ANTHROPOMETRIC STUDIES IN DIABETES IN THE TROPICS

INDIRA PADMALAYAM, SHERRY JOHN, VISWANATHAN MOHAN, AMBADY RAMACHANDRAN, MOOPIL VISWANATHAN

Diabetes Research Center, M.V. Hospital for Diabetes, Royapuram, Madras, India

A unique form of diabetes termed as malnutrition related diabetes mellitus (MRDM) has been included as a separate entity in the recent WHO study group report classification of diabetes[11]. Two subgroups are recognized under MRDM, namely fibrocalculous pancreatic diabetes (FCPD) and protein deficient diabetes mellitus (PDDM). Within India, FCPD is more common in the southern[4] and PDDM in the northern, parts of the country[1]. In this paper, we report on anthropometric data on three groups of diabetic patients namely fibrocalculous pancreatic diabetes (FCPD), insulin dependent diabetes mellitus (IDDM) and non-insulin dependent diabetes mellitus (NIDDM) seen at the Diabetes Research Center at Madras in southern India. To our knowledge this is the first report of detailed anthropometric studies in tropical forms of diabetes.

PATIENTS AND METHODS

The following groups of subjects were studied:

1) *Controls* - Healthy, non-diabetic volunteers who were chosen from the staff of our center. None had a family history of diabetes and all had normal oral glucose tolerance tests according to WHO criteria[11]. None had any evidence of systemic illness, nor different socio-economic status in comparison with the diabetic patients.

2) *Fibrocalculous pancreatic diabetes (FCPD)* - Patients diagnosed as FCPD gave a history of severe recurrent abdominal pain suggestive of pancreatitis, had evidence of pancreatic calculi on plain x-ray abdomen and other features of chronic pancreatitis, e.g. ductal dilation on ultrasonography[8]. None had any evidence of hepatobiliary disease.

3) *Insulin dependent diabetes mellitus (IDDM)* - Criteria for IDDM were abrupt onset of diabetes, requirement of insulin for control of hyperglycemia right from the onset of diabetes, proneness to ketosis in the basal state or documented episodes of ketoacidosis in the past. None had a history suggestive of pancreatitis and all had normal abdominal x-rays and ultrasonograms.

Key-words: Body mass index; Fat mass; Fibrocalculous pancreatic diabetes (FCPD); IDDM; Malnutrition diabetes; Skinfold thickness; Tropical diabetes.

Received: July 9, 1990.

Acta diabetol. lat. *28*, 55-60, 1991.

4) *Non-insulin dependent diabetes mellitus (NIDDM)* - These patients had insidious onset of diabetes, responded to diet or diet and oral hypoglycemic agents and were non-ketosis prone during ordinary conditions of life. They had no history suggestive of pancreatitis and abdominal x-rays and ultrasound studies were normal.

Diagnosis of diabetes was based on the WHO study group criteria[11]. All diabetic subjects were studied at the time of first registration at our center before we could alter the treatment pattern. Consecutive patients who visited our center during the period, January 1988 to December 1988 were studied. Subjects in the age group 20-60 years were chosen to avoid wide disparity in age which could affect anthropometric studies[2].

Anthropometric studies

The following parameters were used in this study: body weight, body mass index (BMI), triceps-, biceps-, subscapular-, and suprailiac-skinfolds, mid-arm circumference and fat mass. Body weight and height were measured by a single trained technician using a beam scale. Measurements were taken with shoes removed and with light clothing. BMI was calculated using the formula: weight in kg/height in square meters. Skinfold thickness measurements were made using Harpenden skinfold calipers (Holtain Ltd., Pembrokeshire, U.K.). Measurements at different sites namely, triceps, biceps, subscapular and suprailiac and mid-arm circumference measurements were done using standard techniques[9]. Fat mass was calculated using the sum of the 4 skinfolds according to the method of DURNIN and WORMSELEY[3]. Wherever possible, the body weight of diabetic patients prior to the onset of diabetes was obtained from previous medical or personal records. All measurements were made by the same individual (SJ) to avoid inter-observer variation.

Statistical Analysis was done using Microstats statistical package on Apricot Fle computer. Analysis of variance (ANOVA) was used to compare differences between groups and paired *t*-test for paired data. Analysis was done separately for males and females. Data are reported as mean ± SD.

	age (years)	duration of diabetes (years)	fasting plasma glucose (mg/dl)	HbA_1 (%)
males				
controls (n = 51)	38.2 ± 10.8 (20-60)	-	80 ± 14	6.6 ± 1.0
FCPD (n = 35)	37.2 ± 11.1[a] (20-60)	5.6 ± 5.3	189 ± 29*	10.1 ± 1.9*
IDDM (n = 37)	34.5 ± 8.2[b] (20-52)	6.9 ± 6.5	196 ± 34*	10.3 ± 2.1*
NIDDM (n = 47)	41.1 ± 6.2 (26-50)	4.6 ± 4.6	160 ± 26*	9.8 ± 1.2*
females				
controls (n = 54)	34.0 ± 12.0 (20-58)	-	84 ± 18	6.8 ± 0.9
FCPD (n = 14)	35.2 ± 8.1[a] (22-50)	6.8 ± 5.6	192 ± 24*	9.9 ± 1.4*
IDDM (n = 18)	33.1 ± 10.6[b] (20-50)	5.7 ± 6.8	208 ± 32*	10.6 ± 1.9*
NIDDM (n = 57)	41.4 ± 6.7 (26-50)	8.6 ± 5.5	176 ± 30*	9.6 ± 1.6*

Tab. 1 - Biochemical parameters in the study groups. (*$p<0.001$ vs *controls; a:* $p<0.05$ vs *NIDDM; b:* $p<0.001$ vs *NIDDM).*

		before diabetes	after diabetes	significance
FCPD males (n = 17)	weight (kg)	63.8 ± 12.7	55.8 ± 11.4	p<0.001
	(BMI)	23.6 ± 4.0	20.5 ± 3.6	
IDDM males (n = 18)	weight (kg)	61.9 ± 9.0	53.4 ± 6.4	p = 0.001
	(BMI)	22.0 ± 3.0	18.9 ± 2.04	
NIDDM males (n = 17)	weight (kg)	65.6 ± 11.4	60.7 ± 9.3	p = 0.001
	(BMI)	24.2 ± 3.1	22.4 ± 2.8	
NIDDM females (n = 17)	weight (kg)	63.7 ± 9.8	58.7 ± 9.4	p<0.001
	(BMI)	28.9 ± 4.7	26.6 ± 4.1	

Tab. 2 - Change in body weight and BMI after onset of diabetes. *(Due to small numbers no analysis was done for FCPD and IDDM females).*

RESULTS

The mean age of the different groups of diabetic patients was similar to that of the controls. The FCPD and IDDM patients were younger than the NIDDM ($p<0.05$ and $p<0.001$, respectively). There were no differences in the duration of diabetes or glycosylated hemoglobin values between the 3 diabetic groups. Tab. 1 shows the biochemical parameters in the study groups.

Reliable body weight data prior to and after the onset of diabetes was available in 17 FCPD males, 18 IDDM males, 17 NIDDM males and 17 NIDDM females (tab. 2). It can be seen that significant weight loss occurred after the onset of diabetes in all diabetic groups.

Table 3 shows the anthropometric data in the males. There were no significant differences in the anthropometric measurements between control and NIDDM groups except for subscapular (NIDDM higher than controls, $p = 0.01$) and fat mass (NIDDM higher than controls, $p<0.05$). In FCPD and IDDM patients skinfold thickness, mid-arm circumference and fat mass were significantly lower compared to NIDDM and control groups ($p<0.001$ for all parameters). The ratio of subscapular/triceps (STR) was not significantly dif-

	body weight (kg)	BMI (kg/m²)	skinfold thickness (mm)				STR	mid-arm circum-ference	fat mass
			triceps	biceps	subsca-pular	supra-iliac			
controls (n = 51)	65.1 ± 10.8	24.7 ± 3.9	11.6 ± 4.6	6.6 ± 2.4	16.7 ± 5.8	15.2 ± 6.7	1.5 ± 0.5	27.8 ± 2.6	22.1 ± 5.4
FCPD* (n = 35)	52.4 ± 11.2	19.8 ± 3.4	7.3 ± 3.9[a]	4.4 ± 1.6	12.8 ± 6.2	8.2 ± 4.8	1.8 ± 0.5[b]	23.9 ± 3.4	16.0 ± 5.3
IDDM* (n = 37)	51.5 ± 7.4	18.7 ± 2.3[a]	7.0 ± 2.2[a]	4.1 ± 1.0	11.3 ± 5.0	7.8 ± 4.3	1.6 ± 0.5	24.1 ± 2.2	15.4 ± 4.7
IDDM (n = 47)	65.7 ± 10.8	24.4 ± 3.7	12.7 ± 4.6	7.8 ± 4.6	19.9 ± 6.9[b]	15.4 ± 7.1	1.7 ± 0.6	27.1 ± 3.5	24.5 ± 6.1[c]

Tab. 3 - Anthropometric data in males. *(STR = subscapular/triceps ratio; a: $p<0.01$ vs controls and NIDDM; b: $p<0.01$ compared to controls; c: $p<0.05$ compared to controls; * $p<0.001$ for all parameters compared to controls and NIDDM.*

	body weight (kg)	BMI (kg/m²)	skinfold thickness (mm)				STR	mid-arm circum-ference	fat mass
			triceps	biceps	subsca-pular	supra-iliac			
controls (n = 54)	57.1 ± 11.1	24.9 ± 4.6	18.0 ± 6.0	9.3 ± 4.1	18.0 ± 6.0	17.4 ± 6.7	1.1 ± 0.3	26.5 ± 3.2	30.8 ± 6.2
FCPD* (n = 14)	42.2 ± 10.2	18.7 ± 3.8	7.7 ± 3.5[a]	4.8 ± 1.9	11.4 ± 5.6	8.8 ± 5.5	1.4 ± 0.4[c]	21.9 ± 3.7[b,d,e]	22.8 ± 5.5
IDDM* (n = 18)	48.0 ± 10.6	20.9 ± 3.8	13.2 ± 6.5	6.6 ± 3.1	15.4 ± 6.3	12.0 ± 5.6	1.3 ± 0.5	24.3 ± 3.3[c,e]	26.3 ± 7.2
IDDM (n = 57)	59.2 ± 10.8	26.4 ± 4.4	17.1 ± 5.4	9.3 ± 3.2	21.4 ± 7.5	19.4 ± 5.3	1.3 ± 0.7	27.5 ± 2.9	33.2 ± 3.8

Tab. 4 - Anthropometric data in females. *(STR = subscapular/triceps ratio; a: $p = 0.007$ vs IDDM; b: $p<0.05$ vs IDDM; c: $p<0.001$ vs controls; d: $p<0.001$ vs controls; e: $p<0.001$ vs NIDDM; *$p<0.001$ for all parameters compared to controls and NIDDM).*

ferent between any of the 3 diabetic groups. Despite significantly lower subscapular and triceps skinfold measurements, the STR was significantly higher in FCPD compared to controls ($p<0.01$). There were no significant differences between the FCPD and IDDM patients with respect to any of the parameters studied.

Table 4 shows the data in females. The results were remarkably similar to those seen in the males except for minor differences between FCPD and IDDM in 2 parameters: triceps (FCPD *vs* IDDM, $p = 0.007$) and mid-arm circumference (FCPD *vs* IDDM, $p<0.05$).

DISCUSSION

Anthropometric measurements are used to approximate and evaluate fat stores and somatic protein[9]. They provide information on current body composition of fat, lean body mass or skeletal muscle for the purpose of assessing nutrition[9]. In this study, anthropometric measurements were made on three groups of diabetic patients seen in a tropical country, namely FCPD, IDDM and NIDDM and compared with a group of healthy, non-diabetic control subjects.

A significant finding observed in this study is the reduction in body weight and BMI after the onset of diabetes in all three groups of diabetics. It is known that uncontrolled diabetes can lead to weight loss consequent to marked protein catabolism[5]. A recent study has reported negative nitrogen balance in IDDM patients with poor metabolic control[10]. This underscores the limitation of BMI which has been suggested as a diagnostic criterion for classification of malnutrition related diabetes mellitus[1]. It is of interest however that the BMI of the FCPD and IDDM patients were significantly lower than those of the control group and the NIDDM patients. This may be related to the severity of diabetes in the FCPD and IDDM groups. We have shown in earlier studies that while patients with IDDM have near total absence of B-cell reserve, FCPD patients have some residual B-cell reserve[7]. However an addi-

tional factor, namely exocrine pancreatic dysfunction with steatorrhea, may contribute to weight loss in FCPD patients[6].

The FCPD and IDDM patients (both male and female groups) had significantly lower skinfold measurements (triceps, biceps, subscapular and suprailiac), mid-arm circumference and fat mass compared to control subjects and NIDDM patients. The fact that FCPD patients had higher subscapular/triceps ratio (STR) compared to controls may indicate more wasting of the arms. Possible factors which are likely to affect skinfold measurements include age, sex, the effects of exercise and muscularity. Age generally alters skin elasticity and compressibility, thereby affecting the ability to measure skinfolds accurately. Females generally have a higher percentage of body fat than males, and hence skinfold measurements are considered to be better indicators of malnutrition in females than in males. It is thus of interest that while females had significantly higher skinfold measurements compared to males among NIDDM and IDDM groups, in the FCPD group females had similar values as males. This suggests that FCPD females could have lower fat stores than other diabetic groups.

Physical exercise and muscularity also affect skinfold measurements. Well muscled individuals generally have lower skinfold measurements. This does not necessarily indicate a compromise in fat stores, but rather an alteration in the proportion and distribution of fat[4]. Combined skinfold and body weight measurements therefore provide a better picture of nutritional status. The finding that the IDDM and FCPD patients had lower skinfold measurements as well as lower body weight suggests that there could be depletion of fat stores in these two diabetic groups.

In summary, we have carried out anthropometric studies on different tropical forms of diabetes seen at a diabetes center. The study shows that reduced body mass and fat mass are a feature of not only FCPD patients but also IDDM patients in developing countries.

SUMMARY

Anthropometric studies were carried out in three groups of diabetics seen in southern India, namely fibrocalculous pancreatic diabetes (FCPD) (n = 49) (a subtype of malnutrition related diabetes), insulin dependent diabetes mellitus (IDDM) (n = 55) and non-insulin dependent diabetes mellitus (NIDDM) (n = 104). Both FCPD and IDDM had significantly lower body mass index, skinfold thickness (triceps, biceps, subscapular and suprailiac), mid-arm circumference and fat mass compared to controls and NIDDM patients, ($p<0.001$ for all parameters). FCPD and IDDM males did not show any significant differences in any of the anthropometric parameters studied. Among the females, FCPD had lower triceps skinfold measurements ($p = 0.007$) and mid-arm circumferences ($p<0.05$) compared to IDDM patients. Patients with NIDDM did not show any significant difference compared to the control group. This study shows that both FCPD and IDDM patients have lower body mass and fat mass compared to NIDDM patients and control subjects.

REFERENCES

1. AHUJA M. M. S.: Diabetes: special problems in developing countries - Bull. Deliv. Health Care *1*, 5-6, 1980.
2. CHUMLEA W. C., BAUMGARTNER R. N.: Status of anthropometry and body composition data in elderly subjects - Amer. J. clin. Nutr. *50*, 1158-1166, 1989.

3. DURNIN J. V. G. A., WORMSELEY J.: Body fat assessed from total body density and its estimation from skinfold thickness: measurements for 481 men and women aged from 16-72 years - Brit. J. Nutr. *32*, 77-97, 1974.

4. GEEVARGHESE P. J.: Calcific Pancreatitis. Varghese Publishing House, Bombay, 1985; pp. 1-5.

5. KROLEWSKI A. S., WARRAM J. H., CHRISTLIEB A. R.: Onset, course, complications and prognosis of diabetes mellitus. In: MARBLE A., KRALL L. P., BRADLEY R. F., CHRISTLIEB A. R., SOELDNER J. S. (Eds): Joslin's Diabetes Mellitus. 12th edition, Lea and Febiger, Philadelphia, 1985; pp. 251-277.

6. MOHAN V., SNEHALATHA C., AHMED M. R., MADANAGOPALAN N., CHARI S., JAYANTHI V., MALATHI S., RAMACHANDRAN A., VISWANATHAN M.: Exocrine pancreatic function in tropical fibrocalculous pancreatic diabetes - Diabet. Care *12*, 145-147, 1989.

7. MOHAN V., SNEHALATHA C., RAMACHANDRAN A., JAYASHREE R., VISWANATHAN M.: Pancreatic beta cell function in tropical pancreatic diabetes - Metabolism *32*, 1091-1092, 1983.

8. MOHAN V., SREERAM D., RAMACHANDRAN A., VISWANATHAN M., DORAISWAMY K. R. I.: Ultrasonographic evaluation of the pancreas in tropical pancreatic diabetes - Acta diabetol. lat. *22*, 143-148, 1985.

9. MURRAY R. L.: Clinical methods in anthropometry. In: KREY S. H., MURRAY R. L. (Eds): Dynamics of Nutritional Support: Assessment, Implementation, Evaluation. Appleton-Century Crofts, Norwalk, Connecticut, 1986; pp. 99-146.

10. NAIR K. S., HALLIDAY D., GARROW J. S.: Increased energy expenditure in poorly controlled Type 1 (insulin-dependent) diabetic patients - Diabetologia *27*, 13-16, 1984.

11. W.H.O. STUDY GROUP REPORT ON DIABETES MELLITUS: W.H.O. Technical Report Series 727, Geneva, 1985.

Requests for reprints should be addressed to:

VISWANATHAN MOHAN
Diabetes Research Center
5, Main Road, Royapuram
Madras - 600 013 India