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RESEARCH

Characteristics of subjects with diabetes mellitus diagnosed before 35 years of age presenting to a tertiary diabetes clinic in Durban, South Africa, from 2003 to 2016

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Background: Most patients diagnosed with diabetes mellitus < 35 years will have type 1 diabetes (T1D). The increase in youth-onset type 2 diabetes (T2D) parallels the obesity epidemic and in African subjects ketosis-prone type 2 diabetes (KPD) may occur in this age group.
Objectives, setting and subjects: To evaluate the clinical, biochemical and immunologic characteristics of patients diagnosed with diabetes < 35 years presenting to a tertiary diabetes clinic in Durban, South Africa over 13 years.
Design: A retrospective chart review of patients < 35 years diagnosed with diabetes was conducted. Data included clinical and laboratory variables, complications and follow-up status.
Results: The study included 517 patients of whom 445 (86.1%) were diagnosed with T1D, 27 (5.2%) with T2D, 27 with KPD (5.2%) and 18 (3.5%) with other forms of diabetes. Mean age of the total group was 28 ± 10 years. Subjects with T1D were younger at diagnosis with a lower BMI than both T2D and KPD. HbA1c was higher in subjects with T1D. Overall mortality was low (3.5%) and follow-up was poor in all groups.
Conclusion: The majority of young people with diabetes in KwaZulu-Natal, South Africa, have T1D, with small numbers of other types. Glucose control is poor with a high loss to follow-up.

Keywords: diabetes in youth, South Africa

Introduction

The aetiologic type of diabetes mellitus occurring in young persons has for many years been regarded as predominantly type 1 diabetes (T1D) and in most parts of the world this is still the case.[1,2] In addition, in many countries, the incidence of T1D is rising at a rate of approximately 3% per year.[1] However, as the prevalence of obesity has rapidly increased in many communities, early onset type 2 diabetes (T2D) has emerged as an increasingly common diagnosis in young people.[3,4] Furthermore, obesity may occur in patients with T1D, making the assignment of a specific aetiologic diagnosis in a young person more difficult.[4]

A recent systematic review of the global trends of T2D in youth found that there was substantial variation in both the incidence and prevalence, depending on the population and study methods.[5] Although methodical dissimilarities have resulted in variable estimates, studies in the USA and Europe have shown a higher prevalence of young-onset T2D in ethnic minorities than in their white counterparts.[5]

The search for diabetes in youth (SEARCH) study, from the USA, is one of the largest studies to examine, through registries, the prevalence, incidence and clinical features of diabetes in young persons with diabetes. This study recruited patients under 20 years of age from five sites in the USA and enrolled incident cases in a prospective cohort study.[6,7] Between 2001 and 2009, the prevalence was found to have increased for all types of diabetes: for type 1 diabetes (T1D) by 21.1% and for type 2 diabetes (T2D) by 30.5%.[8] Of note was that these increases were higher in minority racial and ethnic groups than in non-Hispanic whites.[8]

Other countries in Europe, Canada, Australia and Israel have also developed registries for the study of children and adolescents with early onset T2D.[9] From developing nations, India and Malaysia have commenced systematic data collection on diabetes in young people; these studies have, for the most part, shown that T1D is still the most common aetiologic type amongst youth in those countries, although a substantial number of young patients are diagnosed with T2D.[9,10] From India, a multi-centre registry of diabetes diagnosed under 25 years of age showed that 63.9% of the subjects had T1D and 25.3% had T2D.[9] In Malaysia, the DiCARE registry showed that the majority (71.8%) of patients under 20 years of age had T1D, whereas 17.7% had T2D and 7.1% had other types of diabetes.[10]

There are very few studies examining the prevalence of diabetes in youth in Africa. Studies of diabetes in youth in sub-Saharan Africa (SSA) have been restricted to clinical studies on T1D. The four clinical studies (two in South Africa, and one each in Tanzania and Ethiopia) showed that the peak age of onset of T1D was later in African people than in European populations.[11] Furthermore, the later age of onset of T1D in African subjects may have led to under-estimation of the prevalence of the disease in studies where lower age cut-off points were used.[12]

Ketosis-prone type 2 diabetes (KPD) is a sub-type of diabetes seen most frequently in persons of African origin.[13] Although the mean age at diagnosis of KPD is 40 years, this condition may also affect young people.[13] KPD is characterised by onset of ketoacidosis, male predominance, low prevalence of beta-cell autoantibodies and high rates of either remission or insulin-independence after initial stabilisation.[13]

In view of the changes in the epidemiology and clinical presentation of diabetes in young persons in other parts of the world and the lack of data from South Africa, the present study

was undertaken to determine the specific types of diabetes affecting young people presenting to a tertiary referral hospital in Durban, KwaZulu-Natal and to describe the disease profile in terms of mode of presentation, beta-cell autoimmunity, beta-cell function and treatment requirements. It was hypothesised that diabetes in young people referred to this centre is not only T1D, but includes other aetiological types such as early onset T2D and KPD; furthermore, that T1D is not invariably associated with low body mass, but also occurs in obese individuals.

Subjects, materials and methods

This study was a retrospective chart review of patients attending the adult diabetes clinic at Inkosi Albert Luthuli Central Hospital (IALCH) in Durban, KwaZulu-Natal, over a 13-year period (February 2003–August 2016). IALCH is an 892-bed hospital that provides specialist and sub-specialist levels of health care. It is the tertiary referral hospital for the province of KwaZulu-Natal and parts of the Eastern Cape in South Africa. The study was approved by the University of KwaZulu-Natal Biomedical Research Ethics Committee (reference number BE 548/16).

All patients who were younger than 35 years of age at the time of diabetes diagnosis were included in the study; patients who were diagnosed after the age of 35 years were excluded.

IALCH has a computerised patient record system allowing data storage and retrieval and data for the current study were extracted from this system. For each patient, information was recorded for clinical, laboratory and radiological data.

Demographic data included date of birth, current age, age at diabetes diagnosis, ethnic group and gender. Anthropometric measures included the last recorded weight, height, body mass index, waist and hip circumference. The mode of presentation of diabetes was recorded as asymptomatic, symptomatic or diabetic ketoacidosis (DKA). Hypertension was defined as the use of anti-hypertensive treatment or if the last available blood pressure reading was ≥ 140/80 mmHg. Dyslipidaemia was defined as the use of a lipid-lowering agent or total serum cholesterol > 4.5 mmol/l, low-density lipoprotein (LDL) cholesterol > 2.5 mmol/l or total triglycerides > 1.7 mmol/l on the last measurement.[14]

Each patient's treatment requirements were documented. This included whether the patient was on oral anti-hyperglycaemic agents or insulin therapy or both. Details of oral treatment included the type of medication and dosage. Insulin therapy was recorded as type of insulin and doses used.

Data on diabetes complications included the presence of autonomic and peripheral neuropathy, based on information in the clinical record. Retinopathy was assessed by fundal photography and was documented as 'yes' if present at any point during the course of the disease. Microalbuminuria was present if a spot urine albumin-creatinine ratio exceeded 3.0 mg/mmol. Proteinuria was defined as dipstick positivity.

For laboratory data, the most recent glycated haemoglobin (HbA1c), serum fructosamine and lipids were recorded. The presence or absence of anti-glutamic acid decarboxylase (GAD) and anti-islet antigen 2 (IA2) antibodies was noted and fasting and glucagon-stimulated c-peptide levels, measured within 12 months after diagnosis, were recorded. HbA1c was measured by high-performance liquid chromatography (Tosoh Bioscience LLC, King of Prussia, PA, USA) and fructosamine by calorimetric assay (Roche Modular; Roche Diagnostics, Basel, Switzerland). Serum lipids were measured by enzymatic reaction (Siemens Advia; Siemens Healthineers, Erlangen, Germany). Anti-GAD and anti-IA2 were measured by ELISA (Euroimmun, Lübeck, Germany) and c-peptide by chemiluminescent assay (Roche Electrosys).

The findings of ultrasound of the pancreas were recorded as well the most recent isotope glomerular filtration rate (iGFR), which was measured with the Multi-Channel Well Counter (Perkin Elmer 2470 Wizard 2 gamma counter, USA) after injection of 500 µCi ^{99m}Tc-DTPA (diethylenetriamine penta acetate) and sampling at 2 and 3 hours post-injection.

Patients were categorised according to whether they were attenders, non-attenders (not seen in the last year), known to be deceased according to the records, or unknown status.

Definitions

Type 1 diabetes was defined if ≥ 1 of the following was present: presentation with DKA; positive anti-GAD or IA2 antibodies; fasting c-peptide (measured within the first year) < 0.75 ng/ml or glucagon-stimulated c-peptide < 1.8 ng/ml and absolute insulin dependence.[15] Type 2 diabetes was defined as insidious presentation, absence of anti-GAD and anti-IA2 antibodies, insulin independence, clinical markers of insulin resistance and c-peptide levels above the T1D threshold.[15] Ketosis-prone diabetes was defined in persons who presented with DKA or had an episode of DKA, absence of anti-GAD and anti-IA2 antibodies and initial insulin dependence with possible subsequent transition to oral therapy.[13,16]

Statistical analysis

Data were analysed with SPSS version 23 (SPSS Inc, Chicago, IL, USA). Data are presented as mean ± SD for continuous variables and as percentages for categorical variables. Pearson's chi-square and Fisher's exact test of association were used for categorical variables. Post hoc Bonferroni-corrected ANOVA or Kruskal–Wallis tests were used to correct *p*-values for continuous variables. Student's t-test was used for intergroup comparisons between different aetiological types as well as comparison of aetiological types between Asians. A *p*-value of < 0.05 was considered statistically significant.

Results

The total study group included 517 individuals (males 220: females 297); of these, 86.1% (n = 445) were categorised as T1D and 5.2% (n = 27) as T2D and KPD, respectively. The remaining 3.5% (n = 18) had various types of diabetes. The subsequent results refer to subjects classified as T1D, T2D and KPD. The 18 subjects with miscellaneous diagnoses were excluded from further analysis.

Demography

The patient characteristics are given in Table 1. The majority, in all categories of diabetes, were African (black) who comprised 61.6% (n = 274) of patients with T1D, 55.6% (n = 15) of T2D and all (100%) (n = 27) KPD patients. Asian patients were more often diagnosed with T2D (40.7%; n = 11) than T1D (25.8%; n = 115) (p = 0.047).

Gender distribution was similar, both for the total group as well as for each diabetes type. Mean age at diagnosis was significantly lower in T1D (15 ± 7 years) and T2D (17 ± 6 years) than in KPD (24 ± 7 years) (p = 0.002). Patients with T1D had a longer duration of disease (13 ± 9 years) than the other two groups (T2D 9 ± 7 years; KPD 5 ± 3 years) (p = 0.05).

Table 1: Characteristics of the total study group (***n*** = 499) according to diabetes type

Factor	All	T1D	T2D	KPD	*p*-value
	n = 499	*n* = 445	*n* = 27	*n* = 27	
Ethnic group:					0.002
African	63.3 (316)	61.6 (274)	55.6 (15)	100 (27)	
Indian	25.3 (126)	25.84 (115)	40.7 (11)	0	
White	7.8 (39)	8.5 (38)	3.7 (1)	0	
Mixed race	3.6 (18)	4 (18)	0 (0)	0	
Gender:					0.354
Male	42.5 (212)	43.6 (194)	33.3 (9)	33.3 (9)	
Female	57.5 (287)	56.4 (251)	66.7 (18)	66.7 (18)	
Age (yrs)	28 ± 10	28 ± 11	26 ± 10	30 ± 6	0.512
Age at diagnosis (yrs)	16 ± 7	15 ± 7	17 ± 6#	24 ± 7*	< 0.001
Diabetes duration (yrs)	12 ± 8	13 ± 9	9 ± 7*	5 ± 3*	< 0.001
Presentation:					< 0.001
Asymptomatic	3.4 (17)	2.7(12)	14.8 (4)	3.7 (1)	
Symptomatic	45.1 (225)	45.4 (202)	85.2 (23)	0 (0)	
DKA	46.7 (233)	46.5 (207)	0 (0)	96.3 (26)	
Unknown	4.8 (24)	0	0	0	

Data shown as % (*n*) or mean ± SD.
T1D: type 1 diabetes; T2D: type 2 diabetes; KPD: ketosis-prone diabetes.
P-values are for comparisons between the three groups by ANOVA for continuous variables and Pearson's chi-square test for categorical variables.
*vs. T1D; #vs. KPD, significant difference for inter-group comparison using Bonferroni adjusted *t*-tests.

Mode of presentation

There was a significant overall difference between the groups for mode of presentation ($p < 0.001$). Almost half the group with T1D (46.5%; $n = 207$) presented with ketoacidosis and the majority of the remainder (45.4%; $n = 202$) presented with symptomatic hyperglycaemia. All but one of the KPD patients presented with DKA (96.3%; $n = 26$) and the single patient that did not present with DKA developed this complication shortly after the diagnosis of diabetes. The majority (85.2%; $n = 23$) of patients with T2D presented with symptomatic hyperglycaemia without ketoacidosis (see Table 1).

Clinical characteristics

Subjects with T1D had significantly lower BMI and smaller waist circumference than the other two groups (BMI (kg/m^2) T1D 24.4 ± 5.1; T2D 28.4 ± 4.5, $p < 0.001$; KPD 32.4 ± 6.8, $p < 0.001$) (waist circumference (cm) T1D 80.4 ± 11.1; T2D 89.4 ± 10.6, $p < 0.001$; KPD 97.2 ± 12.8, $p < 0.001$). There was no difference between the groups for blood pressure, prevalence of hypertension, dyslipidaemia or complications (Table 2).

Autoimmunity and beta-cell function

Autoantibodies were available for 364 of T1D, 24 of T2D and 25 KPD patients. Anti-GAD/IA2 antibodies were detected in a significantly higher number of patients with T1D (72.5%; $n = 264$) than those diagnosed as T2D (0%; $n = 0$) ($p < 0.001$) or KPD (8%; $n = 2$) ($p < 0.001$) (Table 3).

Table 2: Clinical features based on aetiological type of diabetes (***n*** = 499)

Factor	T1D	T2D	KPD	*p*-value
	n = 445	*n* = 27	*n* = 27	
Height (m)	1.6 ± 0.10	1.61 ± 0.1	1.6 ± 0.1	0.945
Weight (kg)	62.9 ± 14.6	73.5 ± 12.0*#	83.3 ± 20.5*	< 0.001
BMI (kg/m^2)	24.4 ± 5.1	28.4 ± 4.5*#	32.4 ± 6.8*	< 0.001
Waist (cm)	80.4 ± 11.1	89.4 ± 10.6*#	97.2 ± 12.8*	< 0.001
SBP (mmHg)	126 ± 15	131 ± 14	129 ± 14	0.101
DBP (mmHg)	74 ± 11	75 ± 12	76 ± 13	0.697
Hypertension	22.5 (100)	33.3 (9)	17.9 (5)	0.367
Dyslipidaemia	64.7 (288)	51.9 (14)	66.7 (18)	0.722
Neuropathy	29.5 (131)	25.9 (7)	25.9 (7)	0.991
Retinopathy	21.1 (91)	11.1 (3)	3.7 (1)	0.503

Data shown as % (*n*) or mean ± SD.
T1D: type 1 diabetes; T2D: type 2 diabetes; KPD: ketosis-prone diabetes.
BMI: body mass index; SBP: systolic blood pressure; DBP: diastolic blood pressure.
P-values are for comparisons between the three groups by ANOVA for continuous variables and Pearson's chi-square test for categorical variables.
*vs. T1D; #vs. KPD, significant difference for inter-group comparison using Bonferroni adjusted t-tests.

Fasting and glucagon-stimulated c-peptide levels were significantly lower in those with T1D (fasting 0.36 ± 0.46; 6 minute 0.49 ± 0.64 ng/ml), compared with T2D (fasting 1.84 ± 1.31; 6 minute 3.66 ± 2.97 ng/ml, $p < 0.001$ for both 0 and 6 minutes) and KPD (fasting 1.43 ± 0.89; 6 minute 2.99 ± 1.91 ng/ml, $p < 0.001$ for both 0 and 6 minutes) (see Table 3).

Glycaemic control and treatment

Glycaemic control was suboptimal in all groups, but significantly worse in T1D. Mean HbA1c in subjects with T1D was 11.1 ± 3.0%, (98 ± 33 mmol/mol), compared with T2D (9.4 ± 3.1%, 80 ± 34 mmol/mol, $p = 0.017$) and KPD (8.6 ± 3.3%, 71 ± 36 mmol/mol, $p < 0.001$) (Table 4).

Albuminuria, GFR and ultrasound pancreas

There was no difference observed between the three groups for the categories of urine albumin excretion, isotope GFR and ultrasound characteristics of the pancreas.

Table 3: Antibodies and c-peptide levels according to diabetes aetiology

Factor	T1D	T2D	KPD	*p*-value
	n = 445	*n* = 27	*n* = 27	
Anti-GAD/IA2 positive§	72.5 (264)	0 (0) *	8 (2) *	< 0.001
c-peptide (ng/ml)				
0 minutes	0.36 ± 0.46	1.84 ± 1.31*	1.43 ± 0.89*	< 0.001
6 minutes	0.49 ± 0.64	3.66 ± 2.97*	2.99 ± 1.91*	< 0.001

Data shown as % (*n*) or mean ± SD.
T1D: type 1 diabetes; T2D: type 2 diabetes; KPD: ketosis-prone diabetes.
P-values are for comparisons between the three groups by ANOVA for continuous variables and Pearson's chi-square test for categorical variables.
*vs. T1D; #vs. KPD, significant difference using Bonferroni adjusted t-tests.
§Anti-GAD/IA2 available for 364 T1D, 24 T2D and 25 KPD patients.

Table 4: Measures of glycaemic control, renal function and pancreatic ultrasound according to diabetes type

Factor	T1D	T2D	KPD	*p*-value
	n = 445	*n* = 27	*n* = 27	
HbA1c (%)	11.1 ± 3.0	9.42 ± 3.1*	8.6 ± 3.3*	< 0.001
HbA1c (mmol/mol)	98 ± 33	80 ± 34*	71 ± 36*	< 0.001
Serum fructosamine (µmol/l)	487 ± 171	400 ± 133	345 ± 165*	< 0.001
Urine albumin (mg/mmol)				0.467
Normal	57.3 (254)	51.9 (14)	74.1 (20)	
Microalbuminuria	25.5 (113)	25.9 (7)	14.8 (4)	
Macroalbuminuria	17.2 (76)	22.2 (6)	11.1 (3)	
iGFR (ml/min/m^2)	115.7 ± 33.3	118.8 ± 31.2	116.9 ± 29.7	0.905
Ultrasound pancreas				0.068
Normal	62.9 (280)	85.2 (23)	85.2 (23)	
Calcific	0.9 (4)	0 (0)	0 (0)	
UTV	3.1 (14)	3.7 (1)	3.7 (1)	
Not done	33.0 (147)	11.1 (3)	11.1 (3)	
Insulin total daily dose (units/kg)	1.19 ± 0.5	1.15 ± 0.67	0.89 ± 0.8*	0.038

Data shown as % (*n*) or mean ± SD.
T1D: type 1 diabetes; T2D: type 2 diabetes; KPD: ketosis-prone diabetes.
iGFR: isotope glomerular filtration rate.
P-values are for comparisons between the three groups by ANOVA.
*vs. T1D; ♯vs. KPD, significant difference using *t*-test.

Treatment

Insulin doses in subjects with T1D (1.19 ± 0.5 units/kg) were similar to those with T2D (1.15 ± 0.67 units/kg) but significantly higher than patients with patients with KPD (0.89 ± 0.8 units/kg, $p = 0.038$). In patients with KPD, at last follow-up, most (48.2%; $n = 13$) of the group were being treated with a combination of oral anti-hyperglycaemic therapy and insulin; equal numbers of the remainder were either on oral therapy alone (25.9%; $n = 7$), or insulin alone (25.9%; $n = 7$).

T1D sub-groups

Patients with T1D with positive anti-GAD or IA2 antibodies (72.5%, n = 264) had a similar duration of disease (11 ± 8 vs. 13 ± 10 years, $p = 0.05$), lower prevalence of microalbuminuria (68.6 vs. 84%, $p = 0.004$) and were treated with lower doses of insulin (1.1 ± 0.5 vs. 1.25 ± 0.5 units/kg, $p = 0.047$) than those who were antibody negative.

Follow-up status

No difference was noted between the groups in terms of non-attender rates, although almost half the patients in every category had defaulted on follow-up (T1D 237 (53.3%); T2D 13 (48.2%); KPD 11 (40.7%)). There were 16 known deaths (3.6%) in the T1D group with only one (3.7%) in the T2D group and none in the KPD group. The cause of death was unknown in the majority of cases.

Discussion

This study showed that over a 13-year period, the majority (86.1%) of subjects diagnosed with diabetes under the age of 35 years, presenting to a tertiary diabetes clinic in South Africa, were classified as T1D, with smaller proportions designated as T2D (5.2%) and KPD (5.2%). When compared with T2D and KPD, patients with T1D were leaner, had a higher prevalence of anti-GAD/IA2 antibodies, lower c-peptide levels and worse glycaemic control. All diagnosed with KPD were African patients; KPD patients were characterised by obesity and older age at diagnosis.

The prevalence of the various aetiological types of diabetes found in this study is similar to those reported from India and Malaysia.[9,10] Both the Indian and Malaysian registries showed that most young patients, diagnosed under 25 and 20 years of age respectively, had T1D (63.9% and 71.8%). The SEARCH study in the USA showed a higher prevalence of T1D (1.94/1000) than T2D (0.48/1000) in subjects diagnosed at age < 20 years; but the SEARCH study also showed that the incidence of both T1D and T2D was increasing.[7,8] In Ohio, USA, a study in the greater Cincinnati region showed an increase in incidence in both T1D and T2D between 1982 and 1994; however, the increase in the number of T2D patients outnumbered T1D.[17] Studies in young people in Auckland, New Zealand (NZ) and Western Australia (WA) also showed a sharp rise in incidence of T2D.[18,19]

The finding that only 5.2% had T2D in this study is lower than that reported from India (25.8%) and Malaysia (17.7%).[9,10] By contrast, the prevalence of T2D in youth has been reported to be higher than T1D in a study from a tertiary diabetes centre in India (48%) and in Maoris in New Zealand (55%).[20,21] A possible reason for the lower prevalence of T2D in the current study is the presence of undiagnosed patients in the community, as screening for diabetes would usually only occur with the onset of symptoms. It is also possible that some young patients are treated in peripheral clinics and not referred to the tertiary centre. The patient profile in the present study also differed from the Indian and Malaysian studies in that most of the subjects were African and early onset T2D appears to be less frequent in patients of African origin than other ethnic groups.[11,22,23] Of note, a higher proportion of Asian subjects in the current study were diagnosed with T2D than T1D (T1D 25.8% vs. T2D 40.7%). This may reflect variances in ethnic susceptibility to different types of diabetes. Furthermore, direct comparison between the present study and the SEARCH, Indian and Malaysian studies is influenced by the variable age cut-off points used in the various studies.[7–10,20] The age cut-off point chosen in the current study was < 35 years and this was based on earlier observations that later age of onset of diabetes is reported in African communities (22–29 years) compared with European communities.[4,11,22,24–26] Also, African patients had a bimodal peak of age of onset, with the first peak between 14 and 17 years and the second between 30 and 31 years.[26]

In the current study, all 27 KPD patients were African, older at diagnosis and heavier than subjects with T1D and T2D. The high mean BMI in the KPD group is compatible with other studies, which report BMI in subjects with KPD to range between 28 and 37 kg/m^2.[13] Only two (8%) patients with KPD were anti-GAD/IA2 positive and both were treated with metformin and insulin. This is in line with previous reports that the presence of beta cell auto-antibodies does not exclude KPD; up to 18% of patients with KPD may be antibody positive and this finding may be useful in predicting insulin requirements.[13]

Patients with T1D in this study had a mean BMI within the normal range (24.4 ± 5.1 kg/m^2), similar to the Malaysian report, but different from the south Indian study in which patients with T1D were underweight (mean BMI 17.9 kg/m^2).[10,20] Overweight and obesity were not shown to be a phenotypic feature of T1D in the population in this study. By contrast, 44.4% (n = 12) patients with T2D in this study were overweight and 29.6% (n = 8) patients were obese. This is comparable with the findings in other studies where the majority of patients with T2D were either overweight or obese.[10,21] Similar trends with regard to the high average BMI in young T2D have been noted in developed countries.[17–19] However, this contrasts with results from the South Indian study, where the average BMI in young T2D was < 25 kg/m^2.[20] The overweight phenotype in patients with T2D in the present study is probably a reflection of trends associated with urbanisation and the accompanying lifestyle changes of decreased physical activity and increased caloric intake.[27–29] Sub-Saharan Africa is undergoing one of the fastest rates of urbanisation worldwide with a rapid move from rural to urban living, perpetuating the cycle.[11]

The majority of patients with T1D in this study presented with DKA. More than 80% of those with T2D presented with symptomatic hyperglycaemia. This is similar to findings of both the Malaysian registry and a New Zealand Maori study.[10,21] The Malaysian registry showed that the majority of T1D presented with DKA and more than 80% with T2D presented with symptomatic hyperglycaemia whereas the New Zealand Maori study showed that the majority of T2D presented with symptomatic hyperglycaemia (12/28: 8/28 were unknown).[10,21] This is in contrast to the WA study that revealed that only 38% of patients with T2D presented with symptoms while the majority (57%) were diagnosed incidentally or as part of an obesity workup.[19]

Poor glycaemic control was noted in all three groups in this study, with especially poor control in the T1D (mean HbA1c 11.1 ± 3.0% / 98 ± 33 mmol/mol), and this is similar to that reported from other studies.[10,20] This underscores the difficulty in achieving and maintaining optimal glycaemic control in young patients with diverse forms of diabetes.[10,20] Glycaemic control in young patients with T2D was also sub-optimal in a study from Auckland, where the mean HbA1c was 8.4% (68 mmol/mol).[18] The young New Zealand Maori study also showed that the majority of both T1D and T2D had HbA1c levels exceeding 8% (64 mmol/mol).[21] Details on insulin doses were not reported in either of these studies, but in the current study patients with T1D had very high insulin requirements (exceeding 1 unit per kg per day), despite poor glucose control.[10,20] This is a common observation at the IALCH clinic and is considered to represent sub-optimal treatment compliance due to a multitude of factors, including socio-economic and health-facility-related factors. Some of these factors are beyond the control of the individuals (such as insufficient provision of glucose monitoring strips in some areas) and relate to the challenges in health care in South Africa.

Non-attender rates were high, with almost half the patients in each group defaulting on their last follow-up date and the majority of known deaths were in the group with T1D. This is in contrast to the Malaysian registry, which reported that only one patient with T1D and three with T2D were lost to follow-up and there was only one reported death, in the group with T1D.[10] However, as in this study, the numbers from the Malaysian registry may not be a true reflection of mortality as there was a high percentage of unknown outcomes in both the T1D and T2D groups.[10]

This study had several limitations. The retrospective nature of the study precludes the evaluation of incidence trends in each aetiologic group. Other limitations include the small numbers of patients with T2D and KPD, which limits the accuracy of inter-group comparisons. Furthermore, the high non-attender status prevents assessment of patient outcome and the paucity of data from other countries in Africa regarding young onset T2D prevents comparison within the continent.[12] Furthermore, T2D may be asymptomatic for a number of years prior to the diagnosis and the number of patients with T2D may be higher than currently detected.[21]

Conclusion

The majority of young patients with diabetes in KZN have T1D and most have positive beta-cell autoantibodies. The phenotype of T1D is not characterised by overweight or obesity, in contrast to those with T2D and KPD. Overall glycaemic control is suboptimal and non-attender status is high amongst all the groups. Future prospective population-based studies are needed in order to assess the incidence and prevalence of the various types of diabetes in young people in South Africa.

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