Prevalence of IDDM in Schoolchildren in Khartoum, Sudan

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The prevalence of insulin-dependent diabetes mellitus (IDDM) in 42,981 schoolchildren (aged 7–14 yr) in Khartoum, Sudan, was determined. With the 1985 World Health Organization revised criteria for diagnosis and classification of diabetes mellitus, the overall crude prevalence rate of IDDM was 0.95/1000 in the age groups studied. This figure is thought to reflect the minimum prevalence of IDDM in that population, because there is an inherent tendency in the method of screening used toward underestimating the true prevalence rate. The prevalence of IDDM was found to increase significantly with age and was slightly higher in girls than boys, but this was not statistically significant. Of 41 children with IDDM detected in the survey, 7 were not known to have IDDM before but were showing suggestive symptoms at the time of the study. This study showed that IDDM in childhood is not rare in Sudan and that probably a substantial number of undiagnosed cases exist. *Diabetes Care* 12:430–32, 1989

Diabetes mellitus is the most common endocrine disease in childhood. The impact of the disease on the quality of life, morbidity, and mortality is well documented. Diabetes has a global distribution, but from reported studies it is concluded that the prevalence of the disease varies considerably among different countries and ethnic groups (1). However, recent epidemiological surveys seem to indicate that diabetes mellitus is becoming more common in children all over the world (2). There is a general belief that diabetes mellitus is rare in developing countries, but in fact there are few studies regarding this subject. Information on this subject from Africa is sparse (3). Accurate data do not exist for any African populations, but diabetes, particularly in childhood, has been considered rare (4,5). The prevalence of insulin-dependent diabetes mellitus (IDDM) in three age groups of schoolchildren in Khartoum (Northern Sudan) has therefore been studied. Sudan is the largest and one of the poorest countries in Africa. It has a population of 22 million; 75% of the population live in Northern Sudan and constitute a racially homogenous colored group who have mixed Arab (White) and Noba (Black) blood. The remaining 25% live in the south, and ethnically they are pure African (Black).

MATERIALS AND METHODS

Subjects. The study was performed during July–October 1987. Three of six grades of a public elementary school were chosen for the study: the 1st, 4th, and 6th grades. In Khartoum, there are separate schools for girls and boys. All classes of the chosen grades were enumerated and stratified according to sex and grade into six strata, i.e., each sex and grade was a separate stratum. From each stratum, 100 classes were randomly selected. The total number of children surveyed was 42,981 (Table 1).

Procedure. Teachers and children in selected schools were asked to complete a questionnaire written in Arabic. The form contained an identification preface and six simple questions. The first two questions inquired about presence of established diabetes and insulin therapy, and the other questions covered the main symptoms of diabetes. Children in the 4th and 6th grades were expected to complete the form themselves, whereas teachers were asked to assist pupils in the 1st grade. All children present at school on the days of investigation responded. Absence from school is only allowed on medical grounds, and the number of absent children during the survey was negligible (≤0.5%). Children who responded that they were diabetic subjects and on insulin treatment were referred to the diabetic outpatient clinic for follow-up, whereas children who were not known to have diabetes and who showed suggestive symptoms of diabetes were further analyzed by examination of their urine twice for glucose and ketones with Clinistix and Ketostix urine strips. Children

TABLE 1
Age- and sex-specific prevalence rate of diabetes mellitus in schoolchildren in Khartoum, Sudan (1987)

	Boys			Girls			Total			
Age (yr)	D	P	Total	D	P	Total	D	P	Total	95% Confidence interval
7–8	3	0.41	7336	4	0.55	7213	7	0.48	14,549	0.19–0.99
10–11	7	0.96	7290	9	1.26	7157	16	1.11	14,447	0.63–1.80
12–13	7	1.00	7004	11	1.58	6981	18	1.29	13,985	0.76–2.04
Total	17	0.79	21,630	24	1.12	21,351	41	0.95	42,981	0.68–1.29

D, number of diabetic children; P, prevalence per thousand.

with negative urine tests were not investigated further. The children who showed suggestive symptoms of diabetes and glucosuria and/or ketonuria were referred to University Hospital in Khartoum, where they were interviewed, examined, and tested with an oral glucose tolerance test following the procedure recommended by the World Health Organization (6).

Statistical analysis. Differences in the prevalence of diabetes mellitus between girls and boys and between different age groups were tested with the χ^2-test. The 95% confidence interval was calculated for prevalence figures with the method described by Lilienfeld and Lilienfeld (7).

RESULTS

Thirty-four children were previously known diabetic patients, and all were treated with insulin. One child responded as having diabetes, but he was not on insulin at the time of the survey; this particular patient was not included in the analysis of the results. Eighty-nine children showed suggestive symptoms of diabetes, but only 17 were found to have glucosuria and/or ketonuria. Seven of the 17 children showed both proneness to ketosis and blood glucose concentrations (fasting and 2 h) in the diabetic range, and all were put on insulin.

The total number of diabetic children detected in this survey was 41, giving an overall crude prevalence rate of 0.95/1000. All children with diabetes were within ±2SD regarding height and weight for age according to the National Center for Health Statistics standards (8). Diabetes prevalence increased significantly ($P < .05$) with age in both sexes from early school age to puberty. The number of girls with diabetes seemed to be slightly higher than the number of boys with diabetes in all age groups. However, the difference was not statistically significant in any age group or in the whole group.

DISCUSSION

The general impression among pediatricians in Sudan is that childhood diabetes is probably not common. This study has challenged this impression and showed some interesting features. The prevalence of diabetes found in this study is unexpectedly high, despite the possibility that it might have been underestimated. The screening method excluded asymptomatic cases, if there were any, and children who had no glucosuria and/or ketonuria, besides the possibility of missing some diabetic children among the children who were absent from school on the day of ascertainment. Another interesting point is the discovery of 7 new patients in this survey. Although all showed proneness to ketosis and required insulin treatment, they were apparently healthy and their diabetes went unnoticed in the community. Whether some of these cases represent a variant of malnutrition-related diabetes mellitus (MRDM) needs further elucidation, although MRDM is characterized by being ketosis resistant and rarely occurs before 15 yr of age. Of particular interest is the agreement between this study and that of Ahren and Corrigan (9) in Tanzania, who studied the prevalence of diabetes mellitus in 3145 Africans living in one urban and two rural areas. Of 22 patients with diabetes detected in their survey, only 1 case was previously known. Their findings emphasize that prevalence projections based on patients with known diabetes attending hospitals are likely to result in significant underestimates of the size of the diabetes problem in developing countries (10).

TABLE 2
Age groups and prevalence of childhood diabetes in various countries

Country	Age (yr)	Prevalence/1000	Ref.
Finland	0–14	2.01	15
Finland	10–14	3.43	15
Sweden	0–14	1.54	16
U.S.	5–17	1.90	17
France	0–14	0.24	14
Israel	2–16	0.16	11
China	0–19	0.09	12
Japan	0–18	0.06	13
Tanzania	0–19	0.93	9
Ethiopia	10–19	1.20	3

The prevalence of IDDM in this study is higher than those reported from the Middle East, Asia, and France (11–14) but is lower than those reported from Scandinavia (15,16) and the U.S. (17). However, prevalence studies on diabetes in children are hardly comparable because of the differences in the methods of screening and in the age groups of children surveyed. Obviously, prevalence figures derived for children from 7 to 14 yr of age are inevitably higher than figures derived for children from 0 to 14 yr of age. Table 2 shows age groups and the prevalence of childhood diabetes mellitus in some countries.

This study was based on data obtained from public elementary schools. Because 97% of school-age children in Khartoum do attend the public elementary schools, sample representativeness should not be a limitation (18). The main difference between public schoolchildren and children attending private schools was assumed to be socioeconomic. However, Sultz et al. (19) examined the relationship of childhood diabetes to socioeconomic status and concluded that there was no significant correlation. In conclusion, the data presented here suggest that childhood IDDM is not rare in Sudan and that probably a substantial number of undiagnosed cases exist.

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Effect of Raising Injection-Site Skin Temperature on Isophane (NPH) Insulin Crystal Dissociation

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In eight healthy subjects, skin temperature at the injection site was raised from mean ± SD 31.7 ± 0.5 to 40.8 ± 0.9°C 180 min after injection of 0.25 U/kg isophane (NPH; Human Insulatard) insulin and maintained for 180 min. On the control day, skin temperature was kept constant. On warming of the injection site, serum insulin concentration rose from mean ± SE 14.4 ± 2.5 to 17.7 ± 3.1 mU/L after 40 min ($P < .01$) but did not change on the control day over the same period. The change in insulin concentration from the prewarming hour was higher on the warming day than control day in the 1st h (123 ± 8 vs. 93 ± 7%, $P < .01$), 2nd h (115 ± 14 vs. 83 ± 9%, $P < .05$), and 3rd h (113 ± 17 vs. 80 ± 10%, $P < .05$) of warming, providing evidence for both early increased absorption of the free-insulin pool surrounding the protamine-insulin complexes and continuing increased dissociation of the complexes. *Diabetes Care* **12:432–34, 1989**

Whereas direct techniques have shown various factors such as exercise, changes in ambient temperature, and injection-site massage to influence absorption of unmodified insulin, only limited studies with extended-acting preparations are available (1–3). These techniques, with the exception of massage, have failed to demonstrate any influence on absorption (4). Whereas it would be anticipated that the same factors that affect absorption of