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Obesity and Type 2 Diabetes: A Population Based Study of Urban School Children in South India

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Abstract A cross-sectional population-based study was conducted on 1440 Indian children in Hyderabad to determine the prevalence of obesity, impaired fasting glucose (IFG) and type 2 diabetes mellitus (T2DM), and to determine whether the increase in T2DM among adults is applicable to this population. Information was gathered through a questionnaire. . All the children were screened for fasting capillary blood glucose (FCBG) and anthropometric measurements. None had impaired fasting glucose (IFG) or type 2 diabetes. The school age children and adolescents were categorized into various grades of nutritional status using WHO Reference values of BMI Z-scores. Among the total children, 15.9% of girls, 15.9% of boys were overweight, and 4.2% and 9.5% were obese respectively. Prevalence of overweight/obesity and diabetes among either of the parent or both parents of the children was found among 36.6% and 12.4% respectively. The study found surprisingly no prevalence of dysglycemia amongst children in a city with a high prevalence of diabetes in its adult population. More studies are needed to confirm and explain the paradox. This analysis represents the population based data upon which future studies will be based.

Keywords Type 2 Diabetes Mellitus, Impaired Fasting Glucose, Overweight, Childhood Obesity, BMI

1. Introduction

Chronic medical disorders like diabetes are increasing in global prevalence and seriously threaten the developing nation's ability to improve the health of their populations (1). It is also predicted by Sicree et al., of International Diabetes Federation, that there will be a 65% increase in the number people with diabetes from the current figure of 240 million to 380 million over the next 20 years (2). Three quarters of this increase will occur in developing countries in people aged between 35 and 64 years, who are in their productive years. Shocking as they are, these figures do not tell the full story of the disability, suffering and personal hardship that results from diabetes related complications, or, on a larger economic scale, the enormous healthcare costs and lost productivity. Superimposed on this disturbing picture in adults are the recent reports of the emerging problem of type 2 diabetes in children and adolescents. American Diabetes Association also opined that the incidence and prevalence of type 2 diabetes among children is increasing and if this increase cannot be reversed, our society will face major challenges (3).

Obesity has been on the rise in the adolescent age, which is the strongest determinant of diabetes risk (4-10). Predictions have been made that obesity-driven type 2 diabetes might become the most common form of newly diagnosed diabetes in adolescent youth within 10 years (3). It is also stated that, diabetes develops at a younger age in Indians, i.e., at least a decade earlier than in the Western population (11, 12). Gopalan states that, India is passing through a transitional phase of socio-economic development which has resulted in several undesirable lifestyle alterations that accelerate the incidence of overweight and obesity among adults and children (13). The available population based information in India on type 2 diabetes incidence and prevalence in childhood and adolescence is sparse compared with that of adults. This study made an attempt to assess the prevalence of overweight/obesity, impaired fasting glucose and type 2 diabetes among children and to determine whether the increases around the world can be generalized to the population in India.

2. Methods

Obesity and type 2 diabetes study was conducted among school children of Hyderabad, India. The study population represents school children aged between 10 and 14 years. Seven schools were randomly chosen after stratifying schools according to socio-economic status (SES) categories. The total schools of the city were stratified into low, middle and high SES categories. It was assumed that the Government owned schools catered to lower income families, Semi-private aided schools had students belonging to lower income and lower middle income sections of the population and children from upper middle and high income attended the Private schools. After assigning a unique number to each school, two schools each respectively from low and middle SES and three schools from high SES were selected using a table of random numbers. Because we aimed to study children between ages 10 and 14 years, all children in grades 5 to 9 of the selected schools were included in the study.

From about 2370 eligible students, 1440 families (60.8%) agreed to participate. Meetings with the teachers were arranged to discuss the aims and methods of the study, and to help collecting the informed consent from the parents. The parents were asked to respond to a questionnaire inquiring about the child and family history.

Each family was asked to provide information on socio-economic and demographic data such as religion, community, type of fuel used for cooking purpose, occupation of father and mother, possession of Household (HH) articles, ownership of the house, distance of house from school, and mode of transport used. The proxy income measures collected in the present survey are community, type of cooking fuel used, occupation of the father and mother and possession of household articles. For computation of composite socio-economic status all the proxy measures were given a logical score (1-5), along the lines of National Family Health Survey-2 and National Council of Applied Economic Research survey [14]. The total was summed up into a grand score. This grand score was divided into four quartiles. The first quartile was representing the low socio-economic status (<23 score), second quartile as middle socio-economic status (23-39 score), third as upper middle socio-economic status (39-48 score) and the last as higher socio-economic status (>48 score).

The questionnaire also included questions on the child's perception (normal/overweight/obese), about body size of self, the prevalence of obesity and type 2 diabetes among family members, practices like participation in the sports/games, physical exercises, household activities, time spent on television watching (hours/day), type of diet (vegetarian/non vegetarian/vegetarian + egg) available at home and the child's food preferences.

The questionnaire inquired about the average daily number of hours spent on organized sports, non-sport activity and watching TV. Watching television was categorized based on hours of watching per day into 0, ≤1 and >1hr/day. Similarly, other variables such as outdoor and indoor games and physical activity were also categorized [15]. The responses were scored for each child and the activity level of the child was classified as active, moderate and inactive.

Written signed informed consent was obtained from all the participants' families, heads of the educational institutions and District Educational Officers of Government of Andhra Pradesh.

Data collection: Training was undertaken to assure accurate, uniform collection of data. The children were instructed to arrive at 8.00 A.M after an 8-hour fast. Fasting capillary blood glucose was tested with a glucometer. The fasting capillary blood glucose (FCBG) testing was used as a screening tool for presence of IFG or type 2 diabetes for all the children as it was cost effective. Anthropometric measurements were recorded using standardized equipment. Weight was measured with the student in light clothing (school uniform or equivalent), no belts and no shoes. Height was measured using a stadiometer on a hard, uncarpeted surface. The weight was rounded to the nearest 0.1 kg and the height to 0.5 cm.

Diagnostic criteria: The school age children and adolescents were categorized into various grades of nutritional status using BMI Z-scores (WHO Reference values [16]).

Fasting capillary blood glucose levels were estimated from finger prick blood samples on all the participating students, using one touch Glucometer (ACCU CHEK, Active). Students who had fasting capillary blood glucose (FCBG) levels ≥ 100 mg/dl would undergo an oral glucose tolerance test (OGTT). The criteria for the diagnosis for diabetes mellitus (DM) were those of the American Diabetes Association Expert Committee on the Diagnosis and Classification of DM. The American Diabetic Association (2004) [17] has considered 'diabetes', if the fasting blood glucose levels is ≥126 mg/dL, between ≥110 to <126 mg/dL as impaired fasting glucose and <110 mg/dL is considered as normal.

Statistical analysis: Descriptive statistics and graphical displays were computed for each of the study variable. The distribution of each outcome variable was assessed to determine whether distributional assumptions were valid. All primary outcome variables were discrete. For discrete outcomes, simple tests of proportions, chi-squared analysis, and logistic regression analysis (adjusting for multiple predictors simultaneously) were employed. For continuous variables, the analyses included ANOVA, t-tests, and standard regression analysis adjusting for multiple predictors. All the analysis was conducted using SPSS Window Version 15.0.

3. Results

The study covered a mixed population of 1440 children comprising 52.5% (n=756) boys and 47.5% (n= 684) girls) in the age group of 10-14years of age, with a mean age of 12.5 years. The students were selected from all communities with 40% of them belonging to communities that are considered socially backward communities, as also referred in Census, 2011[18]. The major occupation of the fathers' was either service (38.7%) or business (37.2%). However, a majority of their mothers were engaged in household chores (61.0%). It was observed that 26.1% of children belonged to the high socio-economic status while 25.7% in upper middle socio-economic status, and 24.1% each respectively in middle SES and lower SES. The demographics of the participants are depicted in Table 1.

Table 1. Classification of participants in the Hyderabad Obesity and Type 2 Diabetes Mellitus Study

	Boys	Girls	Total
n (%)	756 (52.5)	684 (47.5)	1440 (100)
Age(yr) (mean± SD) (range)	12±1.41 10.0-14.0	12±1.35 10.0-14.0	12.0±1.38 10.0-14.0
Impaired Fasting Glucose (%)	0	0	0
Type 2 Diabetes mellitus (%)	0	0	0
BMI (kg/m²; mean ± SD) (range)	17.78±3.99 10.59-32.92	18.06±3.66 10.10-34.93	17.9±3.84 10.1-34.9
Overweight (n %) (95% CI)	120 (15.9) (13.3- 18.5)	109 (15.9) (13.2-18.6)	220 (15.9) (11.07-20.7)
Obesity (n %) (95% CI)	72 (9.5) (7.4-11.6)	29 (4.2) (-3.1-11.5)	101 (7) (2.02-11.98)
Weight ≥ 85^{th} percentile	16.1%	13.3%	14.8%

3.1. Prevalence of T2DM and IFG

The analysis for fasting capillary blood glucose (FCBG) was performed among 1440 children. None fulfilled the criteria for the diagnosis for IFG or T2DM.

3.2. Prevalence of Obesity and Overweight

The prevalence of overweight and obesity according to BMI Z-scores of WHO Reference values [16] were 15.9% and 7% respectively. There was difference between the genders (p=0.000). One hundred and nine (15.9%, 95% CI: 13.2-18.6) of the girls and 120 (15.9%, 95% CI: 13.3- 18.5) of the boys were overweight, whereas 29 (4.2%, 95% CI: -3.1-11.5) of the girls and 72 (9.5%, 95% CI: 7.4-11.6) of the boys were obese according to the WHO Reference data. The results are depicted in Table 1.

3.3. Risk Evaluation of IFCBG

There were no participants who satisfied the criteria for IFG or T2DM and to analyze the odds ratio for the relationship of IFG with obesity or overweight.

3.4. Risk Evaluation for Overweight and Obesity Age and Gender

A chi-square test indicated a negative association between age and occurrence of overall overweight and obesity status (≥85^{th} percentile) (p= 0.216). The overall prevalence of overweight and obesity among the age groups 10-14yrs ranged from 12.4%-19.9% and 5.5%-9.1% respectively. Although, the prevalence of overweight among boys and girls was 15.9%, the boys showed a higher percentage of obesity of 9.5% as against the girls with 4.2%. The occurrence of overweight and obesity showed difference between genders (p=0.000). All the school authorities declined to give permission to conduct the staging examination for the sexual maturation of children.

3.5. Socio-Economic Status

The prevalence of overweight and obesity were significantly higher among children studying in private schools 244 (16.95%), aided institutions 73 (5.07%) as compared to children studying in the government institutions 13 (0.9%). When logistic regression analysis was used, it is found that the risk of overweight/obesity was 2.6 times higher in children of private schools (OR= 2.6; 95% CI: 1.11- 6.05) and 1.7 times in children of aided schools (OR= 1.7; 95% CI: 0.75- 3.94) than those in the government schools. The prevalence of overweight and obesity among children across different schools which represent low, middle and high income categories is depicted in Fig 1.

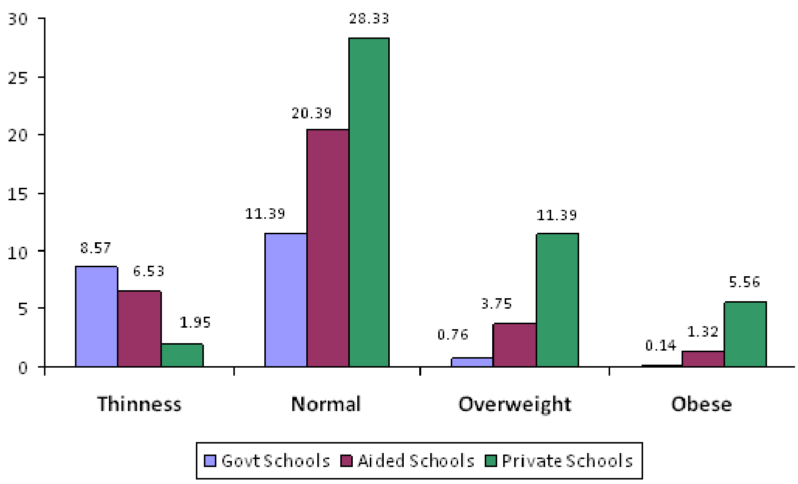

Figure 1. Distribution across BMI categories among children of the different types of schools among the total number of students

A clear socio-economic gradient was observed in the prevalence of overweight/obesity among the study participants. The prevalence of overweight and obesity were significantly lower among children belonging to low SES and lower middle SES (2.6 and 7.3%) and high in upper middle and high socio-economic status (28.1 and 29.4%). Participants belonging to the HSES (OR=6.5; 95% CI: 2.68-15.9; p=0.000) and UMSES (OR= 5.8; 95% CI: 2.38-14.15; p=0.000) were at significantly higher risk for the development of overweight/obesity than LSES and MSES.

3.6. Physical Activity

About more than three fourth of the children reportedly participated in outdoor games and half of them in indoor games every day. Data collected about physical activity showed that 974 participants were classified as inactive, 417 as moderately active and 49 as active. Among the inactive participants, 226 (23.2%) were categorized as overweight/ obesity. The prevalence was lower among the participants who were moderately active with ≤ 1hr of physical activity 75 (17.9) and significantly lower among those who were active and participated in >1hr of physical activity 6 (12.4) (p=0.000).

3.7. TV Viewing

Most of the students (82%) were watching television on school days or on holidays either in their own house or in their neighbor's house. Majority of the children 1289 (89.5%) indicated that they watched TV on holidays. Of these 1181 (82%) of the students watched TV for more than an hour per day. The proportion of overweight/obesity 364 (25%) was significantly higher among children who were watching television >1hr/day as compared to the children who were watching television ≤1hr/day 111 (7.7%) (p=0.000). The odds ratio of children who watched TV for >1hr/day was high (OR=1.5; 95% CI: 0.726- 3.205) suggesting that children who spent less time watching TV were more likely to be active and less likely to have overweight/obesity.

3.8. Food Preferences

Food preferences were recorded for all the children. Participants who reported to prefer fatty foods or carbohydrate dominant diets were at significantly higher risk of having above-normal weight than the others (OR= 1.7; 95% CI: 1.251-2.252; p=0.001).

3.9. Family History

Of the 1440 children, 526 (36.5%) had a positive family history of obesity, while 178 (12.4%) had a positive family history of T2DM. Among these, it was also observed that 137 (9.5%) children were obese themselves along with both the parents and/or one of the parent and 62 (4.3%) also had family history of diabetes among either of the parent or both the parents. Family history of diabetes or obesity may be a risk factor for the development of IFG or T2DM among the children in the future.

4. Discussions

The present study reports on the prevalence of impaired fasting glucose, type 2 Diabetes (T2DM), overweight and obesity among school-going children in Hyderabad and examined its associated factors such as SES, physical activities such as participation in sports and games, sedentary activities such as watching television, dietary behaviors and family history of type 2 diabetes and obesity.

The present study showed no cases of IFG and T2DM, but found that the prevalence of overweight and obesity was 15.9% and 7% respectively. The prevalence of obesity among the students is also supported by similar study findings from Chennai [19].This prevalence in the southern part of India is much lower than that reported from other countries (33% in Italy [20], 49% in Taiwan [21]). This variance could be due to differences in socioeconomic status and dietary behaviors of children and adolescents in these study areas as well as differences in their genetic makeup. The prevalence of overweight and obesity among children in Hyderabad was 22.9 %, which is higher than the previous study conducted in the same population [22], but lower than the West. The increase can be attributed to the change in lifestyle, reduced physical activity and faulty dietary patterns. This suggests that the problem of overweight and obesity is emerging among children and adolescents. Studies conducted in Thiruvananthapuram, Kerala [23] and Delhi [24] reported a higher prevalence of overweight and obesity among adolescents. The study in Delhi, which is a part of North India, was done in a private school. The study in Kerala, which is a part of South India, comprised greater proportion of students from private schools and therefore, clearly, a higher prevalence of overweight and obesity were reported due to the greater purchasing power and higher standard of living of those students.

A clear socioeconomic gradient in the prevalence of overweight and obesity was observed in this study, which is consistent with other studies [19, 22]. Besides greater purchasing power and higher standard of living of children from HSES, these studies have reported that the rise in sedentary behaviors such as increased use of vehicular transport and decreased physical activity has lead to increased prevalence of overweight and obesity. Thus the higher prevalence of overweight and obesity among children and adolescents studying in private schools in this study could also be attributed to their higher socioeconomic status.

With growing affluence and a dramatic increase in TV watching and computer use documented in India, it is likely that a greater proportion of young children have sedentary behavior. The present study confirms this fact and notes that nearly 68% of the adolescents were inactive to minimally active and only 4% were active. It is also observed that 23%

of the inactive children were either overweight or obese and significantly lower among the active children. Similar findings have been reported from studies in developing and developed countries [25, 26, 27, 28], and other parts of India [19, 22, 29].

When we analyzed the daily activities of the children, we found that a significantly greater proportion of study subjects (82%) watch television for more than one hour per day. The prevalence of overweight/obesity was found among 364 (25%) children who were watching television >1hr/day which was significantly higher as compared to the children who were watching television ≤1hr/day 111 (7.7%) (p=0.000). These findings were similar to earlier studies [15, 22]. Additionally Klesges *et al*, reported the effect of watching television on metabolic rate and the occurrence of overweight and obesity [30].

In urban areas, considering the safety of keeping children away from heavy traffic and pollution, parents feel more comfortable if their children play indoor games or watch television and so do not encourage participation in outdoor games. This is a matter of concern, as physical activity is essential for the musculoskeletal and cardiovascular health and fitness of children and adolescents. It is important that parents make efforts to reduce young people's time spent watching TV and involve them in outdoor sports activities. Since adolescents spend one third of the day in school, strengthening school physical education programmes would be effective in improving the levels of physical activity of both boys and girls.

The present study also shows that children who preferred high fat foods had a higher risk for the development of overweight and obesity. As expected, a low activity level, high- fat food preferences and a family history of obesity also increase the risk of being overweight/obese. The fact that family history of obesity and type 2 diabetes increase the risk of the development of the same in children has been also proved in other studies [31]. Allison *et al*, 1996 showed that the relative risk for overweight is 2 folds and increases up to 3-4 folds for higher levels of obesity among siblings of obese parents [32]. Although genes appear to increase vulnerability to obesity, other determinants like dietary, lifestyle and activity patterns must be present for obesity to occur.

Type 2 diabetes among children has been reported from developed countries such as the UK [4-6], the US [7-9], and Japan [33]. Its rising prevalence has been attributed to the increasing rate of obesity in children [34]. In the present study, it was observed that despite substantially higher prevalence of type 2 diabetes among Indian adults, the prevalence of IFG and diabetes is not seen among Indian children as compared to the West. Although clinic based prevalence of type 2 diabetes in children has been reported from India [35], population based studies have not been published. Prevalence of T2DM is high among Asian populations, particularly so in Asian Indians, by virtue of a high genetic susceptibility and enhanced interaction with environmental triggers. Exposure to a high fat diet and lower levels of physical activity are the common factors which trigger the gene-environmental interaction.

The low prevalence in this present study may be due to the younger age group of the children and lower rate of prevalence of overweight and obesity among children than the West [36]. In addition, obese children were heavier in the US than in our study population with maximum BMI 34.9 kg/m^2 (Table1). The degree of obesity is also a factor determining the risk of development of impaired glucose tolerance (IGT) and possibly T2DM. Sinha *et al,* [7] reported that 21% of 112 adolescents with marked obesity had IGT, irrespective of ethnic group. Therefore, we believe that less severe obesity as well as lower prevalence of overweight contributes to the low prevalence of T2DM and IFG in our study group. Given that, long standing obesity and /or overweight eventually leads to type 2 diabetes, longer follow-up of these children might unravel the dormant state. There was no association between IFG and overweight or obese, and we were unable to calculate an odds ratio because there were no participants with IFG in the present study. It is likely that the degree of obesity is a critical risk factor for the development of IGT as well as its progression into T2DM. The absence of children with T2DM in our study population prevented us from defining this connection.

In conclusion, the observations highlight the significance of preventive measures, because the increase in childhood obesity precedes the occurrence and rise in T2DM. Effective prevention and treatment strategies for obesity in childhood should help reduce the prevalence of obesity and its complications among adults. Additionally, more studies have to be conducted in late adolescents and young adults (15-25 years) to identify the inflection point at which type 2 diabetes is occurring in large numbers among the adults in India. There is also an urgent need to conduct similar studies in other parts of the Indian subcontinent to gather information on whether the results are similar to our study or different. Further longitudinal studies have to be conducted to gather information on the associated risk factors.

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