Screening for diabetes mellitus in learners residing in the Belhar, Delft and Mfuleni communities of Cape Town, Western Cape, South Africa

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Abstract

Background
Historically, children and adolescents have been diagnosed with type 1 diabetes mellitus and it was thought that type 2 diabetes mellitus occurred only in adults. There are increasing reports of type 2 diabetes in children globally, with some as young as eight years old being affected. The average age of diagnosis in this group was 13 years. This has been attributed to the "epidemic" of overweight and obesity currently being observed in both developed and developing countries. There is a paucity of data on the incidence and prevalence of type 2 diabetes mellitus in children compared with that for adults. Most studies reported to date have been clinic based. The few population-based studies that were carried out between 1965 and 1995 have shown a several-fold increase in the incidence rates of type 2 diabetes mellitus. The prevalence of diabetes mellitus in South Africa has risen dramatically in the past two decades, with the highest prevalence rates being found in the adult population of Indian origin, followed by the African, Coloured (mixed ancestry) and White population groups.

Objectives
This study was undertaken to screen 10 to 16-year-old learners residing in three urban areas of Cape Town, South Africa for diabetes mellitus.

Methods
Fasting and casual blood glucose levels were measured using a commercial glucometer in 338 randomly selected schoolchildren aged from 10 to 16 from the urban communities of Belhar, Delft and Mfuleni in Cape Town. Early morning urine samples were also tested for the presence of glucose using dipsticks. Anthropometric measurements were carried out using standard procedures. A structured questionnaire on physical activity, demographics and diabetic status was administered to all participants. Overweight and obesity were estimated according to The International Obesity Task Force **(IOTF)** criteria.

Results
A total of 15.7% of the learners were overweight and 6.2% were obese; 11.5% of the learners had a first-degree relative with diabetes and 29.9% had a second-degree relative with diabetes. Mean fasting and casual glucose values of 4.26 ± 0.63 mmol/l and 4.58 ± 0.79 mmol/l ($p < 0.05$) respectively were obtained. Using the American Diabetes Association (ADA) criteria, no learner was found to be diabetic or presented with elevated blood glucose concentrations. No learner presented with glycosuria. Females had marginally higher fasting and casual glucose levels than males, although the difference was insignificant. The overall (fasting and casual) glucose levels in African (4.37 ± 0.67 mmol/l) and Coloured learners (4.48 ± 0.79 mmol/l) were similar, with no gender differences being observed between the two groups. Blood glucose values were similar in those with or without a family history of diabetes. Fasting and casual blood glucose values were also similar between overweight, obese or normal weight learners and were not influenced by body mass index.

Conclusion
These results suggest that population screening of children may not be viable, despite the increase in the prevalence of diabetes mellitus amongst various racial groups in South Africa.

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INTRODUCTION

Historically, children and adolescents have been diagnosed with type 1 diabetes mellitus and it was thought that type 2 diabetes mellitus occurred only in adults. There are increasing reports of type 2 diabetes in children globally, with some as young as eight years old being affected.[1,2,3,4] The average age of diagnosis in this group was 13 years. This has been attributed to the "epidemic" of overweight and obesity currently being observed in both developed and developing countries.[2,5] There is a paucity of data on the incidence and prevalence of type 2 diabetes mellitus in children compared with that for adults. Most studies reported to date have been clinic based. The few population-based studies that were carried out between 1965 and 1995 have shown a several-fold increase in the incidence rates of type 2 diabetes mellitus.[6] The prevalence of diabetes mellitus in South Africa has risen dramatically in the past two decades, with the highest prevalence rates being found in the adult population of Indian origin, followed by the African, Coloured (mixed ancestry) and White population groups.[7,8,9]

In this study, we screened a randomly selected group of learners aged 10 to 16 years from three urban communities in Cape Town, South Africa for the presence of diabetes mellitus.

METHODS

The study population consisted of learners aged 10 to 16 years who were recruited from public or government-funded schools located in the Belhar, Delft and Mfuleni communities of Cape Town. These areas were selected as they not only provided us with a population with the required characteristics, but also were logistically ideal. The Belhar and Mfuleni areas consist of a predominantly Coloured and African population respectively, while Delft has a heterogeneous population of both Coloured and African individuals. Most of the households in these communities are in the lower to middle income bracket. The structure of the educational system provides an almost ready-made sampling frame (age, gender, educational level, geographical area, etc.). Given the demographics of the selected areas it was appropriate to use schools for the sampling frame.[10]

The sample population was obtained through a proportionally stratified multi-staged random sampling technique that was stratified according to the three different areas used for the study, as well as to gender. On the basis of the statistically calculated power (80%), a proportionally repre-sentative sample of 421 learners was required for the study. To provide for exclusions and learners who might wish to discontinue participation, a sample size of 800 was selected. Calculations based on the mentioned sampling technique indicated a required sample of 400 (50%), 328 (40.6%) and 72 (9.4%) from Belhar, Delft and Mfuleni respectively. Schools that refused to participate were approached twice or thrice – either personally or telephonically. Learners were excluded from the study if they were not residing in these areas or were outside the specified age range. The Research Ethics Committee of the Peninsula Technikon approved the study. Written informed consent from the parents, as well as oral consent from the learners, was sought prior to any data collection by the fieldworkers. Permission was also obtained from the Western Cape Education Department, school governing bodies and principals at all schools included in the sample.

Trained health personnel performed all the measurements for the study and the field workers went through intensive training prior to any data collection. All measurements (which were also validated) were performed using standardised anthropometric techniques. In order to enhance the quality of the study, proper calibration of all direct reading instruments was done regularly as per the manufacturer's specifications.

All the learners were given verbal and written instructions to present themselves in the fasting state (i.e. not to consume anything except water from 22h00 until 08h00 the next morning). The learners were also asked to provide early morning urine specimens. All the measurements were taken between 08h00 and 10h00. The learners were asked about their fasting status prior to the glucose measurement. If a learner reported having eaten prior to sampling, the glucose value was classified as a casual blood glucose (CBG) concentration. Learners were allowed to eat after the measurements had been taken, but no postprandial measurements were performed. To ensure reliability and validity, the measurement times were recorded, and all the measurements performed after 10h00 were considered invalid and were repeated the following morning. Elevated or low levels were repeated.

Blood glucose measurements

Blood glucose levels were measured using the Accutrend GCT® glucometer. Recent studies have shown that modern handheld glucose measuring devices have excellent technical characteristics and yield results that are similar to reference laboratory methods.[11] Furthermore, various studies have reported that capillary glucose measurements are as suitable as venous glucose measurements in the diagnosis and detection of type 2 diabetes mellitus in epidemiological studies and may be cost effective in the implementation of pre-screening procedures.[12] The commercial glucometer used in this study had a mean imprecision of <5%, with a range of 1.1 – 33.3 mmol/l on capillary whole blood.

On the day of sampling, the participant's fingertip was first cleansed with sterile webcol alcohol swabs. The side of the finger was then pricked with a lancet (using a readily available, semi-automated lancet device). This part of the finger was used as it is less sensitive than the tip. Sufficient time was allowed for the drop of blood to form and drop onto the test strip.

Urinalysis

Urinary glucose was measured using the commercial Uricheck® test kit. Test strips were dipped into a fresh urine sample, allowed to develop for one minute and compared to the chart provided with the kit.

Questionnaire

A pre-validated questionnaire on demographic data, diabetic status, symptoms of diabetes mellitus, knowledge of family history of diabetes and lifestyle behaviour that had been modified for local conditions was administered to each participant.

Anthropometric measurements

Height was recorded in centimetres to one decimal place using a measuring tape (stature meter). Weight measurements (kg) were taken with each subject in light clothing and without shoes and socks. Weight

was determined on a good-quality Sunbeam® EB710 digital bathroom scale, which was initially calibrated and standardised using a weight of known mass.

Body Mass Index and criteria for obesity

Body Mass Index (BMI) was calculated for each subject as weight (kg)/height^2 (m). Overweight and obesity were determined using age-gender-specific cut-off points according to the criteria developed by Cole et al. and adopted by the International Obesity Task Force.[13]

Diabetes

The criteria for the diagnosis of diabetes were adapted from the Report of the Expert Committee on the Diagnosis and Classification of Diabetes Mellitus, i.e. fasting plasma glucose of ≥7.0 mmol/l or casual plasma glucose concentration ≥11.1 mmol/l (and symptoms of diabetes), equivalent to a fasting glucose concentration of ≥6.1 mmol/l or a casual glucose concentration of ≥11.1 mmol/l respectively for capillary whole blood.[14,15]

Statistical analysis

Exploratory and descriptive statistics were determined. Statistical analyses were performed using the statistical package Intercooled STATA version 7.0.[16] Pearson Chi-square statistics and Fisher's exact statistics were computed to determine the associations between the respective categorical outcomes and predictor variables. Simple logistic regression, multiple logistic regression and stepwise variable selection techniques were employed to determine the individual and combination of variables that predicted the categorical outcomes of this study. To further strengthen the outcome of the results in the study, advanced statistical modelling, i.e. survey estimation: multiple logistic regression analysis, was employed on the data. Group means and medians were compared using the ANOVA, Kruskal-Wallis tests, t-test or Mann-Whitney ranksum tests, where applicable.

Results

Seventeen of the 27 schools in the locations participated in the survey. The participation rates for the schools and the learners were 63% and 50.1% respectively. A final proportionally representative sample of 401 learners (randomly selected children and adolescents attending primary and secondary schools) was obtained. A total of 63 subjects were excluded for not meeting the inclusion criteria. Of the remaining 338 subjects, 57.7% (195) were female. The mean age of the learners was 12.7 ± 1.9 years. The females were slightly older than the males (12.8 ± 1.9 years vs. 12.7 ± 1.9 years). A total of 73.7% (249) of the learners classified themselves as people of mixed ancestry (Coloured) and 25.7% (87) classified themselves as African.

Table I summarises the demographic characteristics of the learners in this study with respect to family history of diabetes, overweight and obesity prevalence and glucose levels. A total of 11.5% (39) of the learners had a first-degree relative with diabetes and 29.9% (101) had a second-degree relative with diabetes. This was not independently confirmed by verifying the information provided by the learners with their parents. The prevalence of obesity and overweight was 6.2% and 15.7% respectively. Despite written and oral instructions to fast for a minimum of ten hours, only 43.8% (148) of the learners complied. As expected, a significant difference was seen between the fasting and casual blood glucose values ($p<0.05$). None of the learners presented with elevated fasting or casual blood glucose levels. Glycosuria was absent in all the learners and none of them had previously been diagnosed with diabetes mellitus or presently had any symptoms.

African males (4.25 ± 0.69) had slightly higher fasting and casual glucose levels than Coloured males (4.2 ± 0.60). Coloured females, on the other hand, demonstrated higher fasting and casual glucose levels than African females. However, none of these differences were significant ($p = 0.4796$ and $p = 0.2446$ respectively). No gender differences were observed between African and Coloured learners.

Similar fasting and casual glucose levels ($p = 0.8177$ and $p = 0.4094$ respectively) were found in non-overweight and overweight learners, as illustrated in Table II. Obese learners had higher fasting and casual glucose levels than non-obese learners ($p = 0.6531$ and $p = 0.0898$ respectively), although the difference was insignificant.

Table I: Demographic characteristics of the learners by gender and race

			Male			Female	
Characteristic	**Total**	**Obs**	**African**	**Coloured**	**Obs**	**African**	**Coloured**
Family history of diabetes							
*First-degree relatives (M=142, F=194)**	**39 (11.5%)**	**19** (13.4%)	3 (8.6%)	16 (15%)	**20** (10.3%)	2 (3.9%)	18 (12.7%)
Second-degree relatives (M=142, F=194)	**101 (29.9%)**	**42** (29.6%)	11 (31.4%)	31 (29%)	**59** (30.4%)	12 (23.1%)	47 (33.1%)
Overweight (M= 142, F=194)	**53 (15.7%)**	**12** (8.5%)	3 (8.6%)	9 (8.4%)	**41** (21%)	16 (30.8%)	25 (17.6%)
Obesity (M= 142, F=194)	**20 (6.2%)**	**5** (3.5%)	1 (2.9%)	4 (3.7%)	**15** (7.7%)	4 (7.69%)	11 (7.8%)
Diabetes (fasting)	**0 (0%)**	**0 (0%)**	0 (0%)	0 (0%)	**0** (0%)	0 (0%)	(0%)
Diabetes (casual)	**0 (0%)**	**0 (0%)**	0 (0%)	0 (0%)	**0** (0%)	0 (0%)	(0%)

Table II. Comparison of Fasting and Casual Blood Glucose Levels of Overweight and Obese Learners, learners of healthy (normal) weight

Parameter	Overweight	Non-overweight	p-Value	Obese	Non-obese	p-Value
Fasting Blood Glucose	4.23 ± 0.69	4.26 ± 0.62	0.8177	4.3 ± 0.89	4.25 ± 0.62	0.6531
Casual Blood Glucose	4.69 ± 0.94	4.56 ± 0.77	0.4094	4.92 ± 0.93	4.55 ± 0.78	0.0898

Table III demonstrates similar fasting and casual glucose values in learners with and those without a family history of diabetes mellitus.

Table III. Comparison of Fasting and Casual Blood Glucose Levels of Learners with and without a Family History of Diabetes

Parameter	Family History	No Family History	P-value
Fasting Blood Glucose	4.49 ± 0.88	4.23 ± 0.60	0.1411
Casual Blood Glucose	4.73 ± 0.76	4.55 ± 0.80	0.3037

Discussion

The incidence of diabetes mellitus is taking an upward trend among all the population groups of South Africa. While the Indian population has the highest prevalence rate of diabetes, this trend has also emerged amongst Black South Africans going through the process of urbanisation.[8,17] Until recently considered rare, type 2 diabetes mellitus is increasingly being observed in Afro-American children and other minorities in the United States. It has emerged as an important health problem during the past decade, with children as young as eight now being diagnosed with type 2 diabetes mellitus.[18] Though there are several population-based studies on the prevalence of diabetes in the adult population, no such study has screened South African children for the presence of diabetes mellitus. Thus, despite being a relatively small study, it nevertheless is an important one as being one of the first community-based studies in South Africa to screen children for the presence of diabetes mellitus. In our study, no fasting (FBG) or casual blood glucose (CBG) was beyond 5.6 mmol/l or 7.8 mmol/l respectively. This observation is similar to that reported from the USA, where 553 students of different ethnic groups were screened and no learner was found to have a postprandial CBG of $\geq$7.8 mmol/l.[19]

Within all racial and ethnic sub-groups, a family history of diabetes is strongly associated with type 2 diabetes mellitus in children. Glaser and Jones reported that 72% to 87% of Hispanic, Native American and Japanese children with type 2 diabetes mellitus have a family history of diabetes.[20] A more recent study found parental history to be more strongly related to type 2 than to type 1 diabetes mellitus.[21] Despite a first-degree family history of diabetes mellitus in 11.5% of the children in this study, no children were found to be diabetic. A family history of diabetes is strongly associated with type 2 diabetes mellitus in children. Gender and puberty are also possible risk factors. In the South African adult population, the prevalence of diagnosed diabetes mellitus is slightly higher in women than in men. We did not observe any gender differences in the glucose values, although mean fasting glucose values tended to be higher in females.

In this study, neither fasting nor casual blood glucose values were associated with either overweight or obesity. Though obesity is a strong risk factor for type 2 diabetes,[22] BMI was not found to be a significant predictor of glucose levels in both genders. Though Brickman et al. did not find a significant relationship between FBG and BMI, they found a significant relationship between postprandial capillary blood glucose and BMI.[19] However, in their study, this aspect, along with a first-degree relative with diabetes mellitus, accounted for only 6% of the variation in CBG. Sinha et al. reported the prevalence of impaired glucose tolerance in obese African Americans to be 27% and undiagnosed diabetes mellitus to be 8%.[23] The absence of hyperglycaemia in overweight or obese subjects in our study may be due to the small sample size or because teens with either an FBG of $\leq$6.1 mmol/l or a CBG of $\leq$7.8 mmol/l may still have abnormal glucose tolerance.

Although type 2 diabetes mellitus is reported to be increasing in children of African origin, the absence of undiagnosed hyperglycaemia and symptoms of diabetes mellitus in our study speaks against population-based studies.

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