Efficacy of Obesity Indices and Age in Predicting Diabetes: Study on a Transitional Tribe of Northeast India

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Objective: To evaluate the association between blood sugar level and obesity, and the interplay of socioeconomic change, and to investigate the efficacy of different obesity indices and age in predicting diabetes.

Methods: Cross-sectional study was carried out among 603 adult Tangkhul Nagas of NE India. Anthropometric measurements, random blood sugar level, general and regional obesity indices were evaluated along with their information on socioeconomic and lifestyle factors.

Results: Socioeconomic change observed among the Tangkhuls influence the rise of overweight/obesity and blood sugar level. Obesity and elevated blood sugar level were highly prevalent and interrelated. Diabetes and obesity were also found to be associated with age. Central obesity indices were highly associated with blood sugar level. Odds ratio showed the likelihood of developing prediabetes/diabetes among centrally obese participants. Correlation between blood sugar level, age and obesity indices showed that waist hip ratio had the highest correlation with blood sugar. It implies the higher reliability of central obesity than general obesity or age in determining blood sugar level.

Conclusion: The transition of the Tangkhul Naga tribe in terms of socioeconomic and lifestyle factors contributes to the escalating prevalence of overweight/obesity and diabetes. The rising epidemic is not restricted to highly urbanized societies but now has penetrated even to traditional and transitional tribes owing to their changing lifestyle. Different facets of the complex associations between obesity, age, diabetes and socioeconomic change were observed. Central obesity indicator, waist hip ratio emerge as the paramount predictors of prediabetes/diabetes. (*Ethn Dis.* 2014;24[3]:342–348)

Key Words: Diabetes, Obesity, Age, Socioeconomic Change, Tribe

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Introduction

Diabetes and obesity are the biggest public health challenge of the 21st century.[1] Obesity is becoming a major public health problem throughout the world and is associated with significant, potentially life-threatening co-morbidities. The nutritional disorder is associated with most of the components of metabolic syndrome, the leading cause of type 2 diabetes[2] and it appears to stimulate the development of diabetes mellitus, and weight loss appears to reduce the risk of this disease.[3,4]

The high proportion of undiagnosed cases of diabetes, complications at clinical diagnosis, and long latent phase of the disease are strong arguments for screening.[5] Type 2 diabetes is common, costly and often goes unrecognized for many years. Evidence is accumulating that earlier detection and management of diabetes and related metabolic abnormalities may be beneficial. Age, sex, body mass index, steroid and antihypertensive medication, family and smoking history contributed to identifying those at risk of diabetes.[6]

Prevalence of diabetes mellitus is increasing rapidly worldwide and countries like India face a major challenge to restrain growth of the disease with 63 million patients with diabetes.[7] With increasing prevalence of diabetes in India, it is important to ascertain its cause and associated factors. In our study, associations of diabetes with different obesity indices were evaluated to assess the efficacy of obesity indices in predicting blood sugar level. Interactions between age, obesity and diabetes were evaluated.

In India, the traditional tribes represent a substantial percent of the country's population but only few tribes, especially in the northeastern region, have been explored. Studies attempting to understand the relationships between change in socioeconomic factors, traditional practices, and its influence on body composition and health are scarce in spite of growing urbanization and social change in the region. An in-depth study related to lifestyle change and health outcomes of the Tangkhul Nagas, a tribe in transitional stage, had not been conducted earlier and hence the present effort.

Participants and Methods

A cross-sectional study was carried out among 603 Tangkhul Nagas, aged 20–70 years. Participants were divided into five decadal age groups to study age trend. Complete personal information and anthropometric measurements were taken on all the participants, except for random blood sugar in which 292 participants (122 males and 170 females) were taken. All experiments were performed in accordance with relevant guidelines and regulations.

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Tangkhul Naga is one of the subgroups of Naga tribe inhabiting Ukhrul district of Manipur, Northeast India. The Nagas are a conglomerate of more than sixty sub-tribes sharing common cultural traits, political system, legends and physical features, though there are some variations. In Manipur, Tangkhul Nagas are the second largest tribe. Nagas are Mongoloid and settled in Northeastern region of India as well as in Western parts of Myanmar. The region occupies a distinctive place due to its geographical, historical, social, cultural, and political features.

The population of Tangkhul Naga is 146,075 and literacy rate is 72.7%. With urbanization and economic development there has been nutritional and socioeconomic transition in terms of occupation, education and income.[8] Traditionally the Tangkhuls were agricultural-based and had habitually active lifestyles. The advent of Christianity and Western education in later part of the 19th century played a major role in transformation of the tribe. The Tangkhul tribe has been undergoing transformation in every sphere of their lives, in terms of socioeconomic factors, religion, traditional practices, dietary habits, habitual activity and overall lifestyle. This transition has brought about changes in their body composition and functions as well as health.

Methods

Height, weight, waist circumference (WC), hip circumference, random blood sugar level, general and regional obesity indices (ie, body mass index [BMI], waist hip ratio [WHR] and waist stature [height] ratio [WSR] were evaluated. A door-to-door survey was carried out among Tangkhul Nagas. The data collected were analyzed using SPSS 13.0 for descriptive statistics, t-test, correlation and multinomial logistic regression analyses.

Anthropometric measurements were taken using standard protocols given by Weiner and Lourie.[9] Height was measured

by anthropometer to nearest .1 cm and body weight was measured using portable spring weighing machine with least count of .5 kg. Waist circumference was measured with a steel tape at the narrowest portion of participant's waist. Hip circumference was measured at the maximum circumference of hips. Accucheck active glucometer were utilized for measuring blood glucose by collecting a drop of blood from finger tip of the participant.

Body mass index was assessed using recommended cut-off points for Asians.[10] A WHR of .9 for males and .8 for females, and WC ≥90 cm in men and ≥80 cm in women were used to define central obesity.[11] Optimal WSR cutoff value recommended was .48 for both men and women.[12] Normal level of sugar in blood was between 70–140 mg/dL. Blood sugar level ≥140 mg/dL was considered pre-diabetic and ≥200 mg/dL as diabetic.[13,14]

RESULTS

Table 1 demonstrates height, body weight and BMI of the Tangkhuls in different age groups. Mean height increased from oldest to the youngest age group in each decade; males were found to be significantly taller and heavier than females. Weight and BMI showed an increasing trend from youngest till middle age and then declined in both sexes. Differences in BMI were significant between most of the age groups. Body mass index was higher in females (21.2 kg/m^2) than males (20.9 kg/m^2) but differences were not significant.

Distribution of participants in different BMI categories is shown in Table 2. The greatest number of participants had normal BMI. Among males, there were 16% overweight, 1.6% obese and 14.4% underweight. In females, there were 16.2% underweight, 25.1% overweight and 2.0% obese participants. The prevalence of overweight/obesity was much higher in females (27.1%) than males (17.6%).

Table 3 shows age trends in central obesity indices. Waist circumference was greater in males than females in the middle age groups while in other age groups it was greater in females; both differences were not significant Waist to hip ratio and waist to height (stature) ration showed an increasing trend with advancing age until the fifth decade, after which they declined in both sexes. The highest values were found the 50–59 years group while the lowest were in in the 20–29 years group.

The prevalence of central obesity among Tangkhul Nagas was assessed from WC, WHR and WSR. As assessed from WC, there were 7% males and 35% females who were centrally obese. According to WSR, the prevalence of central obesity among males was 40.9% while in females, it was 66.5%. Assessment of WHR showed the prevalence of central obesity among males to be 34.6% and 59.2% in females. All the central obesity indices showed that females had much higher percentage of central obesity than males (data not shown).

Random blood sugar level test showed that the mean value was 112.3 mg/dL among males and 113.7 mg/dL among females (Table 4). Blood sugar level increased from youngest to oldest age groups with a slight fluctuation among females while there was no clear trend among males. The decadal differences in mean blood sugar level were found statistically non-significant between most of the age groups. Blood sugar level was found to be greater among females in most of the age groups but a significant sex difference was found only in 30–39 years group.

Table 4 also shows the distribution of participants according to blood sugar level. Most of the participants had normal blood sugar level. There were more participants with high than low blood sugar level. Among males, there were 10.7% prediabetic and 2.5% diabetic participants. Among females,

Table 1. Height, body weight and BMI of the participants

Age group, years	Males Mean	± SD	t^a	Females Mean	±SD	t^a	t^b
Height, cm							
20–29	164.0	6.16		153.2	5.67		12.74[e]
30–39	162.3	4.67	1.85	151.9	4.70	1.78	13.16[e]
40–49	161.7	5.33	.59	151.9	5.53	0.01	8.57[e]
50–59	161.6	5.40	.03	149.9	4.67	2.07[c]	10.59[e]
60–70	156.9	5.35	3.59[e]	146.6	4.48	3.51[e]	9.23[e]
Total	162.0	5.94		151.3	5.50		22.93[e]
Body weight, kg							
20–29	54.1	5.65		48.2	6.57		6.72[e]
30–39	56.1	5.60	2.13[c]	48.6	7.05	.44	6.76[e]
40–49	58.2	7.95	1.51	50.9	7.79	1.86	4.46[e]
50–59	57.5	10.87	.32	50.6	8.06	.21	3.34[d]
60–70	49.9	7.14	3.39[e]	44.1	7.21	4.03[e]	3.50[e]
Total	54.9	7.40		48.7	7.49		10.23[e]
Body mass index, kg/m²							
20–29	20.1	1.78		20.5	2.35		1.34
30–39	21.3	1.93	3.89[e]	21.1	2.75	1.52	.53
40–49	22.3	2.62	2.00[c]	22.0	2.47	2.09[c]	.51
50–59	21.9	3.2	.48	22.5	3.18	.96	.80
60–70	20.3	2.37	2.39[d]	20.5	2.97	3.06[d]	.46
Total	20.9	2.39		21.2	2.78		1.50

[a] Between age groups.
[b] Between males and females.
[c] $P<.05$.
[d] $P<.01$.
[e] $P<.001$.

7.6% participants were prediabetic while 2.9% were diabetic. The prevalence of high blood sugar level was greater among males whereas females were slightly more likely diabetic. Low blood sugar level was found only among the younger age groups in both sexes while diabetic participants were found only among the three oldest age groups in both sexes.

Table 5 shows blood sugar level assessment according to different obesity indices. Assessing mean blood sugar level of participants in different categories of obesity indices shows that blood sugar level increased with increasing BMI from underweight to normal weight in males while in females it increased until overweight. Blood sugar level assessed according to WC was higher in centrally obese participants than those in the normal category of both sexes. Waist/ height (stature) ratio and WHR also showed higher values of blood sugar among centrally obese participants than those who were below the cutoff point in both sexes. Blood sugar level increased with increasing values of central obesity indices.

Table 5 also displays the odds ratio for predicting high blood sugar level using obesity indices as the independent/predicting variables. Normal categories of obesity indices (ie, BMI, WHR, WSR, WC) as well as blood sugar level were taken as reference categories for multinomial regression. As assessed from BMI, overweight/obese participants had greater odds of high blood sugar than those with normal BMI in both sexes. The waist circumference index showed that centrally obese participants had .83 times more chance in males and 2.43 times more chance in females to have high blood sugar level than those in normal category. The waist to hip ratio showed centrally obese males had 2.51 times more likelihood and females 4.11 times more likelihood to develop high blood sugar level than their normal counterparts. WSR also showed that centrally obese participants had more likelihood of developing prediabetes/diabetes than those in normal category.

Correlation analyses between blood sugar level, age and obesity indices (Table 6) showed that blood sugar level had positive correlation with age as well as with all the obesity indices in both sexes, however not all correlations were significant. The strongest correlation was in WHR in both sexes while the weakest was for BMI.

Table 2. Age wise distribution of participants based on BMI

Age group, years	BMI Male, % Underweight	Normal	Overweight	Obese	Total	Female, % Underweight	Normal	Overweight	Obese	Total
20–29	7.0	29.2	1.6	-	37.7	5.2	18.5	4.3	.3	28.3
30–39	1.6	16.7	4.3	-	22.6	4.9	13.6	6.6	.3	25.4
40–49	.8	7.4	5.1	.4	13.6	.9	11.0	6.6	.3	18.8
50–59	1.6	6.2	3.5	1.2	12.5	1.4	7.2	5.5	1.2	15.3
60–70	3.5	8.6	1.6	-	13.6	3.8	6.4	2.0	-	12.1
Total	14.4	68.1	16.0	1.6	100	16.2	56.6	25.1	2.0	100

Table 3. Central obesity indices assessment

Age group, years	Central obesity indices						
	Males			Females			
	Mean	± SD	t^a	Mean	± SD	t^a	t^b
Waist circumference, cm							
20–29	71.7	4.78		72.5	6.08		.89
30–39	76.6	5.77	5.61[e]	75.5	8.23	2.88[d]	.87
40–49	82.6	8.02	4.19[e]	79.5	9.14	2.87[d]	1.65
50–59	83.6	11.01	0.44	82.7	11.6	1.69	.34
60–70	77.5	7.31	2.69[d]	78.3	10.9	1.90	.36
Total	76.6	8.15		76.8	9.5		.36
Waist/hip ratio							
20–29	.84	.041		.83	.056		1.92
30–39	.88	.042	4.86[e]	.85	.062	2.98[d]	2.22[c]
40–49	.92	.062	4.51[e]	.89	.072	3.42[e]	2.20[c]
50–59	.93	.075	.46	.92	.074	1.99[c]	.75
60–70	.90	.063	1.61	.91	.082	.35	.53
Total	.88	.063		.87	.075		1.57
Waist/height (stature) ratio							
20–29	.44	.030		.47	.040		6.89[e]
30–39	.47	.038	6.20[e]	.50	.053	3.46[e]	3.09[d]
40–49	.51	.050	4.21[e]	.52	.055	2.98[d]	1.12
50–59	.52	.062	0.43	.55	.072	2.37[d]	2.26[c]
60–70	.49	.043	1.78	.53	.073	1.15	2.87[d]
Total	.47	.052		.51	.063		7.30[e]

[a] Between age groups.
[b] Between males and females.
[c] *P*<.05.
[d] *P*<.01.
[e] *P*<.001.

DISCUSSION

Obesity and diabetes are public health problems that have raised concern worldwide, with health consequences and economic costs. With the increasing prevalence of obesity and diabetes worldwide, including traditional tribal populations, it becomes vital to evaluate the cause and associated factors.

Obesity and diabetes are interrelated independently apart from the influence of age and other lifestyle factors. As the Tangkhul Nagas advance from traditional to a contemporary way of living,[8] there have been nutritional transition and associated consequences.

Socioeconomic factors, age and biological factors are interrelated. Age is a strong dynamic that influences structure and functions of body. In our study, mean BMI and prevalence of overweight/obese increased with age until middle age, and declined thereafter. This phenomenon can be attributed to age related change in body weight due to decrease in muscle mass in response to reduced protein intake as well as decline in number and size of muscle fibers due to degenerative diseases associated with the advancing age. It also may partly be due to bones becoming lighter because of gradual mineral mass loss.[15]

Nutritional disorders, both overweight/obese and underweight were present among Tangkhul Nagas with a higher frequency of overweight/obesity. Overall Indian data showed that overweight and obesity coexist with the undernourished, as was found among the Tangkhuls. Sex differences in the prevalence of nutritional disorder exist. Prevalence of both undernutrition and overweight/obesity was higher among Tangkhul women than men as indicated in the National Family Health Survey (NFHS-3).[16] Among Tangkhuls, BMI was also slightly higher among females than males, while NFHS-3[16] reported similar BMI values for Indian men (20.2 kg/m^2) and women (20.5 kg/m^2). The BMI of Tangkhul males and females were slightly lower than Manipuri males (21 kg/m^2) and females (21.5 kg/m^2), however BMI values of Tangkhuls were higher when compared to the scheduled tribe and cast population of India.[16] The scheduled tribe and cast population of India had lower BMI

Table 4. Mean blood sugar level and distribution of participants according to blood sugar level

Age group, years	Mean blood sugar level, mg/dL		Prevalence of prediabetes and diabetes									
	Males	Females	Male, %					Female, %				
	Mean ± SD	Mean ± SD	Low	Normal	High	Diabetic	Total	Low	Normal	High	Diabetic	Total
20–29	103.5 ± 24.5	103.6 ± 16.1	-	17.2	.8	-	18.0	.6	11.8	.6	-	12.9
30–39	99.3 ± 17.7	109.6 ± 22.1	1.6	19.7	-	-	21.3	.6	20.0	2.4	-	22.9
40–49	116.6 ± 34.5	116.7 ± 51.7	-	13.1	4.1	.8	18.0	.6	24.1	1.2	1.8	27.6
50–59	122.3 ± 55.9	114.2 ± 30.4	-	17.2	3.3	.8	21.3	-	14.7	.6	.6	15.9
60–70	119.0 ± 31.0	120.1 ± 28.8	-	18.0	2.5	.8	21.3	-	17.1	2.9	.6	20.6
Total	112.3 ± 36.1	113.7 ± 34.7	1.6	85.2	10.7	2.5	100	1.8	87.6	7.6	2.9	100

Table 5. Blood sugar level assessment according to different obesity indices

Obesity indices		Mean blood sugar level, mg/dL		Distribution of participants according to blood sugar level, %						Odds ratio of high blood sugar	
		Males	Females	Males			Females			Males	Females
		Mean ± SD	Mean ± SD	Low	Normal	High	Low	Normal	High	OR (CI)	OR (CI)
BMI	underweight	106.6 ± 21.5	110.2 ± 26.3	-	12.3	.8	-	14.7	1.2	.57(.06, 5.61)	1.23(.18, 8.46)
	normal	114.1 ± 42.1	111.1 ± 21.9	.8	52.5	8.2	.6	46.5	5.3		
	overweight[a]	107.6 ± 31.1	111.9 ± 36.5	.8	20.5	4.1	1.2	26.4	4.1	1.00(.22, 4.66)	.73(.22, 2.40)
WC	normal	112.0 ± 37.2	108.3 ± 21.2	1.6	77.0	11.5	1.2	52.9	3.5		
	obese[b]	115.3 ± 24.7	121.1 ± 46.5	-	8.2	1.6	.6	34.7	7.1	.83(.11, 6.04)	2.43(.62, 9.59)
WSR	normal	105.6 ± 26.2	108.9 ± 19.6	.8	41.0	4.1	.6	22.9	1.2		
	obese[b]	117.9 ± 42.2	115.2 ± 38.4	.8	44.3	9.0	1.2	64.7	9.4	.95(.16, 5.67)	.61(.03, 11.60)
WHR	normal	104.2 ± 26.4	107.4 ± 18.7	1.6	51.6	4.9	1.2	30.6	1.2		
	obese[b]	123.5 ± 44.3	116.8 ± 40.1	-	33.6	8.2	.6	57.1	9.4	2.51(.52, 12.0)	4.11(.27, 61.94)

WC, waist circumference; WSR, waist/height (stature) ratio; WHR, waist/hip ratio; CI, 95% confidence intervals.
[a] Overweight/obesity.
[b] Centrally obese.

than the overall rural and urban India, reflecting the impact of socioeconomic status on BMI with lower socioeconomic groups showing lower mean values. WHO[17] reported that most people with diabetes in low and middle income countries were middle aged (45–64), not elderly (65+). Among the Tangkhuls, prevalence of prediabetes and diabetes was more likely among middle and older age groups (40–70 years). In our study, diabetes was found only among the three oldest age groups in both males and females showing its association with age.

The studied population is Mongoloid in ethnicity unlike the rest of the Indian subcontinent and very little information exists on diabetes in the isolated areas of Northeast Indian region. In a study among residents of Khowai district of Tripura prevalence of known diabetes was reported to be 9%.[18] When compared with this population of Northeastern India, Tang-

khuls had lower prevalence of diabetes or pre-diabetes. A previous study had measured diabetes prevalence and risk factors in the hill-tribes of Bangladesh, demonstrating an age-standardized prevalence of diabetes of 6.4%, and 8.4% for impaired fasting glucose significantly higher than the non-indigenous rural population.[19] Few epidemiological studies among indigenous people of South-East Asia exist and the studies indicate that different environment and socioeconomic level influence the prevalence of diabetes.

In India, the prevalence rate of diabetes in urban areas was about 9% whereas in rural areas it has increased to around 3%.[20] When compared to the Indian urban figures, the prevalence of diabetes among Tangkhul males (2.5%) and females (2.9%) were lower but were roughly equivalent to the rural prevalence. Changing lifestyle and transition in dietary habits towards more sodium and fat-rich diets among the Tangkhul[8]

was associated with the rising prevalence of overweight and diabetes. Countries experiencing rapid economic growth typically undergo a period of epidemiological transition; prevalence of infectious disease and parasitic disease decreases while prevalence of non-communicable disease increases. This pattern is paralleled by the nutrition transition. Infectious and parasitic diseases are very often predicated and/or exacerbated by macro and micro-nutrient deficiencies. Conversely, non-communicable disease is closely linked to overweight and consumption of foods that are high in saturated fat, sodium and cholesterol.[21,22]

Obesity, which is a major recognized risk factor for type-2 diabetes, is rapidly increasing in prevalence resulting in a diabesity epidemic.[23] Our study among the Tangkhuls showed an increasing trend of blood sugar level with the increase in adiposity level, especially central obesity.

Table 6. Correlation between blood sugar level, age and obesity indices

Blood sugar	Males					Females				
	BMI	WC	WSR	WHR	Age	BMI	WC	WSR	WHR	Age
	.064	.159	.128	.226[a]	.206[a]	.088	.185[a]	.191[a]	.239[b]	.150

WC, waist circumference; WSR, waist/height (stature) ratio; WHR, waist/hip ratio.
Correlation is significant at: [a] .05; [b] .01.

Our study among the Tangkhuls showed an increasing trend of blood sugar level with the increase in adiposity level, especially central obesity.

Diabetes mellitus and obesity have a complex relationship, with type 2 diabetes strongly associated with obesity.[24] Among Tangkhul Nagas, blood sugar level showed a significant positive relationship with central obesity but a non-significant relationship with general obesity. Most researchers consider that this relationship is different in general and regional obesity and type 2 diabetes mellitus.[25] Although both diabetes and obesity risk factors are often associated with race, age, and family history, it is becoming more and more clear that the conveniences of modern life also contribute to the development of both diseases.[1]

Higher blood sugar level among Tangkhul females corresponded with the higher adiposity level in females than males. There are strong correlations between diabetes and changes in body composition components.[26,27] Our study showed the associations of increase in blood sugar level with elevation of central obesity. Though there were positive correlations between blood sugar level, age and obesity both general and central, correlation coefficients showed that the relationship of blood sugar level was strongest with waist/hip ratio, a central obesity index. Multiple logistic regression analysis showed overweight/obesity to be a significant risk factor for development of diabetes.

Cross tabulation of different obesity indices with blood sugar level showed that central obesity indices are a good indicator of blood sugar while a general

obesity index (BMI) was not a good indicator of blood sugar level. Among those who had high blood sugar, in both Tangkhul males and females, most of the participants were centrally obese as assessed from WHR and WSR. An earlier study[2] also showed that not all participants with type 2 diabetes were obese and many obese participants did not have diabetes, but most of the participants with diabetes were overweight/obese.

Rates of type 2 diabetes continue to rise globally, particularly among developing countries undergoing the epidemiological transition to chronic disease and ethnic minorities in industrialized countries.[28,29] Overweight/obesity and diabetes are mostly preventable with alteration in habitual activity, diet and lifestyle. The transition of the Tangkhul Naga tribe in terms of socioeconomic factors and lifestyle, alteration in dietary habits and reduced physical activity are likely contributing to the increasing prevalence of overweight/obesity and its accompanying health problems. Our findings are consistent with the trend that has been occurring in many developing and transitional societies, contributing to the escalating global epidemic of obesity and associated health outcomes.

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