Cyril Fernando Memorial Oration - 1994

Malnutrition related diabetes in Sri Lanka: fact or fiction?

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Dr. Cyril Fernando was born on the 30th of April 1900 and was educated at St. Benedict's College Colombo and University College Hospital, London. His brilliant academic carear culminated in passing the MD London examination in 1929 and being awarded the gold medal for the best candidate of the year. In 1934 he was appointed Physician at General Hospital, Colombo where he acquired a reputation as an astute clinician and an able diagnostician. The name of Cyril Fernando occupies a prominent place in the list of eminent medical men who nurtured the best traditions of medicine and set the pace for medical education and research in this country.

Dr. Fernando contributed extensively to the medical literature. Among his varying clinical interests was the subject of diabetes and the topic of my oration would have indeed interested Dr. Fernando had he been alive today.

In 1955 which happened to be the year of demise of Dr. Cyril Fernando, Hugh-Jones[1] working in Jamaica described 15 diabetics whose clinical presentaton differed from what has been described in the west. He called this type of diabetes the J-type. This type of diabetes was associated with malnutrition and is considered to be the earliest description of malnutrition related diabetes in the world literature. Since the early descriptions of patients with diabetes who have associated malnutrition, several such cases have been reported from the tropical countries which prompted the World Health Organization (WHO) in 1985 to classify it as a separate entity and name it as Malnutrition Related Diabetes Mellitus (MRDM)[2]. Malnutrition Related Diabetes Mellitus has been further subdivided into Protein Deficient Pancreatic Diabetes (PDDM) and Fibrocalculous Pancreatic Diabetes (FCPD). Both types of malnutrition related diabetes have been reported from several countries in Asia, Africa and South America[3,4,5,6,7].

An essential prerequisite of an epidemiological study on MRDM in any country is the determination of the nature and prevalence of malnutrition in that country. According to a recent survey (in press) conducted by the author adopting a Body Mass Index (BMI) of 20 kg/m^2 as the cut off point to denote undernutrition it was found that 55% of males and 47% of females out of a total of 1037 normal adults (> 18 years) were undernourished. Thus with such a significant number of Sri Lankans being undernourished and thereby predisposed to develop MRDM it is of considerable importance to establish its presence or otherwise in the country.

The main objectives of our study were to determine the prevalence, aetiology, clinical features and biochemical characteristics of MRDM in central Sri Lanka, to determine the similarities and differences between MRDM and established types of diabetes and to determine, as in other developing countries, whether it is overnutrition and not undernutrition which is more closely related to diabetes. With a view to fullfilling these objectives two sets of studies, one population based and the other hospital based were carried out.

Screening for diabetes in an undernourished estate Tamil population

The estate Tamil population is considered to be an economically deprived community in the country even-though there have been recent attempts to improve their living standards. There have been only one recent study addressing to the health status of estate Tamils[9] but none had been conducted to determine the prevalence or the nature of diabetes among them. Such a study was conducted to screen an estate Tamil population, resident in central Sri Lanka, for diabetes with the intention of later studying them in detail to determine whether they have MRDM according to accepted criteria. For this study we adopted a postprandial urianalysis as an initial screening procedure for diabetes. It has been shown previously that such screening has a sensitivity of 100% and a specificity of 96% compared to the Oral Glucose Tolerence Test (OGGT)[10].

Out of a total adult (> 18 years) Estate Tamil population of 5146 distributed over 15 Grama Niladari Divisions, in the Hindagala Community Health Project Area, a random sample of 230 was selected. Each of these subjects had a postprandial sample of urine analysed for the presence of glycosuria and those who were positive had a formal OGTT.

This study revealed that 183 (80%) out of the 230 subjects were undernourished. Table 1 shows the mean age and the BMI of the study sample.

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Table 1. Mean age and body mass index of 183 estate Tamils

	Number	*Mean age (SD) in years*	*Mean BMI (SD) in kg/m*
Male	66	43.5 (13.1)	16.9 (1.5)
Female	117	42.4 (13.2)	17.0 (1.7)

The extremely low BMI values signify significant undernutrition. Analysis of the socio-economic data revealed that 38% of the subjects have not attended school at all and another 55% have studied only upto grade 5. Ninety four percent were labourers and in 93% the monthly income was less than Rs. 1000. In this study only two subjects were found to have glycosuria but a formal OGGT revealed that none of them had overt diabetes.

Prevalence of diabetes among undernourished rural Sinhalese

A very large proportion of people in developing countries live in the villages and the majority of them are considered to be undernourished. Epidemiological studies conducted on such populations would therefore afford an opportunity to investigate the relationship between undernutrition and diabetes.

One hundred and fifty subjects with a BMI of < 20 kg/m were selected from a random sample of 200 adult ($>$ 18 years) Sinhala population of 7140 resident in the Hindagala Community Health Project Area. Their demographic and socio-economic status was recorded and each subject underwent an OGGT.

The prevalence of undernutrition in the sample of 200 subjects was 75% (150/200). Of the 150 subjects 64 were males and 86 females. Table 2 shows the mean age and the BMI of the study sample.

Table 2. Mean age and body mass index of 150 rural subjects

	Number	*Mean age in years (SD)*	*Mean BMI in kg/m*
Male	64	41.5 (16.5)	17.4 (1.2)
Female	86	40.9 (15.0)	17.1 (1.4)

The low BMI values signify extreme undernutrition. Socioeconomic analysis revealed that 95% of the subjects have not studied beyond grade 10 and 78% were farmers. In 92% the family income was less than Rs. 2000 per month.

Two patients out of whom one was previously known to have diabetes were identified. Neither of them appeared to have MRDM.

Prevalence of known diabetes in an overnourished affluent community

Previous epidemiological studies have convincingly demonstrated that recently acquired affluence which is therefore invariably accompanied by better nutrition has contributed to an increased incidence of diabetes. With a view to determining whether this phenomeneon has infact occured in Sri Lanka a study was conducted to determine the prevalence of known diabetes in an affluent community in the central province and compare with the prevalence rate in a rural community. For the purpose of the present study possession of a domestic telephone was considered to be the criterion of affluence.

The subjects for the study were selected from the current telephone directory. Out of a total of 3202 telephone numbers with the Kandy area code, a random sample of 1300 were selected. With the aid of a postal questionnaire enquiry was made as to the number of family members with known diabetes. Based on analysis of 1251 questionnaires the total number of family members in the study sample was 9344 and 461 patients with known diabetes were identified. Their ethnic composition and the age distribution are shown in Table 3 and 4.

Table 3. Ethnic composition of the sample of affluent subjects

Ethnicity	*Number (%)*	*Population of Kandy district*
Sinhala	6309 (67)	79%
Moor	2395 (25)*	7%
Tamil	478 (5)	12%
Others	162 (3)	2%

* Significantly higher than the Moor population of Kandy district ($p < .05$)

Table 4. Age distribution of the study population and 461 patients with diabetes

Age group	*Number of subjects*	*No. with diabetes (%)*
< 18	2256	5 (.22)
18-20	2337	3 (.12)
30-40	1318	27 (2.0)
40-50	1266	97 (7.6)
50-60	1064	133 (12.5)
60-70	667	134 (20.8)
70-80	272	51 (18.7)
$\triangleright$ 80	164	11 (6.4)
Total	9344	461 (4.9)

Majority of the subjects were between the ages of 40 and 80 years. The prevalence of diabetes in the whole population was 4.9%. Howèver if those who were less than 18 were excluded, the prevalence would go upto 6.4%. Table 5 shows the prevalence of diabetes aocording to ethnicity.

Table 5. Prevalence of diabetes according to ethnicity

Ethnicity	*No. of subjects*	*No. with diabetes*	*Prevalence*
Sinhala	6309	303	4.8%
Moor	2395	127	5.3%
Tamil	478	23	4.8%
Others	162	8	4.9%

There were no significant differences in the prevalence rates of diabetes among the different ethnic groups.

For the purpose of comparing the prevalence rates of diabetes in an affluent and a rural community in Sri Lanka, data from the present study were analysed with those of a previous survey conducted by the author in a rural non-affluent community[11] (Table 6).

The difference between the prevalence rates of known diabetes between the affluent and the non-affluent communities is statistically significant.

Prevalence of diabetes in an affluent community in Sri Lanka: the Dangolla Survey

The determination of known diabetes in a community as described in the previous study does not accurately represent the true prevalence due to the occurance of asymptomatic cases who could be only identified by the OGGT. The WHO has advocated the OGGT for population screening of diabetes[2]. We used this test to determine the prevalence of diabetes in a highly affluent community in central Sri Lanka.

The criteria that were adopted to define affluence were family income of more than Rs. 15,000/month and ownership of a house, telephone or a motor vehicle. One hundred and twenty affluent houses randomly selected were visited by members of the research team and from among the residents those who were over the age of 40 years were selected for the study. They underwent clinical and biochemical investigations after a 12 hour overnight fast. Those who had a FBS of more than 5 mmol/l were refered to hospital for a formal OGGT. These results were compared with an age matched sample of rural adults reported in a previous study conducted in the Hindagala Community Health Project Area[11].

Seventy nine people over the age of 40 years were identified to be the study subjects. Of these 62 subjects attended the study. Table 7 shows the level of education of the subjects at Dangolla and Hindagala and Table 8 the occupational categories.

Majority of the subjects at Hindagala were either farmers or housewives whereas in Dangolla most were executives, University lecturers or professionals. Table 9 shows the distribution of the BMI.

Only 8.7% of the subjects from Dangolla had a BMI less than 20 kg/m whereas in Hindagala the figure was 78% ($p < .001$). Forty percent of those at Dangolla had a BMI of > 25 kg/m suggestive of obesity whereas in Hindagala only 1% ($p < .001$) were obese.

Ten subjects of whom 6 were known to have diabetes were identified at Dangolla. The prevalence of diabetes among the males was 21% whereas in the females it was 14% and the total prevalence was 17.5%. Table 10 shows the comparison of the socioeconomic status, BMI and the diabetes prevalence rates between the two communities.

There were significant differences in the BMI values and the diabetic prevalence between the subjects at Dangolla and Hindagala.

Prevalence of Protein Deficient Pancreatic Diabetes among clinic patients at Teaching Hospital, Peradeniya

Clinical notes of patients who regularly attend the clinic registered over a 8 year period (from 1/3/1986 to 30/4/1994) were studied. The different types of diabetes

Table 6. Prevalence rates of known diabetes in an affluent and a nonaffluent community in Sri Lanka

Age group (years)	*Affluent*		*Non-affluent*		*Significance*
	No:	*No. with Diabetes (%)*	*No:*	*No. with Diabetes (%)*	
18-30	2104	3 (.14)	60	0	NS
30-50	2351	74 (3.1)	88	1 (1.1)	NS
50-70	1497	217 (14.4)	39	1 (2.5)	$p < .001$
70-90	357	9 (2.5)	9	0	$p < .05$
Total	6309	303 (4.8)	196	2 (1.0)	$p < .05$

Table 7. Level of education of the subjects at Dangolla and Hindagala

Level	*Dangolla (%)*	*Hindagala (%)*
No schooling	0	22
Primary school	2	63
GCE 'O' level	19	12
GCE 'A' level	12	3
Trained teacher	2	0
Graduate	19	
Postgraduate	46	0
	100	100

Table 8. Occupational categories of the subjects at Dangolla and Hindagala

Occupation	*Dangolla (%)*	*Hindagala (%)*
Farmer	0	36
Housewife	16	56
Teacher	23	6
University Lecturer	25	0
Executive	11	0
Professional	22	0
Retired Govt. servant	2	2
Other	0	2
	100	100

were identified according to established criteria. To determine whether there were differences in the clinical profile between PDDM and IDDM and between PDDM and NIDDM, a comparative study was carried out on a group of IDDM and NIDDM, selected from the same clinic matched for age, gender and duration of diabetes.

Comparison was carried out between these three types in their socio-economic status, degree of malnutrition, the BMI, blood sugar values and daily insulin requirements. The mean income was considered as an index of socio-economic status. The degree of malnutrition was assesed by recording evidence of childhood malnutrition such as marasmus, by the presence of stigmata of malnutrition and the BMI. Six stigmata namely anaemia, Bitots spots, parotid enlargement, brown hair, glossitis and peripheral oedema were considered to denote current malnutrition. A 'malnutrition index' was adopted to determine the severity of malnutrition. To calculate the 'malnutrition index' each stigmata was given one point so that for example those who had all the stigmata of malnutrtion mentioned above were given the maximum of 6 points. The mean malnutrition index of patients belonging to each type of diabetes was calculated by the addition of all the points obtained by patients within each category of diabetes and dividing by the number of patients. Table 11 shows the breakdown of the different types of diabetes identified and the clinical characteritics of PDDM are shown in Table 12.

Table 9. Distribution of the body mass index at Dangolla and Hindagala

	Dangolla		*Hindagala*	
BMI (kg/m)	*Male (%)*	*Female (%)*	*Male (%)*	*Female (%)*
< 20	7	10	78	77
20-25	60	47	22	21
> 25	33	43	0	2
	100	100	100	100

Table 10. Socio-economic characteristics, body mass index and diabetes prevalence in Dangolla and Hindagala

	Dangolla	*Hindagala*	*Significance*
Number	57	86	
Mean income/month	> Rs.15.000	Rs.737	
Food stamp holders	-	45%	
Mean BMI in kg/m			
Males	23.5	16.8	$p < .05$
Females	25.7	18.0	$p < .05$
Diabetes prevalence (%)			
Males	21.0	1.1	$p < .05$
Females	14.0	1.0	$p < .05$
Total	17.5	2.1	$p < .001$

Table 11. Number of subjects with different types of diabetes registered at Teaching Hospital, Peradeniya from 1/3/1986 to 30/4/1994

	Age range (yrs)	*Number (%)*
Non-insulin dependent diabetes mellitus	19-84	850 (90.3)
Insulin-dependent diabetes mellitus	14-32	38 (4.0)
Fibrocalculous pancreatic diabetes	16-64	32 (3.5)
Protein deficient diabetes mellitus	15-25	11 (1.2)
Diabetes due to chronic pancreatits	21-30	4 (0.4)
Other types	30-68	6 (0.6)
Total		941 (100)

Table 12. Protein Deficient Pancreatic Diabetes — clinical characteristics

Gender	*Age*	*Income /month**	*Stigmata of Malnutrition*	*BMI in kg/m*	*Daily Insulin*
Male	15	400	4	17.3	64
Female	20	600	3	15.5	78
Female	17	500	3	15.8	60
Male	18	500	3	16.3	74
Male	22	400	2	15.4	68
Female	16	400	3	17.3	90
Female	23	500	2	15.5	68
Male	19	600	4	16.6	76
Female	25	300	3	18.6	78
Male	17	500	2	17.3	84
Female	19	400	4	14.3	90

* approximate estimate

All patients were Sinhalese. The mean age of the patients with PDDM was 19 years, the mean monthly income Rs. 463, the mean BMI in males 16.5 kg/m, females 16.1 kg/m and mean daily insulin 75 units. Table 13 shows the results of the comparative study between PDDM and IDDM.

Table 13. Clinical characteristics of patients with protein deficient pancreatic diabetes and insulin dependent diabetes mellitus (mean values)

	PDDM No=11	*IDDM No=18*	*Significance*
Monthly family income	Rs.380	Rs.2008	$p < .001$
Malnutrition index	5+	0	$p < .001$
BMI (kg/m) Male	16.5	15.2	NS
Female	16.1	16.7	NS
Fasting blood sugar (mmol/l)	18.4	22.5	NS
Units of insulin/day	75.4	80.5	NS

Patients with PDDM are of a lower socio-economic status and have more stigmata of malnutrition than those with IDDM. Comparison of patients with PDDM and NIDDM revealed that the former were more malnourished and having a lower mean BMI and higher mean fasting blood sugar values (Table 14).

Table 14. Clinical characteristics of patients with protein deficient pancreatic diabetes and non-insulin dependent diabetes mellitus (mean values)

	PDDM No=11	*NIDDM No=37*	*Significance*
Monthly family income	Rs.380	Rs.542	NS
Malnutrition index	5+	2+	$p < .05$
BMI (kg/m) Male	16.5	20.6	$p < .05$
Female	16.1	22.8	$p < .05$
Fasting blood sugar	18.4	10.8	$p < .05$
Units of insulin/day	75.4	-	-

Clinical and biochemical profile of fibrocalculous pancreatic diabetes

Those patients who were identified to have FCPD had their demographic, socio-economic and clinical data recorded. A detailed dietatic history with special emphasis on consumption of cassava and other foods containing cyanide was obtained since these compounds are reported to contribute to pancreatic calcification in FCPD. The characteristics of abdominal pain were documented and the presence of stigmata of malnutrition recorded. The presence of diabetic complications too were noted. The presenting clinical features and the complications were compared with 124 patients with NIDDM randomly selected from the clinic.

Those with FCPD and 32 patients with NIDDM matched for age and gender were subjected to biochemical analysis. These included glycosylated haemoglobin, an oral GTT, serum proteins, serum lipids and insulin. Table 15 depicts the clinical features of FCPD and NIDDM.

All patients with FCPD had loss of weight and the presence of a family history of diabetes was more often associated with NIDDM. Table 16 describes the characteristics of abdominal pain in patients with FCPD.

The character of the abdominal pain in most patients with FCPD was suggestive of peptic ulcer or pancreatic disease. Table 17 shows the prevalence of diabetic complications in patients with FCPD and NIDDM.

Table 15. Clinical features of fibrocalculous pancreatic diabetes and non-insulin dependent diabetes mellitus (all figures are percentages)

	FCPD No=32	*NIDDM No=124*	*Significance*
Family history	19	51	$p < .05$
Loss of weight	100	54	$p < .05$
Abdominal pain	100	16	$p < .0001$
Polyuria	97	90	NS
Polydipsia	94	90	NS

Table 16. Characteristics of abdominal pain in patients with fibrocalculous pancreatic diabetes

	Number (%)
Site of pain	
Epigastric	28 (88)
Circumumbilcal	2 (6)
Hypogastric	2 (6)
Type of pain	
Burning	20 (62)
Aching	10 (32)
Pricking	2 (6)
Radiation to back	
Present	30 (94)
Absent	2 (6)
Relationship to meals	
Related	32 (100)
Unrelated	0 (0)

There were significant differences in the incidence of neuropathy, nephropathy and hypertension between the two types of diabetes. Table 18 shows the demographic characteristics and glycosylated haemoglobin status of patients with FCPD and NIDDM. In FCPD nearly 87% of the patients were below the age of 40 years whereas in NIDDM only 24% were below this age. There were no Moor patients with FCPD. A family history of diabetes was more often present in NIDDM compared to FCPD ($p < .05$) and surprisingly, the mean family income was higher in the latter. Eventhough there were no significant differences between the incidence of childhood malnutrition and in the malnutrition index the BMI was significantly higher in NIDDM than in FCPD (Table 19).

The rise in mean serum insulin concentration after glucose challenge was significantly higher in NIDDM compared to FCPD (Table 20).

Table 17. Prevalence of diabetic complications

	FCPD No=32	*NIDDM No=124*	*Significance*
Neuropathy	22	8	$p < .05$
Retinopathy	6	6	NS
Peripheral vascular disease	0	9	NS
Cerebrovascular disease	0	8	NS
Ischaemic heart disease	0	12	NS
Proteinuria	0	17	$p < .05$
Autonomic neuropathy	0	7	NS
Hypertension	0	20	$p < .05$

Table 18. Demographic characteristics and glycosylated haemoglibin status of patients with fibrocalculous pancreatic diabetes and non-insulin dependent diabetes mellitus

	FCPD	*NIDDM*	*Significance*
Number of patients	32	124	
Male: Female	1:1	1.1:1	NS
Age range in years (mean)	15-62 (30)	22-79 (40)	NS
Race (%) Sinhala	30 (93)	106 (85.2)	NS
Moor	0 (0)	12 (9.6)	$p < .001$
Tamil	2 (7)	6 (4.8)	NS
Mean glycosylated haemoglobin	11.68pc	11.66pc	NS

Table 19. Parameters of nutrition in fibrocalculous pancreatic diabetes and non-insulin dependent diabetes mellitus

	FCPD	*NIDDM*	*Significance*
No. with childhood malnutrition	8 (25)	30 (24)	NS
'Malnutrition index'	4+	3+	NS
BMI in kg/m			
Male	17.07	21.5	$p < .05$
Female	17.4	21.2	$p < .05$
Mean haemoglobin	10.5 g/l	11.3 g/l	NS
Mean serum albumin	41.5 g/l	40.3 g/l	NS

Table 20. Mean fasting and post-glucose insulin levels (microunits/dl)

	FCPD	*NIDDM*	*Significance*
No. of patients	32	32	
Fasting	125.1	66.8	NS
Post-glucose	138.2	100.2	NS
Rise in insulin as a pc	10	51	$p < .001$

Discussion

The first two studies conducted in two undernourished communities while not identifying any patients with MRDM revealed that the prevalence of NIDDM too was low. In contrast the studies in affluent overnourished communities demonstrated a higher prevalence of diabetes compared to the nonaffluent communities. Such differences in the prevalence rates of diabetes in urban affluent communities and rural nonaffluent communities have been previously reported from several parts of the world (Table 21).

Among several factors which contribute to a lower prevalance of diabetes in nonaffluent communities the role of undernutrition has been investigated extensively. In this respect previous studies have demonstrated that low weight caused by undernutrition reduces the risk of diabetes[12,13,14,15].

Table 21. Prevalence rates of diabetes in some urban and rural populations

	Age group (years)	*Prevalence (%)* *Men*	*Women*
African			
Mali (rural)	15+	0.8	0.0
Asian			
Indian (urban)	20+	6.0	4.0
Sri Lankan (rural)	18+	2.5	2.5
(urban)	40+	8.7	8.7
Pacific Islands			
Melanesians (rural)	18+	0.0	1.5
Aborgines (urban)	20+	16.7	14.6
Micronesians (rural)	20+	3.7	3.9
Papua New Guinea (rural)	20+	1.8	0.0

If undernutrition plays a role in preventing diabetes how does one reconcile to the existence of another type of diabetes which is said to be related to undernutrition? There are 3 possible explanations. Firstly it could be postulated that malnutrition is only an association in MRDM or in other words an epiphenomenon. Secondly another factor such as an environmental agent or a food toxin precipitates diabetes in people who are predisposed to develop the illness because of undernutrition. Thirdly malnutrition being so common in countries where MRDM is reported that these could really be cases of IDDM with superadded undernutrition.

The results of the surveys conducted in the two affluent communities suggest they were of a very high socio-economic status than the nonaffluent subjects at Hindagala. The level of education, occupational categories and income were different in the affluent and the nonaffluent communities. There were also important differences in the quality of nutrition between the affluent and rural subjects with obesity almost non existent in the latter.

The total prevalence of diabetes of 4.9% and 17.5% in the two affluent communities appears to be similar to what has been reported from urban communities in other countries (Table 22).

Table 22. Prevalence rates of diabetes in some affluent communities

Community	*Age group*	*Prevalence (%)*	
		Men	*Women*
Indian	20+	6.0	4.0
Urban Aborgines	20+	16.7	14.6
Urban Africans	30+	6.5	6.4
Sri Lankans	40+	21	14

A high prevalence of diabetes has also been reported from affluent migrant Indians in South Africa, Fiji, Trinidad, Singapore and Southall in London[16,17,18,19,20]. These studies have convincingly demonstrated that adoption of a higher standard of living either by migration or while being resident in the native country leads to a higher incidence of diabetes[21]. This increased incidence of diabetes in affluent communities may be due to improved nutritional status, lack of excercise, mental stress or increased life expectancy of those with diabetes[22]. The relatively high BMI in the affluent subjects signifies a higher standard of nutrition and it has been shown previously that overnutrition predisposes to diabetes[23].

The results of the hospital based study revealed that in common with other communities the most frequent type of diabetes to be NIDDM. The prevalence of IDDM appears to be low, situation not uncommon in developing countries. Similarly the prevalence of MRDM too appeared to be low. The prevalence rate of PDDM observed by us appears to be even lower than what has been reported from some other communities except what has been reported from Ethiopia[24] (Table 23).

Table 23. Prevalence of Protein Deficient Pancreatic Diabetes in different countries

Ethiopia	%
Sri Lanka*	1.1
India	22.9
Indonesia	80

* Present study

The prevalence rate observed by us in a hospital based study may not reflect the exact situation in the community. However the relatively low prevalence of PDDM in our study reflects a certain degree of protection against diabetes in a population with a high incidence of undernutrition. Projection of the prevalence rate of PDDM (1.1%) to the approximate national figure of diabetics[25] indicates that there are only about 5000 patients with PDDM in Sri Lanka of a total population of 17 million.

The results of the present study indicates that PDDM eventhough rare exists as a well defined clinical entity. The comparison of PDDM and IDDM reveals that patients with PDDM are of a lower socio-economic status compared to those with IDDM and have more stigmata of malnutrition. Therefore it is apparent that there exists a relationship between and PDDM. However we were not able to establish a direct causal role for malnutrition in the development of this type of MRDM.

We found certain important differences between patients with PDDM and NIDDM. In the former there was higher evidence of malnutrition including lower BMI values and higher mean fasting blood sugar values. Thus in hospital practice it is mandatory to consider a diagnosis of PDDM, eventhough rare, in patients labelled as having NIDDM who have evidence of malnutrition, very high blood sugar values and dependency on insulin.

Three point two percent of the clinic patients appear to have FCPD; a prevalence rate higher than that of PDDM. The role of pancreas causing diabetes was originally postulated more than 200 years ago in a patient with diabetes who had pancreatic calcification[26]. Since then it has been reported from several tropical countries including Sri Lanka[2,3,4,5,6,7]. Accurate prevalence rates of FCPD have not been worked out for all countries yet but in Nigeria it has been reported that 50% of all diabetics under the age of 20 years had FCPD[27]. The lower occurance of a family history in FCPD in comparison to NIDDM suggests that the pancreatic damage is more

likely to be due to an environmental cause whereas in NIDDM the effect of genetic factors appear to be more pronounced.

In both groups of patients with FCPD and NIDDM the socio-economic status appeared to be relatively low. This would reflect the social class of patients who attend a government hospital but nevertheless in FCPD, surprisingly, the socio-economic status was significantly higher than those with NIDDM. In our study FCPD appears to have affected a comparatively younger group of patients compared to NIDDM. This is in agreement with studies conducted on FCPD in other countries[27]. The earlier onset of FCPD could be attributed to early reduction of beta cell mass due to structural damage to the pancreas whereas in NIDDM the delayed onset reflects the ability of the pancreas to secrete insulin for a longer period of time. The aetiology of FCPD in most studies have been attributed to malnutrition combined with consumption of cassava or other cyanide containing food[28]. Childhood malnutrition in combination with consumption of cassava or ingestion of foods that are rich in cyanogenic glucosides may be the underlying pathogenetic mechanism in many cases of FCPD[27]. In countries where cassava in not the staple diet there could be other toxic factors that may interact with malnutrition to produce FCPD. Most of the earlier reports of FCPD from South India have been from the state of Kerala where cassava is consumed extensively as a staple food item[29]. However it is rare in South African Indians who have migrated from India[30]. It appears that the relatively higher socio-economic status of the Indian population living in South Africa has protected them from developing FCPD. Even among our patients the higher socio-economic status in those with FCPD in comparison to those with NIDDM suggests that it may be some other mechanism other than malnutrition which causes the diabetes. In our patients evidence of childhood malnutrition and stigmata of malnutrition were present in only 9 (28%) patients with FCPD and there was no evidence of consumption of cassava or other cyanide containing foods. Furthermore the cassava-malnutrition theory relating to the origin of FCPD has been challenged recently[31]. Therefore the aetiology of FCPD in our patients remain obscure.

The fasting blood sugar levels in our patients with FCPD were only moderately elevated. This would suggest the presence of some amount of beta cell function. Indeed it has been shown that the more sensitive index of pancreatic beta cell mass namely the C-peptide levels are higher in patients with FCPD than those with NIDDM[32]. However, in NIDDM since there is minimal destruction of the pancreatic gland the beta cell mass could be higher than FCPD and this was clearly seen in our patients where the stimulated rise in serum insulin after glucose challenge was higher in NIDDM than in FCPD. Insulin resistance too has been reported in FCPD[33].

Our study also showed that both similarities and differences between FCPD and NIDDM. The low socio-economic status, prevalence of childhood malnutrition and the presence of stigmata of malnutrition were similar in both conditions. This suggests that patients with NIDDM presenting to government hospitals in Sri Lanka share certain clinical features with FCPD and a possible diagnosis of FCPD should be entertained in every such patient particularly in those who have evidence of malnutrition, abdominal pain suggestive of peptic ulcer disease and who are on insulin therapy. The dissimilarities between FCPD and NIDDM were the earlier age of onset, lower occurence of a family history in FCPD, a lower BMI and the lower rise in post-glucose insulin concentrations. These observations, however, apply only to patients who have presented to the hospital and therefore further studies are needed to ascertain whether this applies to the whole community.

Summary and conclusions

1. Malnutrition related diabetes as defined by the WHO was not demonstrated in two undernourished populations in Sri Lanka.
2. However a study conducted in a hospital diabetic clinic revealed that both types of MRDM exists in Sri Lanka. Protein deficient pancreatic diabetes appears to be extremely rare and its prevalance among the hospital patients was only 1.1%. The prevalence of FCPD was 3.2% and it exists as a well defined clinical entity. However its aetiology in Sri Lanka is not known. Definite evidence of malnutrition was present in only less than half of the patients.
3. Therefore inspite of wide spread malnutrition the prevalence of MRDM was extremely rare in the communities we studied.
4. There are similarities and differences between PDDM and IDDM and between PDDM and NIDDM.
5. The BMI, blood sugar and daily insulin requirements were similar in PDDM and IDDM.
6. As expected patients with PDDM had a lower socio-economic status and more stigmata of malnutrition than those with IDDM.
7. The differences between patients with PDDM and NIDDM were a higher occurence of stigmata of malnutrition, lower BMI values and dependency on insulin in the former. These differences and similarities would enable one to identify those patients with PDDM who masquerade either as IDDM or NIDDM.

8. A less frequent family history, presence of characteristic abdominal pain and lower BMI values differentiates FCPD from NIDDM enabling one to identify patients with FCPD in hospital practice.
9. The aetiology of FCPD is obscure.
10. Prevalence rates of diabetes in two affluent communities were 6.4% and 17.5% whereas in the rural undernourished population it was only 1%.
11. Diabetes in Sri Lanka therefore more often associated with overnutrition than with undernutrition.
12. Exact role of malnutrition in the aetiology of diabetes was not demonstrated.

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