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Prevalence of insulin resistance syndrome in a selected south Indian population — The Chennai urban population study-7 [CUPS-7]

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Background & objectives: **Although earlier studies had shown socio-economic factors to be strongly associated with the insulin resistance syndrome (IRS) and its components, there is still a paucity of data on Indians who have increased insulin resistance. In this study, we assessed the prevalence of IRS in two socio-economic groups in an urban south Indian population.**

Methods: **The Chennai Urban Population Study (CUPS) is an epidemiological study involving two residential areas in Chennai in south India. Of the 1262 eligible subjects (age ≥ 20 yr) who participated in the study, 1070 (76.5%) subjects who had a complete set of data were recruited for this study. Insulin resistance was calculated using the homeostasis assessment (HOMA) model. Insulin resistance syndrome was defined as the presence of insulin resistance in combination with at least 2 of the following conditions: hyperglycaemia, hypertension, dyslipidemia or central body obesity.**

Results: **The overall prevalence of IRS was 11.2 per cent (95% confidence interval: 9.4 - 13.3). The prevalence of the IRS in the middle-income group (18.7%) was significantly higher compared to the low income group (6.5%; $P<0.001$). Multiple logistic regression analysis revealed age ($P < 0.001$), body mass index ($P < 0.05$) and socio-economic status ($P = 0.014$) to be associated with IRS.**

Interpretation & conclusion: **The overall prevalence rate of IRS was 11.2 per cent. Age and higher socio-economic status were the risk factors for insulin resistance in this selected urban south Indian study population.**

Key words Chennai urban population study - diabetes - dyslipidemia - hypertension - insulin resistance - insulin resistance syndrome - obesity - south Indians

Insulin resistance plays a pivotal role in the metabolic disorders which includes hypertension, dyslipidaemia, glucose intolerance and coronary artery disease. The clustering of these disorders are collectively termed as insulin resistance syndrome (IRS) or syndrome X or Reaven's syndrome[1]. A recent review on IRS revealed a rapid escalation of this syndrome among Indians[2]. Earlier studies both on migrant Indians and native Indians have shown high prevalence rates of the components of IRS namely hyperinsulinaemia[3], insulin resistance[4] and diabetes[5,6]. In fact, the components of IRS particularly hyperinsulinaemia have been shown to have a contributing role for coronary events in Asian Indians[7,8]. However, very few studies have reported on the prevalence of IRS as a whole in the native Indian population based on epidemiological studies. This is particularly relevant as India has the maximum number of diabetic patients in any given country in the world[5].

Though urban-rural differences have been reported in the prevalence of diabetes in Indians[9], not many studies have looked at the differences in the prevalence of IRS within an urban environment. The aim of the present study was to assess the prevalence of insulin resistance syndrome among people from different socio-economic groups in an urban south Indian population.

Material & Methods

The Chennai Urban Population Study (CUPS) is an ongoing epidemiological study in Chennai (formerly Madras), India. The aim of this study was to obtain prevalence data on diabetes and its various complications among people of different socio-economic strata in urban Chennai. The methodological details of the study have been published elsewhere[10]. Briefly, two residential colonies at Tirumangalam and T. Nagar representing the middle income and lower income groups respectively in Chennai were selected for the study. An initial survey was done in all family members using a questionnaire to obtain the basic census details such as number of individuals, age, sex and presence or absence of diabetes in every household in the two colonies.

All individuals aged 20 yr and above living in these colonies were then invited to participate in a screening programme. A total of 479 of the 524 eligible subjects in the Tirumangalam colony (91.4% response rate) and 783 of the 875 eligible subjects in the T. Nagar colony (89.4% response rate) participated in the study.

A fasting blood sample was taken for estimation of glucose, lipids and insulin following which an oral glucose load (75 g) was administered to all individuals (excluding known diabetic subjects) and a 2 h post glucose plasma sample was also obtained. All blood samples were transported to the M.V. Diabetes Specialities Centre within 2-3 h in ice boxes for analysis which was carried out immediately.

All biochemical assays were carried out using a Corning Express Plus Auto Analyser (Corning, Medfield, MA, USA) using kits supplied by Boehringer Mannheim (Mannheim, Germany). Fasting and postprandial plasma glucose (GOD-POD method)[11], serum cholesterol (CHOD-PAP method)[12] and serum triglycerides (GPO-PAP method)[13] were measured. HDL cholesterol (after precipitation of LDL and chylomicrons) using phosphotungstic acid was measured with a commercial kit (Boehringer Mannheim, Germany)[14]. Plasma insulin levels were estimated by enzyme linked immunosorbent assay using the Dako kit (DAKO Diagnostic Ltd., Denmark). The intra-assay and the inter-assay co-efficient of variation for insulin assay were 5.7 and 8.9 per cent respectively and the lower detection limit was 0.5 μIU/ml.

Physical activity: Study individuals were categorized based on a physical activity (PA) questionnaire. The questionnaire included job related and leisure time activities and specific questions on exercise[15]. The following questions were asked (*i*) How do you get to work? (*ii*) Overall is your work very demanding/ fairly demanding/not demanding? (*iii*) How many days per week do you take exercise and what type of exercise? and (*iv*) How much do you walk during the whole day? The physical activity was then graded as light, moderate and heavy, using a scoring system[10].

Income: The monthly income of the family was recorded which was the combined income of husband and wife taken as a single unit. Family income was graded as 1 (≤ Rs.1000), 2 (Rs.1001-5000), 3 (Rs.5001-10,000) and 4 (> Rs.10,000).

Smoking and alcohol consumption: Individuals were classified as non-smokers if they had never smoked, ex-smokers if they had smoked until one year earlier to the survey, and current smokers (habitual smokers regardless of quantity smoked). Pack years of smoking was calculated as the number of cigarettes smoked per year divided by 10. Alcohol intake was categorized as none, social (if occasional drinkers) and regular (individuals who admitted to take alcohol everyday regardless of the quantity consumed).

Anthropometric measurements: Height was measured with a tape to the nearest 0.1 cm. Subjects

were requested to stand without shoes and stand upright with the back against the wall, heels together and eyes directed forward.

Weight was measured with a traditional balance (Kohinoor, Pune, India), which was kept on a firm horizontal surface. The scale was checked every day and calibration was done with an individual of 'known' weight. The subjects were asked to wear light clothing, weight was recorded to the nearest 0.1 kg. Body mass index (BMI) was calculated using the formula: weight (kg)/height (m^2).

Waist circumference was measured using a non-stretchable fibre measure tape. The subjects were requested to stand erect in a relaxed position. One layer of light clothing was accepted. Waist circumference was measured at the mid point between the iliac crest and the lower margin of the ribs. Waist circumference was measured to the nearest 0.5 cm.

For hip measurements, the subjects were asked to stand erect in a relaxed position with their feet together. Hip girth was recorded at the greater trochanter (the widest portion of the hip) on both sides. Measurements were made to the nearest 0.5 cm. The waist to hip ratio (WHR) was calculated.

Blood pressure measurements: Blood pressure was recorded in the sitting position, in the right arm to the nearest 2 mm Hg with a mercury sphygmomanometer. Two readings were taken 5 min apart and the mean of the two was taken as the blood pressure[10].

Dietary profile: Food frequency questionnaire[16], three day 24 h diet recall and weighment of raw foods were used to determine the dietary pattern[17,18]. The mean food intake per day was calculated using food frequency questionnaire and 24 h diet recall. The nutrient intake was calculated based on the average value of foods per 100 kg.

Definitions

Diabetes - Diabetes was diagnosed based on drug treatment for diabetes (insulin or oral hypoglycaemic agents) and/or criteria laid by the WHO,[19] *i.e.*, fasting plasma glucose (FPG) ≥126 mg/dl (≥ 7.0 mmol/l) and/or 2 h post glucose value ≥ 200 mg/dl (≥ 11.0 mmol/l).

Hypertension - Hypertension was diagnosed in all subjects who reported to be known hypertensives and were under antihypertensive medication and/or had systolic blood pressure (SBP) of 140 mmHg or greater and/or diastolic blood pressure (DBP) of 90 mmHg or greater[20].

Dyslipidaemia - Dyslipidaemia was diagnosed if serum cholesterol levels were greater than 200 mg/dl (5.2 mmol/l) and/or serum triglyceride levels were greater than 200 mg/dl (2.26 mmol/l) and/or HDL cholesterol levels were less than 35 mg/dl (0.91 mmol/l)[21].

Central body obesity - Central body obesity was defined as WHR > 0.9 for males and > 0.85 for females[21].

Insulin resistance - Insulin resistance was calculated using the homeostasis assessment (HOMA) model[22] using the formula: Fasting insulin (μIU/ml) X fasting glucose (mmol/l)/22.5. Subjects whose HOMA insulin resistance values exceeded the 75th percentile of the total population (*i.e.*, 1.93) were considered to have insulin resistance.

Insulin resistance syndrome - Insulin resistance syndrome was defined in accordance with the recently published criteria proposed by the European Group for the Study of Insulin Resistance[23] as follows: presence of HOMA insulin resistance (IR) in combination with at least two of the following conditions, hyperglycaemia, hypertension, dyslipidaemia or central body obesity.

Of the 1262 individuals involved in CUPS, 1070 subjects (76.5%) who had a complete data set (inclusive of anthropometric measurements, oral glucose tolerance test, blood pressure, lipid parameters and fasting insulin values) were included for the study. There was no difference between the 1070 responders and 192 non-responders with respect to age, sex distribution, body mass index and waist to hip ratio.

Statistical analysis: Windows based SPSS (Chicago, IL) was used for the statistical analysis. 95 per cent confidence intervals for proportions were calculated using square root method[24]. Chi-square test and two-tailed *P* values were used to compare proportions among groups. The quartiles of HOMA IR was determined to analyze the association of various risk factor with IR in a fashion similar to that described by Barbieri *et al*[25]. Univariate regression analysis was done using age, sex, pack years of smoking, physical activity, income grade and socio-economic status as independent variables. The continuous variables were transformed into categorical variables for multiple logistic regression analysis. The independent variables which had a significant association with IRS ($P<0.05$) on univariate analysis were used for risk factor analysis in multiple logistic regression analysis.

Results

Baseline characteristics: The Tirumangalam subjects, both males and females were significantly older than the T. Nagar subjects ($P<0.001$). The Tirumangalam individuals had significantly higher BMI and waist hip ratios, systolic and diastolic BP compared to the T. Nagar subjects. Pack years of smoking was significantly higher in the T. Nagar group compared to the Tirumangalam group ($P<0.05$). Regular alcohol consumption was more common among the T. Nagar population compared to the Tirumangalam population ($P<0.001$; Table I).

Prevalence of IRS: Overall 11.2 per cent (120/1070, 95% confidence intervals: 9.4 - 13.3) of the population had evidence of IRS. The middle income group (18.7%) (77/411, 95% CI : 15.1-22.9) had a

Table I. Demographic, behavioral and baseline details on the study population

	Males		Females	
	T. Nagar	Tirumangalam	T. Nagar	Tirumangalam
n	287	177	372	234
Age (yr)	37±14	50±13**	41±14	48±14**
Systolic blood pressure (mm Hg)	117±22	129±14**	120±21	125±16**
Diastolic blood pressure (mm Hg)	76±14	83±10**	77±13	79±9*
Waist hip ratio	0.86±0.07	0.92±0.62**	0.80±0.08	0.82±0.08**
Body mass index (kg/m^2)	20.4±4.1	23.8±3.5**	22.5±4.5	24.6±4.3**
Smoking:				
Ex-smokers n (%)	19 (6.6%)	13 (7.3%)	-	-
Current smokers n (%)	119 (41.5%)	21 (11.9%)**	-	-
Pack years of smoking	23.4±22.2	19.2±17.3*	-	-
Alcohol:				
Regular n (%)	84 (29.3%)	22 (12.4%)**	-	-
Social n (%)	107 (37.3%)	49 (27.7%)*	-	-
Physical activity grade:				
Heavy n (%)	105 (36.6%)	9 (5.1%)**	110 (29.6%)	6 (2.6%)**
Moderate n (%)	148 (51.6%)	76 (42.9%)	78 (20.9%)	57 (24.4%)
Light n (%)	41 (14.3%)	92 (52.0%)**	181 (48.7%)	171 (73.1%)**

*$P<0.05$, **$P<0.001$ compared to the T. Nagar counterparts

significantly ($P<0.001$) higher prevalence rate of IRS compared to the low income group (6.5%) (43/659, 95% CI: 4.8-8.7).

The prevalence of IRS among males was 12.9 per cent (60/464) and among females 9.9 per cent (60/606). The prevalence of IRS was 8.5 per cent (22/258) in subjects with income grade 1 (income ≤ Rs.1000), 10.5 per cent (61/581) in those with income grade 2 (Rs. 1001-5000), 16.2 per cent (24/148) in those in income grade 3 (Rs.5001-10000), and 15.7 per cent (13/83) in those in income grade 4 (income > Rs.10000). This increase was significant (trend Chi square - 6.4, $P=0.01$).

The prevalence of IRS was 6.5 per cent (15/230) in subjects with heavy grade physical activity, 10.3 per cent (37/359) in those with moderate activity and 14.0 per cent (68/485) in those with light activity. The trend was significant (trend Chi square - 9.25, $P=0.002$).

The mean monthly income of a family at Tirumangalam was significantly higher compared to a T. Nagar family (Rs.7935±3775 vs Rs.1375±901, $P<0.001$). The Tirumangalam study group consisted of businessmen, professionals, executives and clerical workers while the T. Nagar population consists mostly of manual labourers, maid servants and some clerical workers.

The dietary pattern was determined in a subset of 100 subjects in the Tirumangalam and T. Nagar groups. There was no significant difference in the daily consumption of carbohydrates between the study groups (281.6±92.5 g/day vs 288.1±101.6 g/day). However, the consumption of calories (1877±400 kcal/day vs 1572±434 kcal/day), proteins (44.1±10.8 g/day vs 38.2±9.5 g/day), fibre (8.6±2.1 vs 4.7±0.8 g/day), total fat (60.7±17.9 g/day vs 32.3±9.3 g/day), saturated fat (15.9±6.4 g/day vs 11.3±5.0 g/day), and sugar (73.1±39.2 kcal/day vs 43.8±15.9 kcal/day) were significantly higher ($P<0.001$) among the Tirumangalam group compared to their T. Nagar counterparts. Thus the Tirumangalam subjects are representative of a higher socio-economic status (middle income group) than the T. Nagar subjects (low income group).

The prevalence of hypertriglyceridaemia was computed against alcohol consumption. In the middle income group, the prevalence of hypertriglyceridaemia among regular drinkers was 22.7 per cent (5/22), among social drinkers 12.2 per cent (6/49) and 12.1 per cent (41/340) among non-drinkers. In the low income group, the prevalence of hypertriglyceridaemia was 11.9 per cent (10/84) among regular drinkers, 10.3 per cent (11/107) among social drinkers and 7.1 per cent (33/468) among non-drinkers. The differences however were not significant.

The prevalence of various components of the IRS by quartiles of insulin resistance as assessed by HOMA IR is shown in Table II. There was a

Table II. Prevalence of various components of the IRS by quartiles of insulin resistance (HOMA IR)

	Quartiles of insulin resistance				Trend Chi^2	*P* value
	I	II	III	IV		
Central body obesity	21.8%	24.1%	33.8%	37.9%	21.8	<0.001
Hypertension	10.9%	14.8%	17.5%	25.3%	20.2	<0.001
Diabetes	4.4%	7.4%	16.7%	23.8%	54.2	<0.001
Hypercholesterolaemia	16.4%	21.0%	27.5%	31.2%	19.4	<0.001
Hypertriglyceridaemia	5.8%	7.0%	13.0%	14.5%	15.2	<0.001
Low HDL cholesterol	38.6%	36.2%	34.6%	33.8%	0.3	0.59

Quartiles of insulin resistance : I - HOMA IR < 0.45; II- HOMA IR 0.45-0.90; III - HOMA IR 0.91 - 1.93; IV - HOMA IR > 1.93
HDL cholesterol, high density lipoprotein cholesterol

significant ($P<0.001$) increase in the prevalence of central body obesity, hypertension, diabetes, hypercholesterolaemia and hypertriglyceridaemia with increase in quartiles of insulin resistance.

Risk factors: Risk factors for IRS are presented in Table III separately for males and females. Body mass index and waist-hip ratio increased significantly with increase in quartiles of insulin resistance both in males and females. Similarly fasting plasma glucose, serum cholesterol, and serum triglycerides showed a gradual increase with increase in quartiles of insulin resistance. An increase in systolic and diastolic blood pressure was also observed with increase in quartiles of insulin resistance.

Univariate regression analysis revealed age, BMI, physical activity, income grade and high socio-economic status to be associated with IRS (Table IV). Thus, the odds ratios (ORs) were 8.2, 15.4 and 11.02 in subjects aged 36-50, 51-65 and >65 yr; 3.2, 6.4 and 10.5 in those with BMI of 20.01-25.00, 25.01-30.00 and >30.00 kg/m^2, and 3.3 in those with high socio-economic status. Those with light physical activity had an OR of 2.5, while those with incomes of Rs. 5001-10,000 and > Rs.10,000 had ORs of 2.08 and 1.99 respectively.

As the different characteristics are correlated, multiple logistic regression was undertaken to determine the independent importance of each. In this analysis, only variables identified as important in the univariate analysis were included; further, to avoid colinearity among variables such as socio-economic status, physical activity and income grade, we considered only socio-economic status. This

Table III. Risk factors of IRS by quartiles of insulin resistance (HOMA IR)

	Male				Female			
	Quartiles of insulin resistance				Quartiles of insulin resistance			
	I	II	III	IV	I	II	III	IV
n	135	105	115	109	140	152	154	160
Age (yr)	39±16	44±16*	41±14	44±14*	40±14	43±15	45±15*	47±14*#
Body mass index (kg/m^2)	20.3±3.5	20.8±4.1	22.8±4.0*#	23.1±4.7*#	21.1±4.0	22.3±4.6*	24.1±4.1*#	25.3±4.4*#‡
Waist hip ratio	0.86±0.07	0.87±0.07	0.89±0.07*	0.91±0.07*#‡	0.81±0.10	0.80±0.06	0.81±0.07	0.82±0.08#
Systolic blood pressure (mm Hg)	122±17	121±16	124±14	124±16	119±17	122±14	123±18*	126±18*#
Diastolic blood pressure (mm Hg)	78±10	79±10	81±19*	82±10*‡	75±8	78±9*	78±10*	80±11*
Fasting blood glucose (mg/dl)	68±16	81±33*	87±37*	111±74*#‡	75±15	83±24*	92±41*#	107±61*#‡
Serum cholesterol (mg/dl)	158±33	169±41*	175±43*	180±37*#	170±36	176±36	183±43*	189±41*#
Serum triglycerides (mg/dl)	114±72	115±57	130±75	149±114*#	93±44	105±50*	124±76*#	127±63*#
HDL cholesterol (mg/dl)	37±9	37±9	36±8	37±8	43±10	42±11	43±11	41±10
Activity grade:								
Heavy (%)	25.2	27.6	24.3	20.0	21.4	25.6	21.4	13.7#
Moderate (%)	53.3	48.6	45.2	40.4*	20.7	24.3	22.1	20.6
Light (%)	21.5	23.8	30.4	37.6*#	57.9	50.0	56.5	65.6#‡

Quartiles of insulin resistance : I-HOMA IR < 0.45; II-HOMA IR 0.45-0.90; III-HOMA IR 0.91-1.93; IV-HOMA IR > 1.93. HDL cholesterol, high density lipoprotein cholesterol. *$P<0.05$ compared with first quartile; #$P<0.05$ compared with second quartile; ‡$P<0.05$ compared with third quartile

Table IV. Association of risk variables with IRS based on an univariate regression analysis

Variable	Odds ratio	95% Confidence intervals	*P* value
Age (yr):			
≤ 35	Reference		
36-50	8.24	3.69 - 18.41	< 0.001
51-65	15.45	6.82 - 34.97	< 0.001
>65	11.02	4.47 - 27.19	< 0.001
Body mass index (kg/m^2):			
≤20	Reference		
20.01-25.00	3.22	1.64 - 6.32	< 0.001
25.01-30.00	6.45	3.26 - 12.75	< 0.001
> 30	10.54	4.64 - 23.94	< 0.001
Pack years of smoking (yr):			
0	Reference		
0.1-5.0	0.92	0.46 - 1.84	0.82
5.01-15.0	0.75	0.24 - 2.80	0.75
> 15	0.20	0.71 - 5.08	0.20
Physical activity:			
Heavy	Reference		
Moderate	1.75	0.94 - 3.3	0.077
Light	2.50	1.38 - 4.42	0.0023
Income grade (Rs.):			
≤ 1000/-	Reference		
1001-5000/-	1.25	0.75 - 2.09	0.378
5001-10,000/-	2.08	1.12 - 3.85	0.02
> 10,000/-	1.99	0.95 - 4.1	0.06
Sex:			
Female	Reference		
Male	1.35	0.92 - 2.0	0.12
Socio-economic status:			
Low (T. Nagar)	Reference		
High (Tirumangalam)	3.3	2.2 - 4.9	<0.001

analysis confirmed that age, BMI and socio-economic status are significant prognostic factors but all the adjusted ORs were smaller. Thus, the adjusted ORs were 5.40, 10.72 and 7.93 for those aged 36-50, 51-65 and > 65 yr; 2.04, 3.77 and 6.74 for those with BMI of 20.01-25.00, 25.01-30.00 and >30.00 kg/m^2, and 1.7 for those with high socio-economic status (Table V).

Discussion

The overall prevalence of IRS among the study population was 11.2 per cent which is high compared to that reported in Mexicans (3.0%)[26] and Japanese (1.6%)[27]. Earlier studies have indicated that there are racial and ethnic differences in the prevalence of the components of the metabolic syndrome

Table V. Multiple logistic regression analysis using IRS as a dependent variable

Variable	β	SE	*P* value	OR (95% CI)
Age (yr):				
≤ 35	Reference			
36-50	1.69	0.4199	< 0.001	5.40 (2.37 - 12.29)
51-65	2.37	0.4271	< 0.001	10.72 (4.64 - 24.75)
> 65	2.07	0.4754	< 0.001	7.93 (3.12 - 20.14)
Body mass index (kg/m^2):				
≤ 20	Reference			
20.01-25.00	0.72	0.3580	0.046	2.04 (1.01 - 4.12)
25.01-30.00	1.33	0.3654	<0.001	3.77 (1.84 - 7.71)
> 30	1.91	0.4395	<0.001	6.74 (2.85 - 15.94)
Socio-economic status:				
Low (T. Nagar)	Reference			
High (Tirumangalam)	0.54	0.219	0.014	1.7 (1.11 - 2.6)

OR, Odds ratio; CI, Confidence interval

particularly diabetes and coronary artery disease[5-7]. Further, Indians have been shown to have a greater propensity to both these diseases compared to other ethnic populations[3-7]. In addition, studies have also revealed that Asian Indians are more insulin resistant than Caucasians, independent of their generalized or truncal adiposity[28]. Genetic predisposition could be one of the explanations for this escalation in prevalence of the components of the metabolic syndrome in Indians although it is most likely to represent rapid urbanization. Studies on the relationship of birth weight with IRS variables in Indian children revealed that a lower birth weight is associated with insulin resistance[2]. It has been hypothesized that lower birth weight followed by increased obesity could lead to IRS during adulthood[2]. Thus the rapid increase in the prevalence of IRS could be due to rapid changes consequent to affluence and urbanization that is occurring in India[10].

We had earlier reported significant differences in the prevalence of the individual components of the metabolic syndrome between the middle and low income groups in the same population[10]. Very recently the European group for study of insulin resistance (EGIR) has laid down comprehensive criteria for a standardized definition of the Insulin Resistance Syndrome[23]. Since the publication of this report, very few papers have been published looking at IRS in different populations using the EGIR criteria. The CUPS study provided an unique opportunity to compare IRS in two socio-economic groups within an urban environment using the EGIR criteria. The prevalence of IRS was significantly higher among the middle income group compared to the low income group (P<0.001). There is also a strong association between the actual income and the prevalence of insulin resistance syndrome.

This finding is of great interest because studies from developed countries have shown an inverse relation between socio-economic status and IRS *i.e.*, a higher prevalence of the metabolic syndrome in the individuals of low socio-economic status[29]. An explanation for this paradox is the difference in the stage of epidemiological transition between developing and developed countries[30]. In developing

countries affluence is associated with a sedentary life-style and excess of fat and calorie consumption. In contrast, affluence in developed countries is associated with better education and health awareness and hence greater physical activity which leads to a reduction in the prevalence of the metabolic syndrome. According to the "genetically unknown foods" hypothesis, adopting western dietary habits with a high fat and sucrose intake could lead to an epidemic of the IRS[31]. This is what is presently occurring in India and other developing countries.

In summary, the results of the present study suggest that the overall prevalence of the IRS is high in this selected urban south Indian population and significant differences exist in its prevalence among different socio-economic groups even within an urban environment. It is possible that by diet, exercise and changes in life-style, the prevalence of IRS can be reduced and such a preventive strategy is the urgent need of the hour in our country which is facing a twin epidemic of diabetes and coronary artery disease.

References

1. Reaven GM. Banting lecture 1988. Role of insulin resistance in human disease. *Diabetes* 1988; *37* : 1595-607.
2. Yajnik CS. The insulin resistance epidemic in India: fetal origins, later lifestyle or both? *Nutr Rev* 2001; *59* : 1-9.
3. Mohan V, Sharp PS, Cloke HR, Burrin JM, Schumer B, Kohner EM. Serum immunoreactive insulin responses to a glucose load in Asian Indian and European Type 2 (non-insulin-dependent) diabetic patients and control subjects. *Diabetologia* 1986; *29* : 235-7.
4. Sharp PS, Mohan V, Levy JC, Mather HM, Kohner EM. Insulin resistance in patients of Asian Indian and European origin with non-insulin dependent diabetes. *Horm Metab Res* 1987; *19* : 84-5.
5. King H, Aubert RE, Herman WH. Global burden of diabetes, 1995-2025—prevalence, numerical estimates, and projections. *Diabetes Care* 1998; *21* : 1414-31.
6. Misra A, Pandey RM, Rama Devi J, Sharma R, Vikram NK, Khanna N. High prevalence of diabetes, obesity and dyslipidaemia in urban slum population in northern India. *Int J Obes* 2001; *25* : 1722-9.
7. Mckeigue PM, Miller GJ, Marmot MG. Coronary heart disease in South Asian overseas: a review. *J Clin Epidemiol* 1989; *42* : 597-609.
8. Misra A, Shukla P, Reddy KS, Lall SB, Peshin SS, Pandey RM. Serum insulin levels in non-obese, non-diabetic Asian Indians with acute coronary and non-coronary events. *Indian Heart J* 2000; *52* : 280-4.
9. Ramachandran A, Snehalatha C, Dharmaraj D, Viswanathan M. Prevalence of glucose intolerance in Asian Indians. Urban-rural difference and significance of upper body adiposity. *Diabetes Care* 1992; *15* : 1348-55.
10. Mohan V, Shanthirani S, Deepa R, Premalatha G, Sastry NG, Saroja R. Intra urban differences in the prevalence of the metabolic syndrome in southern India - The Chennai Urban Population Study (CUPS Paper No. 4). *Diabet Med* 2001; *18* : 280-7.
11. Trinder P. Determination of blood glucose using 4-amino phenazone as oxygen acceptor. *J Clin Pathol* 1969; *22* : 246.
12. Siedel J, Hagele EO, Ziegenhorn J, Wahlefeld AW. Reagent for the enzymatic determination of serum total cholesterol with improved lipolytic efficiency. *Clin Chem* 1983; *29* : 1075-80.
13. Nagele U, Hagele EO, Sauer G, Wiedemann E, Lehmann P, Wahlefeld AW, *et al*. Reagent for the enzymatic determination of serum total triglycerides with improved lipolytic efficiency. *J Clin Chem Clin Biochem* 1984; *22* : 165-74.
14. Lopes - Virella MF, Stone P, Ellis S, Colwell JA. Cholesterol determination in high-density lipoproteins separated by three different methods. *Clin Chem* 1977; *23*: 882-4.
15. Vaz M, Bharathi AV. Practices and perceptions of physical activity in urban employed, middle-class Indians. *Indian Heart J* 2000; *52* : 301-6.
16. Begum R. *Textbook of foods, nutrition and dietitics*, 2nd ed. Part I *Nutrition. dietary survey.* New Delhi, India : Sterling Publishers (P) Ltd. 1991 p. 354-6.
17. Hebert JR, Hurley TG, Chinboga DE, Barone J. A comparison of selected nutrient intakes derived from three diet assessment methods used in a low-fat maintenance trial. *Public Health Nutr* 1998; *1* : 207-14.
18. Raghuram TC, Pasricha S, Sharma RD. *Diet and diabetes.* 2nd ed. Hyderabad : National Institute of Nutrition (Indian Council of Medical Research); 1993 p. 54-6.
19. Alberti KG, Zimmet PZ. Definition, diagnosis and classification of diabetes mellitus and its complications. Part 1 : Diagnosis and classification of diabetes mellitus, provisional report of a WHO Consultation. *Diabet Med* 1998; *15* : 539-53.
20. The fifth report of the Joint National Committee on Detection, Evaluation and Treatment of High Blood Pressure (JNCV). *Arch Intern Med* 1993; *153* : 154-83.
21. National Cholesterol Education Program. Second report of the Expert Panel on Detection, Evaluation, and Treatment

of High Blood Cholesterol in Adults (Adult Treatment Panel II). *Circulation* 1994; *89* : 1329-445.

22. Matthews DR, Hosker JP, Rudenski AS, Naylor BA, Treacher DF, Turner RC. Homeostasis model assessment: insulin resistance and β-cell function from fasting plasma glucose and insulin concentrations in man. *Diabetologia* 1985; *28* : 412-9.
23. Balkau B, Charles MA. Comment on the provisional report from the WHO consultation. European Group for the Study of Insulin Resistance (EGIR). *Diabet Med* 1999; *16* : 442-3.
24. Radhakrishna S, Murthy BN, Nair NG, Jayabal P, Jayasri R. Confidence intervals in medical research. *Indian J Med Res* 1992; *96* : 199-205.
25. Barbieri M, Ragno E, Benvenuti E, Zito GA, Corsi A, Ferrucci L, *et al*. New aspects of the insulin resistance syndrome: impact on hematological parameters. *Diabetologia* 2001; *44* : 1232-7.
26. Gonzalez Villalpando C, Stern MP, Haffner S, Arredondo Perez B, Martinez Diaz S, Islas Andrade S. The insulin resistance syndrome in Mexico. Prevalence and clinical characteristics: a population based study. *Arch Med Res* 1995; *26* : Spec No. S9-15.
27. Imamura M, Kishitani Y, Saika T, Iio K, Ikami H, Kagita A, *et al*. Epidemiological investigation of insulin resistance syndrome (syndrome X) in a city in Japan. *Clin Exp Pharmacol Physiol* (Suppl) 1995; *1* : S30-1.
28. Chandalia M, Abate N, Garg A, Stray-Gundersen J, Grundy SM. Relationship between generalized and upper body obesity to insulin resistance in Asian Indian men. *J Clin Endocrinol Metab* 1999; *84* : 2329-35.
29. Hazuda HP, Haffner SM, Stern MP, Eifler CW. Effects of acculturation and socioeconomic status on obesity and diabetes in Mexican Americans. The San Antonio Heart Study. *Am J Epidemiol* 1988; *128* : 1289-301.
30. Omran AR. The epidemiologic transition. A theory of the epidemiology of population change. *Milbank Mem Fund Q* 1971; *49* : 509-38.
31. Baschetti R. Diabetes epidemic in newly westernized populations: is it due to thrifty genes or to genetically unknown foods? *J R Soc Med* 1998; *91* : 622-5.

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