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Short Report

Prevalence of Metabolic Syndrome in Two Tribal Populations of the Sub-Himalayan Region of India: Ethnic and Rural–Urban Differences

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ABSTRACT This study was undertaken to estimate prevalence of metabolic syndrome in traditional societies in the sub-Himalayan region and to assess the impact of modernization on the risk to the syndrome. Two tribal populations—Toto and Bhutia—with a shared ancestry and habitat were selected. Some Bhutians have adopted a modern lifestyle. The study design permitted assessment of the relative roles of lifestyle and genetic factors in influencing the prevalence of metabolic syndrome. Our study has revealed that metabolic syndrome (or its contributing variables) can be a major health problem, even in traditional rural ethnic groups, indicating that this syndrome is not necessarily a result of modernization or urbanization. Dyslipidemia seems to be the major contributor to metabolic syndrome. Further, our study indicates that genetic factors that adversely affect the levels of such variables have long antiquities in Indian ethnic groups. We find that there is an additional adverse impact of adoption of urban lifestyles (perhaps primarily mediated through dietary changes) on metabolic syndrome. Am. J. Hum. Biol. 17:814–817, 2005.

Epidemiological studies have recorded a higher prevalence of metabolic syndrome (Deepa et al., 2002; McKeigue et al., 1992; Misra and Vikram, 2002) and cardiovascular mortality (Enas et al., 1996; Kamath et al., 1999; McKeigue et al., 1993) among Indians, including those settled outside of India. A recent review (Misra and Vikram, 2004) has concluded that lifestyle factors, with minimal modulation by inherited factors, are the prime determinants. Although the prevalence of metabolic syndrome, obesity, and dyslipidemia is known to vary across defined ethnic groups (Crossrow and Falkner, 2004), most epidemiological studies have been conducted in conglomerate populations without adequate regard to ethnicity of the sampled individuals (e.g., Deepa et al., 2002; Misra et al., 2002). With a view to assessing the relative roles of environmental (urbanization related modernity of lifestyles) vis-à-vis ethnic factors in the determination of metabolic syndrome, we undertook a study of two tribal groups of India—Toto and Bhutia—who share a common ancestry (Sanyal, 1971) and live in a similar ecological habitat (rural sub-Himalayan region). A large section of one tribe (Bhutia) has adopted a modernized lifestyle and lives in an urban area. The a priori expectation, if indeed environmental factors are of primary importance, is that the prevalence of dyslipidemia, hyperglycemia, and metabolic syndrome will be low and of similar magnitude among the Toto and rural Bhutia (since these are traditional societies) and higher among the urban Bhutia (modernized section). If genetic factors are important, then if the Toto has a high prevalence of these conditions, the rural Bhutia will also have prevalence of a similar magnitude (because of shared ancestry).

The Toto are a demographically small population comprising (as counted in this study) 1,206 individuals (637 males and 569 females). The Bhutia, on the other hand, are a large population and number several million. The Toto are geographically localized in a single village (Totopara) of Jalpaiguri dis-

trict of West Bengal, bordering Bhutan. The Bhutia are geographically widely distributed throughout Bhutan and Sikkim as well as in the Darjeeling district of West Bengal. The Toto are exclusively rural, while the Bhutia live in both rural and urban habitats. As a result of urbanization, dietary habits and lifestyles of the Bhutia have changed in recent decades. For example, while the use of sugar was and continues to be conspicuously low among the rural Bhutia (even tea is consumed without sugar, but with salt), the Bhutia living in urban habitats use considerable quantities of sugar. Both groups consume large quantities of red meat. The Bhutia, but not the Toto, also consume large quantities of milk products. Both the Toto and the rural Bhutia are predominantly engaged in agri-horticultural activities. The urban Bhutia, on the other hand, are predominantly white-collar workers or are engaged in petty businesses and various types of sedentary work. Both Toto and Bhutia possess Mongoloid morphological features and speak dialects that belong to the Tibeto–Burman linguistic family (Grierson, 1927).

MATERIALS AND METHODS

After obtaining institutional ethical approval, we collected data and blood samples, with written informed consent, from Totos above 20 years of age, numbering 258 individuals (127 males and 131 females). Although biospecimens and data were collected from about 90% of individuals belonging to this group, only a subset of the complete data—avoiding inclusion of data on first-degree relatives—have been analyzed for this report. Bhutians living in Sikkim were sampled with informed consent from both rural and urban (inclusion criterion for urban Bhutia was that the individual should have been living in Gangtok, the capital town of Sikkim, or vicinity for at least 10 years continuously) habitats. A total of 75 unrelated individuals (29 males and 46 females) were sampled from the rural habitat (Ralong revenue block, located in the South district), and 230 individuals (102 males and 128 females) were sampled from the urban habitat. All sampled individuals were above 20 years of age. The sampled individuals from the rural habitat represents nearly all unrelated adults of the Ralong revenue block, while the individuals (sampled using a systematic sampling scheme) from Gangtok represent a small fraction of the total Bhutia population living in Gangtok. Self-reported ages of the individuals were cross-ascertained with reference to the major local events or with reference to the traditional Bhutia calendar, especially when records for date of birth were unavailable.

From each individual, we collected relevant demographic (age, sex, education, marital status, etc.) and lifestyle (occupation, food habit, tobacco and alcohol usage, etc.) information using a questionnaire. Anthropometric data were collected from each individual using standard methodology (Lohman et al., 1988). These included height, weight, and waist circumference (WC). Body mass index (BMI) was calculated as weight (in kg)/height^2 (in meter^2). Blood pressure—both systolic (SBP) and diastolic (DBP)—were measured, using a mercury sphygmomanometer, in sitting position. Blood pressure was measured twice, with an interval of 5 min of resting between measurements. The average of two measurements was considered.

Blood samples were collected from each individual by venipuncture, after a overnight fasting. Clinical biochemistry analyses were performed, and levels of the following parameters were determined: fasting blood glucose (FBG), total cholesterol (TCHOL), high-density lipoprotein cholesterol (HDLC), low-density lipoprotein cholesterol (LDLC), very low-density lipoprotein cholesterol (VLDLC), and triglycerides (TG). The VLDLC value was obtained by subtraction of HLDC and LDLC values from TCHOL. An individual was considered to be suffering from metabolic syndrome if the s(he) satisfied at least three of the following five criteria (NCEP, 2001): (a) waist circumference > 102 cm (for a male) or > 88 cm (for a female); (b) triglyceride level $\geq$ 150 mg/dl; (c) HDL cholesterol level < 40 mg/dl (for a male) or <50 mg/dl (for a female); (d) blood pressure (SBP/DBP) $\geq$ 130/85 mmHg; and (e) fasting glucose $\geq$ 110 mg/dl.

Test of proportions, χ^2, and t-tests were performed to determine the statistical significance of differences between the study groups with respect to prevalence of metabolic syndrome and other morbidities that are linked to it. Age- and sex-adjusted stepwise linear regression analysis was performed to identify significant predictors of parameters that underlie metabolic syndrome.

RESULTS AND DISCUSSION

Percentages of sampled individuals who exceeded the cut-off values of the variables pertinent to metabolic syndrome, among the Toto and the Bhutia (urban and rural), by sex are presented in Table 1. The last row of this table provides the percentages of sampled individuals suffering from metabolic syndrome. The prevalence of metabolic syndrome is alarmingly high (28–52%) among both the rural and the urban Bhutia. The rural–urban difference is not statistically significant ($P = 0.055$; Fisher's exact test). The prevalence is significantly ($P < 0.05$) higher among females (50%) than among males (30%) in both locations. Rural Bhutia have significantly ($P < 0.01$) higher prevalence of metabolic syndrome compared to Toto. No statistically significant gender difference in prevalence was observed for the rural Bhutia or the Toto, but the urban Bhutia females have a significantly higher ($P = 0.032$) prevalence (48%) than males (34%). The prevalence of metabolic syndrome (4–9%) among the Toto is not high.

To investigate impacts of relevant parameters on the components of metabolic syndrome we carried out multiple linear regression after adjusting for age and sex effects. Using the anthropometric variables as independents, and blood pressures and biochemical variables (log-transformed) as independents, our analyses showed that while BMI is a significant predictor of systolic blood pressure and several biochemical variables (LDLC, VLDLC, TG, and FBG) in case of Bhutia, waist and hip circumferences or their ratio (WHR) are significant predictors of most biochemical variables among the Toto (results not shown). Among the Toto, central obesity, therefore, is a significant correlate of lipid and blood sugar levels, while among the Bhutia overall adiposity and obesity are the significant correlates.

We also carried out a logistic regression analysis with metabolic syndrome as a binary (affected/unaffected) variable, with the anthropometric and biochemical variables as independents and with age and gender as covariates. Among Toto and rural Bhutia, we found that the only significant predictor was FBG [Wald statistic values were 6.1 ($P = 0.010$) for Toto and 4.0 ($P = 0.045$) for rural Bhutia], while among the urban Bhutia the only significant predictor was BMI [Wald statistic value = 4.0 ($P = 0.046$)].

The Toto and the Bhutia, who have descended from a common ancestral population, show marked differences in prevalence of metabolic syndrome, primarily due to dyslipidemia, and in mean values of its component variables. This indicates that environmental factors have large effects on determining susceptibility to metabolic syndrome. Our results indicating large differences in prevalence and in mean values in component variables between rural and urban Bhutia bolsters this view. This finding corroborates that of Rakugi and Ogihara (2005) in the Asian population. Dietary changes resulting from urbanization are possibly responsible for adversely affecting the mean levels of lipids and other relevant parameters, as evidenced by our data on rural and urban Bhutia. There are two possible reasons for the large difference in prevalence of metabolic syndrome between the Toto and rural Bhutia: (a) founder effect among the demographically small Toto resulting in genetic homogeneity for non-predisposing genes, and (b) high levels of consumption of dairy products among the Bhutia but not among the Toto. We are conducting further studies

TABLE 1. Percentages of unrelated adults suffering from metabolic syndrome and its component variables among Totos and Bhutias, by sex

	Toto		Rural Bhutia		Urban Bhutia	
Metabolic syndrome criteria	M (127)	F (131)	M (29)	F (46)	M (102)	F (128)
WC (M > 102 cm; F > 88 cm)	0.00	1.53	0.00	17.39	3.92	47.66
TG (≥150 mg/dl)	47.24	36.64	27.59	23.91	64.71	37.50
HDLC (M < 40 mg/dl; F < 50 mg/dl)	53.54	66.41	82.76	100.00	64.71	99.22
SBP (≥130 mmHg)	18.11	11.45	55.17	52.17	60.78	46.09
DBP (≥85 mmHg)	16.54	9.92	34.48	36.96	60.78	39.06
FBG (≥110 mg/dl)	3.15	0.76	20.70	41.30	19.61	7.03
Metabolic syndrome	8.66	3.82	27.60	52.17	34.31	48.44

to investigate these possibilities. However, our study clearly demonstrates that metabolic syndrome can be a major health problem even in traditional societies, as well as in an Indian urban cosmopolitan population (Gupta et al., 2004), suggesting that this syndrome is not necessarily a result of modernization or urbanization.

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