave S. Obesity and adolescents; Time for increased physical activity! Indian Pediatr. 2004;41: 545-50.
21. Bhave S, Bavdekar A, Otiv M. IAP National Task Force for childhood prevention of adult diseases: Childhood Obesity. Indian Pediatr. 2004;41:559-75.
22. Kapil U, Singh P, Pathak P, Dwivedi S, Bhasin S. Prevalence of obesity amongst affluent adolescent school children in Delhi. Indian Pediatr. 2002:39:449-52.
23. Ramachandran A, Snehalatha C, Vinitha R, Thayyil.M, Sathishkumar CK, Shubha C, *et al*. Prevalence of overweight in urban Indian adolescent school children. Diabetes Res Clin Pract. 2002;57:185-90.