

## Original Article

# Anthropometric, metabolic and dietary fatty acids profiles in lean and obese diabetic Asian Indian subjects

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The present study was aimed to study anthropometric, metabolic and dietary fatty acids profiles among 200 (Group I: lean control,  $N = 80$ ; Group II: lean diabetic,  $N = 70$  and Group III: obese diabetic,  $N = 50$ ) Asian Indians (aged 30 years and above) living in the eastern part of India. Anthropometric [height, weight, waist (WC) and hip circumference] metabolic [total cholesterol (TC), triglyceride (TG), high (HDL), low density lipoprotein (LDL) and fasting plasma glucose (FPG)] and dietary profiles were collected from each participant. Body mass index (BMI), waist-hip ratio (WHR) and conicity index (CI) were subsequently computed from anthropometric measures. An open-ended 24 h food recall proforma consisting of three sections and in local language was used to collect nutrient information from each participant. Daily intake of nutrients including saturated (SFA), monounsaturated (MUFA) and polyunsaturated fatty acids (PUFA) were estimated by adding all the foodstuffs consumed on weekly and monthly basis. One-way ANOVA with Scheffe's post-hoc test revealed that Group I has significantly lower mean than both Group II and Group III for age, WC, WHR, CI, TC, TG, LDL, FPG and total carbohydrates; Group I has significantly lower mean than Group II only for HDL and Group I has significantly lower mean than Group III only for BMI, total proteins and total fats. On the other hand, Group I has significantly greater mean than both Group II and Group III for UFA/SFA, MUFA/SFA and PUFA/SFA whereas Group I has significantly lower mean than Group III only for trans fatty acids and Erucic acid. Pearson's partial correlation (controlling age and sex) analysis showed that the ratios of unsaturated fatty acids and saturated fatty acids had significant negative association with lipids, lipoprotein and fasting glucose. Discriminant analysis revealed that overall 86.2% of all cases were correctly (positively) classified in three groups using fatty acids and their ratios. In conclusion, it seems reasonable to argue that dietary management including dietary guidelines would be useful to retard the growing incidence of diabetes in Indian population.

**Key Words:** obesity, central obesity, dietary fatty acids, lipids, diabetes, Asians, India.

## Introduction

The prevalence of coronary heart disease (CHD) is known to be very high in the people of Asian Indian origin.<sup>1</sup> Cardiovascular mortality in Indian population is likely to climb up 103% in men and 90% in women by 2015.<sup>2</sup> In fact, CHD has been predicted to rank first among the causes of death in Indian population by 2015.<sup>3</sup> Although the prevalence of conventional risk factors such as smoking, hypertension and hypercholesterolemia is no higher in south Asians than other ethnic groups yet it seems reasonable to state that some risk factors for atherosclerosis are particularly widespread among them namely high plasma triglyceride (TG), increased level of total cholesterol (TC) and high-density lipoprotein (HDL) ratio or TC: HDL, type 2 diabetes mellitus (T2DM), central or visceral obesity.<sup>4-6</sup> Most interestingly, in Asian populations, mortality and morbidity from chronic diseases such as CHD, T2DM etc., is occurring in people with lower body mass index (BMI) therefore they tend to accumulate intra-abdominal visceral fat without developing generalized obesity.<sup>7</sup> The metabolic syndrome or 'syndrome x' which has been defined as the constellation of CHD risk factors is associated with striking

tendency to central obesity in south Asians although they are no more overweight than European or Americans.<sup>8-10</sup>

All the major treatment guidelines highlighting risk stratification and management as imperative for those at high risk of chronic diseases. Framingham's risk score is one such method to assessing the relative 'odds' of risk of an individual to develop CHD over the next 10 years.<sup>11</sup> Although Framingham's risk score has not been adequately tested in Indian population, one retrospective case-control study failed to identify a large proportion of high-risk individuals who actually developed acute coronary syndrome (ACS) in diabetogenic condition. In fact, in diabetic patients there was no significant difference in the mean projected risk between patients with ACS and patients without any manifestation of CHD.<sup>11</sup> Available literature also emphasized that T2DM is a silent killer and increased the risk to develop CHD prematurely.

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The prevalence of T2DM is also very high in Asian India population and in turn emphasized the effective management including nutrient profile to identify individual who are at greater risk of T2DM.<sup>12</sup>

Indian subcontinent is characterised by cultural heterogeneity results in differences in food consumption among different Indian communities across the Indian Diaspora.<sup>6</sup> This difference in food consumption is unquestionably a potential risk factor for diabetic catastrophe among the Asian Indians. Although vegetarianism is the general rule in this population however variations in the carbohydrate, protein and fat intake largely depend upon the geographical region<sup>13</sup> and religion of individuals. Rural people in this part of the universe usually consumed simple diets consisting of low total saturated fat and high dietary fiber by means of green leafy vegetables. On contrary, urban people use to live on high consumption of total saturated fat, carbohydrates and decreased intake of dietary fiber. Furthermore, like other developing countries across the continents, large-scale urbanization is taking place in India and in turn brings with effective changes in lifestyles including food habits attributable to evolving circumstances of CHD and T2DM in Asian Indians.<sup>12</sup> However to the best of author's knowledge, no study has been undertaken to compare anthropometric, lipids, lipoproteins, glucose and nutrient profiles in lean and obese diabetic Indian subjects. In view of the above consideration, the present study was undertaken among 200 (Group I: lean control,  $N = 80$ ; Group II: lean diabetic,  $N = 70$  and Group III: obese diabetic,  $N = 50$ ) Asian Indians living in eastern part of India with the following objectives:

1. To compare obesity measures, lipids, lipoproteins, plasma glucose and nutrient profiles in lean control, lean diabetic and obese diabetic subjects.
2. To study the association of dietary fatty acids, their ratios and obesity measures.
3. To study the association of dietary fatty acids, their ratios, lipids, lipoproteins and plasma glucose.
4. To find out how well (discrimination) dietary fatty acids and their ratios could be used for corrected group size in this population.

## Materials and methods

### Study population

The sample comprised of 200 apparently healthy individuals of both sexes and were aged 30 years and above. The following three groups were studied: Lean control (Group-I,  $N = 80$ , Male: Female = 50:30); Lean diabetic (Group-II,  $N = 70$ , M: F= 40:30) Obese diabetic (Group-III,  $N = 50$  M: F = 40:10). The study was conducted during the period of December 2003 to January 2005 at the 'out patient department' (OPD) of B.R.Singh Hospital, Eastern Railway, Calcutta and Medical College and Hospital, Calcutta, India. All participants were occupant of Calcutta and suburb. Informed consent was taken from all participants prior to actual commencement of the study. The institutional ethics committee have had approved the present study. All participants were interviewed at the OPD of the Hospitals by the recorder (AG). The majority of the participants (85%) were engaged in

non-manual work and because of that they generally led sedentary lives.

### Anthropometric measures

Height, weight, circumferences of waist (WC) and hip were recorded using a standard technique<sup>14</sup> by the recorder. Height and weight were measured to the nearest 0.1cm and 0.5kg respectively. Waist and hip circumferences were measured with an inelastic tape to the nearest 0.2cm. Body mass index (BMI), waist-hip ratio (WHR) and conicity index (CI)<sup>15</sup> were computed using the following formulae:

$$\text{BMI} = \text{Weight (kg)} / \text{Height}^2 (\text{m}^2)$$

$$\text{WHR} = \text{Waist circumference (cm)} / \text{Hip circumference (cm)}$$

$$\text{CI} = \text{Waist circumference (m)} / (0.109) \times \sqrt{[\text{weight (kg)} / \text{Height (m)}]}$$

### Metabolic measures

A fasting blood sample (7 ml) was collected from each subject for the determination of metabolic profiles. All subjects were maintained an over night fast of  $\geq 12$  hour prior to blood collection. Plasma was separated by centrifugation at  $1000 \times g$  for 20 minutes at room temperature within 2 hours of collection. Estimation of total cholesterol (TC), triglyceride (TG), fasting plasma glucose (FPG) was carried out on separated plasma using auto-analyzer. High-density lipoprotein cholesterol (HDL) was measured after an overnight stand of plasma in a refrigerator and then precipitation non-high density lipoproteins, namely low density lipoprotein (LDL), very low-density lipoprotein (VLDL), and chylomicrons with manganese-heparin substrate.<sup>16</sup> LDL was then estimated using the following formula<sup>17</sup>:

$$\text{LDL} = \text{TC} - (\text{HDL} + \text{TG} / 5)$$

All biochemical analyses were done at the Biochemistry unit of hospitals. All metabolic variables were measured in mg/dl (mg%). Both anthropometric and metabolic measures were recorded in a predesigned proforma to maneuver efficiently during computation.

### Dietary profile

An open-ended 24h food recall proforma consisting of three sections and in local language was used to collect nutrient information from each participant. The proforma was equipped according to the guidelines prepared by the National Institute of Nutrition (NIN), Hyderabad, India.<sup>18,19</sup> The validation of tools used to assess diet had been made in a study pertaining to urban slum dwellers in northern India.<sup>13</sup> The responses to the open-ended schedule were free and spontaneous and respondents were not limited in their replies to a particular question posed to them. The sole purpose of using an open-ended schedule in the study was to collect quantitative cross-sectional data on dietary pattern. The first section of the proforma was meant for collecting 24h nutrient intake including break-fast, lunch, evening snacks and dinner. The second version dealt with various foodstuffs usually not consumed daily. The consumption was recorded on a monthly basis. The third section included the type and amount of fats used as the cooking medium as well as utensils commonly used in making food. Daily intake of nutrients was estimated by adding all the foodstuffs

consumed on a weekly and monthly basis. To convert foods stuffs into nutrients, a programme was used with the standard nutrient values of Indian foods. Preliminary testing of the programme was carried out on the nutrition data of a small subset of present population.

### Definitions

Obesity was defined as individuals having BMI  $\geq 25$  kg/m<sup>2</sup>. All other individuals were considered as lean. Participants were considered as type 2 diabetic when fasting plasma glucose  $>125$ mg%<sup>20</sup> or when they were on any hyperglycemic drug. Individuals on insulin therapy were not incorporated in the study.

### Statistical analyses

Descriptive statistics such as mean and standard deviation were undertaken separately for three groups. Comparison of groups for variables was done using analysis of variance (ANOVA) and with *Scheffe's* post-hoc test. Pearson's partial correlation was also undertaken for three groups separately and cumulatively to study the association of dietary fatty acids, their ratios and obesity measures as well as to assess the association of dietary fatty acids, their ratios, lipids, lipoproteins and plasma glucose. Finally, to find out how well (discrimination) dietary fatty acids and their ratios could be used for corrected group size in this population discriminant analysis was undertaken. Discriminant analysis is one such approach and is useful for situations where one want to build a predictive model of group membership based on observed characteristics of each case. The procedure generates a discriminant function (or, for more than two groups, a set of discriminant functions) based on linear combinations of the predictor variables that provide the best discrimination between the groups. The functions are generated from a sample of cases for which group membership is known; the functions can then be applied to new cases with measurements for the predictor variables but unknown group membership. All statistical analyses were performed using the SPSS (PC+ version 10). A *P* value of  $<0.05$  (two tailed) was considered as significant.

### Results

The distribution of all variables were checked for normality and was found that distribution of WC, WHR, CI, all the metabolic measures except LDL and two fatty acids ratios namely MUFA/SFA and PUFA/SFA were significantly skewed. Necessary Log<sub>10</sub> transformation was undertaken to normalize their distribution. The mean and standard deviation (SD) of anthropometric, metabolic and dietary profiles of three groups as well as group differences were presented in Table 1. The mean ages (in years) for three groups were 38.4 (SD=10.2), 40.2 (SD=11.2) and 41.3 (SD=10.5) respectively. The mean WC (in cm) for lean control, lean diabetic and obese diabetic were 80.4 (SD=6.4), 83.0 (SD=3.2) and 94.5 (SD=8.2) respectively. One-way ANOVA with *Scheffe's* post-hoc test revealed that Group I has significantly lower mean than both Group II and Group III for age, WC, WHR, CI, TC, TG, LDL, PG and total carbohydrates;

**Table 1.** Anthropometric, metabolic and nutritional characteristics in lean controls (*N* = 80) lean diabetic (*N* =70) and lean obese subjects (*N* =50).

Variables	Lean controls (Group I, <i>N</i> =80)	Lean diabetics (Group II, <i>N</i> =70)	Obese diabetics (Group III, <i>N</i> =50)
<sup>1</sup> Age (years)	38.4±10.2	40.2±11.2	41.3±10.5
Male: Female	50:30	40:30	40:10
<sup>3</sup> Body mass index (BMI in kg/m <sup>2</sup> )	20.4±2.	21.2±2.6	25.8±2.3
<sup>1</sup> Waist circum- ference (cm)	80.4±6.4	83.0±3.2	94.5±8.2
<sup>1</sup> Waist-hip ratio (WHR)	0.82±0.21	0.90±0.24	0.98±0.32
<sup>1</sup> Conicity index (CI)	1.08±0.23	1.14±0.21	1.29±0.31
<sup>1</sup> Total cholesterol (mg/dl)	190.4±28.4	200.5±25.2	245.4±36.4
<sup>1</sup> Triglyceride (mg/dl)	95.4±19.2	125.2±24.4	142.0±27.2
<sup>2</sup> High-density lipoprotein Cholesterol(mg/dl)	42.2±7.8	44.0±8.2	43.2±7.4
<sup>1</sup> Low-density lipoprotein cholesterol (mg/dl)	129.4±22.4	131.2±21.5	174.0±26.4
<sup>1</sup> Fasting plasma glucose (mg/dl)	102.4±14.5	121.8±12.8	129.7±13.4
<sup>1</sup> Total carbohydrates (g)	226.4±32.2	208.2±28.4	266.5±31.2
<sup>3</sup> Total proteins (g)	60.4±17.5	60.2±18.4	62.4±21.4
<sup>3</sup> Total fat (g)	45.5±14.2	44.2±12.4	62.2±11.4

Values are in Mean ± SD; One-way ANOVA with *Scheffe's* test revealed that, <sup>1</sup> Group I has significantly lower mean than both Group II and Group III. <sup>2</sup>Group I has significantly lower mean than Group II only. <sup>3</sup>Group I has significantly lower mean than Group III only

Group I has significantly lower mean than Group II only for HDL and Group I has significantly lower mean than Group III only for BMI, total proteins and total fats.

Descriptive statistics and group differences for dietary fatty acids and their ratios were presented in Table 2. The results revealed that Group I has significantly greater mean than both Group II and Group III for UFA/SFA, MUFA/SFA and PUFA/SFA whereas Group I has significantly lower mean than Group III only for *trans* fatty acids and Erucic acid. Pearson's partial correlations (controlling age and sex) were undertaken separately for three groups as well as for total study sample (*N* = 200) for obesity measures, dietary fatty acids, their ratios and metabolic variables. However, only two results were included as tabular fashion. Pearson's partial correlation analysis (controlling age and sex) of obesity measures with dietary fatty acids and their ratios in the lean diabetic subjects were presented in Table 3. It revealed that all central obesity measures had significant association with dietary fatty acids and their ratios. However, no significant relation was established for BMI with dietary fatty acids and their ratios. The result also revealed that there

**Table 2.** Dietary fatty acids and their ratios in lean controls ( $N = 80$ ) lean diabetic ( $N = 70$ ) and lean obese subjects ( $N = 50$ )

Variables	Lean controls	Lean diabetics	Obese diabetics
	(Group-I, $N = 80$ )	(Group-II, $N = 70$ )	(Group-III, $N = 50$ )
<sup>2</sup> Trans fatty acids (g)	3.6 ± 0.96	3.4 ± 1.2	4.8 ± 1.4
<sup>2</sup> Erucic acid (g)	5.5 ± 1.2	5.2 ± 0.98	7.4 ± 1.4
<sup>1</sup> UFA/SFA	1.7 ± 0.89	1.2 ± 1.2	0.94 ± 0.12
<sup>1</sup> MUFA/SFA	0.94 ± 0.12	0.90 ± 0.14	0.32 ± 0.10
<sup>1</sup> PUFA/SFA	2.1 ± 0.82	1.9 ± 0.86	0.75 ± 0.12

Values are in Mean ± SD; UFA= unsaturated fatty acid, MUFA= monounsaturated fatty acid, PUFA= polyunsaturated fatty acid, SFA= saturated fatty acid. One-way ANOVA with *Scheffe's* test revealed that, <sup>1</sup> Group I has significantly greater mean than both Group II and Group III. <sup>2</sup>Group I has significantly lower mean than Group III only

**Table 3.** Pearson's partial correlation (controlling age and sex) analysis of obesity measures with dietary fatty acids and their ratios in lean diabetic subjects ( $N = 70$ )

Variables	TFA	Erucic acid	UFA/SFA	MUFA/SFA	PUFA/SFA
BMI	0.12	0.12	-0.13	-0.10	-0.13
<sup>#</sup> WC	0.38***	0.37***	-0.45***	-0.46***	-0.42***
<sup>#</sup> WHR	0.35***	0.44***	-0.54***	-0.50***	-0.53***
<sup>#</sup> CI	0.43***	0.48***	-0.31**	-0.34**	-0.24*

BMI= body mass index, WC= waist circumference, WHR= waist-hip ratio, CI= conicity index, TFA= *trans* fatty acid, UFA= unsaturated fatty acid, MUFA= monounsaturated fatty acid, PUFA= polyunsaturated fatty acid, SFA= saturated fatty acid. # = Log<sub>10</sub> transformed values are used Significant at \* $P < 0.05$ ; \*\*  $P < 0.01$ ; \*\*\* $P < 0.001$

that there existed significant inverse association between unsaturated fatty acids, their ratios with all central obesity measures. More clearly, the ratios of unsaturated fatty acids and saturated fatty acids (e.g. PUFA/SFA) had significant negative association with all central obesity measures. The result of Pearson's partial correlation analysis (controlling age and sex) of metabolic profiles with dietary fatty acids and their ratios in obese diabetic subjects was presented in Table 4 and it showed that the ratios of unsaturated fatty acids and saturated fatty acids (e.g. PUFA/SFA) had significant negative association with lipids (TC & TG), lipoprotein (LDL) and FPG. HDL on the other hand had significant ( $P < 0.001$ ) positive relation with UFA/SFA, MUFA/SFA and PUFA/SFA. *Trans* fatty acids and Erucic acid had significant ( $P < 0.01$ ) negative association with HDL. Since dietary fatty acids and their

**Table 4.** Pearson's partial correlation (controlling age and sex) analysis of metabolic profiles with dietary fatty acids and their ratios in obese diabetic subjects ( $N = 50$ )

Variables	TC <sup>#</sup>	TG <sup>#</sup>	HDL	LDL <sup>#</sup>	FPG <sup>#</sup>
TFA	0.42***	0.44***	-0.32**	0.30**	0.33**
Erucic acid	0.55***	0.48***	-0.34**	0.40***	0.24*
UFA/SFA	-0.36**	-0.36***	0.44***	-0.44***	-0.27*
<sup>#</sup> MUFA/SFA	-0.38***	-0.34**	0.45***	-0.51***	-0.35**
<sup>#</sup> PUFA/SFA	-0.36**	-0.36**	0.45***	-0.42***	-0.27*

TC= total cholesterol, TG=triglyceride, HDL= high-density lipoprotein cholesterol, LDL= low-density lipoprotein cholesterol, FPG= fasting plasma glucose, TFA= *trans* fatty acid, UFA= unsaturated fatty acid, MUFA= monounsaturated fatty acid, PUFA= polyunsaturated fatty acid, SFA= saturated fatty acid. # = Log<sub>10</sub> transformed values are used. Significant at \* $P < 0.05$ ; \*\* $P < 0.01$ ; \*\*\* $P < 0.001$

**Table 5.** Results of the discriminant analysis by dietary fatty acids and their ratios in study population ( $N = 200$ )

Actual group	Sample size	Predicted group membership		
		I	II	III
I	80	60 (75%)	19 (23.7%)	1 (1.2%)
II	70	10 (14.3%)	58 (82.8%)	2 (2.9%)
III	50	0 (0.0%)	8 (16%)	42 (84%)

Group I= Lean controls, Group II= Lean diabetics, Group III= Obese diabetics, Percent of grouped cases correctly classified = 86.2%

ratios were negatively associated with obesity and metabolic measures, discriminant analysis (corrected for group size) was undertaken to determine how well individuals in the three groups could be correctly classified utilizing dietary fatty acids and their ratios. Results (Table 5) revealed that over-all 86.2% of all cases were correctly (positively) classified in three groups.

## Discussion

In the present study, it was observed that there existed significant inverse association between central obesity measures and intake of unsaturated fatty acids. Moreover, all the numerators in fatty acids ratios were unsaturated fatty acids e.g. MUFA/SFA, PUFA/SFA etc. Therefore, it seems reasonable to argue that increased intake of unsaturated to saturated acids ratio would be beneficial across the groups particularly diabetic subjects to have a control over their waist line, one of the best known predictor of chronic diseases such as diabetes. An observation on north Indian slum dwellers had reported that high oral intake of *trans* fatty acids increased LDL and

lowered HDL level in circulation. In addition, *trans* fatty acids elevate the level of Lp (a), an independent risk factor of CHD. This fact is critically important in Asian Indians to whom one of the highest levels of Lp (a) was observed and correlated to CHD.<sup>21</sup> People in this part of the world often used *Vanaspati*, a kind of hydrogenated oil, as cooking medium to preparing sweets and snacks. This hydrogenated oil contains more than 50% *trans* fatty acids.<sup>13</sup> In the midst of altering lifestyles and abundant use of *Vanaspati* to prepare fast food, intake of *trans* fatty acid is likely to increase further in the Asian Indian population.<sup>6</sup> Besides, people in this part also used mustard along with rapeseed oil (often distributed by government ration shops) as cooking medium for domestic purposes. Both mustard and rapeseed oil contains a number of long chain MUFA e.g. erucic acids, PUFA and SFA. In analyzing data, unlike many workers, author calculates MUFA in mustard and rapeseed oil by excluding the erucic acid. The similar procedure was also observed by another study pertaining to Asian Indians. In present study also, erucic acid had significant positive associations with all central obesity measures, lipids (TC, TG), lipoprotein (LDL), and plasma glucose. It was observed that people who were using mustard and PUFA oil (e.g. sunflower oil) in a weekly fashion (2:5 days) had better lipids profiles and less body fat compared to those who were using mustard oil only. However, till date no data on permissible levels of erucic acid in Asian Indian population existed. Moreover, its role to developing myocardial infarction has not well been tested in any population.

Study also revealed that daily total intake of carbohydrates and fats was on the higher limit of the recommendations of World Health Organization (WHO). Interestingly, in the slum dwellers of northern India, the total fat intake was on the higher limit of the recommendations of WHO.<sup>13</sup> In the present study, there were significant differences for daily total intake (in grams) of carbohydrates (226.4 vs. 266.5) and fat (45.5 vs. 62.2) between lean control and obese diabetic subjects. The major sources of carbohydrates were from rice, wheat, - sweet potatoes and green leafy vegetables whereas the major sources of fat intake were from milk and milk product, hydrogenated fat and fatty inland fish. In fact, rice (rich source of carbohydrates) and fish (not meat) are the staple foods in this part of the world.<sup>10</sup> The *atherogenic* dyslipidaemia<sup>22</sup> (HDL<35 mg%) was absent in the study. This could have been owing to frequent consumption n-3 PUFA by means of fish eating that lowers blood triacylglycerol concentration significantly and reduces CHD risk as well, in part, independently of their influence on lipoprotein concentrations.<sup>23</sup> In hind sight, however, they are consuming a large quantity of saturated fat daily from inland fish. No study has been done so far to find out the fatty acid composition of inland fish in Indian diets. Most fascinatingly, lean diabetic subjects had consumed (in grams) less daily total carbohydrates (208.2 vs. 226.4) compared to lean control subjects during the study. However, no significant differences were evident between lean control and lean diabetic subjects so far as daily total intake of carbohydrates (60.4 vs. 60.2) and proteins (45.5 vs. 44.2) were concerned. Lean diabetic subjects had con-

siderably lower mean for plasma glucose (121.8 vs.129.7) compared to obese diabetic in spite of the fact that bulk of the subjects for both groups were under hyperglycemic medication. Less consumption of daily carbohydrates and fats by lean diabetic subjects compared to obese diabetic subjects could possible be one valid reason of why lean diabetic subjects had considerably lower mean for FPG compared to obese diabetic individuals.

No significant differences between Group I and Group II was also evident for BMI (20.4 vs. 21.2). However, significant differences for all central obesity measures were evident between Group I and Group II member and in turn reinforce the fact that health risks associated with chronic diseases such as T2DM etc., occur in people with lower BMI in the Asia-Pacific region- in particular, South Asians (e.g. Indians) have more centralized obesity for a given level of BMI compared to Caucasians.<sup>24</sup> The result of the discriminant analysis, which is useful to build a predictive model of group membership based on observed characteristics of each case, revealed that overall 86.2% of all entries could correctly be classified (lean control, lean diabetic and obese diabetic) using fatty acids and their ratios means dietary management including dietary guidelines would be useful to retard the growing incidence of diabetes in Indian population. However, no such policy exists at present in India.

The study has some of the limitations inherent in a case-control design. Although the community-based controls would have been ideal, however, hospital-based controls were taken because this was easier to recruit and generally belonged to the same population as hospital-based cases. Furthermore, all participants were recruited consecutively with predefined criteria. Finally, the patients in the study were predominantly male so any extrapolation of these results to women would have to be done with great care. Longitudinal studies investigating the interaction between modifiable and non-modifiable risk factors are needed to further our understanding of the etiology of diabetes in the Indian population. Comparisons of Indian migrant populations elsewhere with that of local population of respective countries would yield valuable information about the 'gene-environment' interaction involved in the chronic diseases e.g. type 2 diabetes.

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## Original Article

## Anthropometric, metabolic and dietary fatty acids profiles in lean and obese diabetic Asian Indian subjects

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### 对印度瘦的和胖的糖尿病患者的人体各测量指标，代谢以及饮食脂肪酸方面的比较研究

本研究的目的是为了探讨 200 位住在印度东部地区的居民(年龄在 30 岁以上; 分别为瘦的对照组(N=80), 瘦的糖尿病组(N=70)和肥胖糖尿病组(N=50))的人体各指标测量, 代谢以及饮食脂肪酸方面的比较研究. 人体测量指标包括身高, 体重, 腰围以及臀围, 代谢指标包括总胆固醇(TC), 总甘油三脂(TG), 高密度脂蛋白(HDL)以及低密度脂蛋白(LDL), 以及包括空腹血糖浓度(FPG). 我们对上述指标以及这些试验人员的饮食方面的资料进行了收集整理. 然后通过人体测量得到的各项数据来计算 BMI 值, 腰围与臀围之间的比值(WHR)以及锥形指数. 我们通过让被测者回忆一日三餐饮食的方式来收集每人所摄取的营养素的情况. 我们通过对每位受试者每周和每月所消耗的食物总量来计算包括饱和脂肪酸(SFA), 单不饱和脂肪酸(MUFA)以及多不饱和脂肪酸(PUFA) 在内的每日摄入的营养素. 通过单因子方差分析, 我们发现在年龄, WC, WHR, CI, TC, TG, LDL, FPG 以及总糖各指标上, 第一组的平均值比第二和第三组的明显要低; 在 HDL 方面, 第一组的要比第二组明显低, 而在 BMI, 总蛋白和总脂方面, 第一组要明显低于第三组. 在另一方面, 第一组在 UFA/SFA, MUFA/SFA 和 PUFA/SFA 比值上的平均值要明显高于第二组和第三组的平均值, 而在反式脂肪酸和芥酸方面, 第一组的平均值要明显低于其他两组. 通过皮尔森偏相关分析(通过控制年龄和性别), 我们发现不饱和脂肪酸和饱和脂肪酸的比值与脂类, 脂蛋白以及空腹血糖浓度成相反的比例关系. 判别式分析结果表明: 利用脂肪酸及其它们的比率可以使患者在各实验组的合理分布率达到 86.2%. 最后, 我们可以得出一个较合理的结论: 合理的膳食管理(包括饮食方针)可以延缓印度人群中不断增长的糖尿病发生率。

**关键词:** 肥胖症, 向心性肥胖, 饮食脂肪酸, 脂类, 糖尿病, 亚洲人, 印度