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Research Article

Body Mass Index Cut-off Associated with Diabetes and Metabolic Abnormality in Indo-Guyanese Adults

Hosler AS[1]*and Lu T[1]

[1]Department of Epidemiology and Biostatistics, University at Albany School of Public Health, USA

***Corresponding author:** Akiko S. Hosler, Department of Epidemiology and Biostatistics, University at Albany School of Public Health, GEC 147 One University Place, Rensselaer, NY 12144, USA

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Abstract

Aim: To identify body mass index (BMI) cut-offs associated with diabetes and glucose abnormality (diabetes, pre-diabetes and borderline diabetes combined) among Indo-Guyanese adults in a U.S. urban community.

Methods: Cross-sectional health survey data of Indo-Guyanese adults in Schenectady, NY were analyzed. Diagnosed diabetes and glucose abnormality were verified for its reporting accuracy and used as the outcome variables. Unadjusted and adjusted Poisson regression models were fitted to estimate the prevalence ratio (PR) by BMI cut-offs of 1.0 kg/m^2 increment. The adjusted models included age, sex, high blood pressure, high blood cholesterol, and family history of diabetes.

Results: The analysis sample (n=316) was 54.4% female with a mean age of 45.1 years. BMIs ranged from 16.9 kg/m^2 to 45.2 kg/m^2. Ninety-five (30.1%) and 15 (4.7%) participants reported diabetes and pre-diabetes/borderline diabetes respectively. PR for diabetes was highest at BMI 23.0 kg/m^2 (unadjusted PR 3.34, 95% CI 1.68, 6.63; adjusted PR 1.83, 95% CI 1.01, 3.33). Similarly, PR for glucose abnormality was highest at BMI 23.0 kg/m^2 (unadjusted PR 3.90, 95% CI 1.97, 7.71; adjusted PR 2.28. 95% CI 1.24, 4.17).

Conclusion: This study demonstrated that both diabetes and glucose abnormality were associated with BMI of 23.0 kg/m^2 in Indo-Guyanese adults. These results were consistent with previously reported optimal BMI cut-offs for diabetes and pre-diabetes among various South Asian populations. Public health and medical professionals should be aware of the elevated likelihood of having diabetes or pre-diabetes among Indo-Guyanese adults whose BMIs are below the overweight range.

Keywords: Indo-Guyanese; Diabetes risks; Glucose abnormality; Body mass index; Prevalence ratio; Cut-off points

Abbreviations

BMI: Body Mass Index; CI: Confidence Interval; PABAK: Prevalence-Adjusted Bias-Adjusted Kappa; PR: Prevalence Ratio; SD: Standard Deviation; WHO: World Health Organization

Introduction

Body mass index (BMI) has been widely used to assess risks for obesity-related chronic diseases including type 2 diabetes. BMI of 25kg/m^2, which defines the lower limit of the overweight range by the WHO criteria [1], is the most commonly recognized cut-off to identify elevated diabetes risk in U.S. adults [2]. Epidemiologic studies have demonstrated, however, an appropriate BMI cut-off for diabetes can vary by race and ethnicity [3,4]. Experts explain that this is largely because the associations between BMI, proportion of body fat, and body fat distribution pattern differ across populations [3]. For South Asians, evidence suggests that diabetes is associated with a BMI between 22.0 kg/m^2 and 24.0 kg/m^2 [4-8].

It has not been investigated whether a BMI cut-off lower than 25 kg/m^2 is feasible to indicate elevated likelihood of having diabetes in Indo-Guyanese population in the U.S. The Indo-Guyanese is one of the largest new immigrant groups in cities in the northeast U.S. [9]. They migrated from the English-speaking South American country of Guyana, but most of them can trace their ancestry to the 19th century India, and they remain phenotypically and genetically South Asian due to a low rate of intermarriage [10]. This unique group is largely medically underserved, and their health conditions are not well investigated. Recently published studies reported a highly elevated prevalence of diabetes and its complications in Indo-Guyanese adults, and also found that BMI for the Indo-Guyanese with diabetes was significantly lower compared to that for other racial/ethnic groups with diabetes [11,12].

Identifying individuals likely to be affected by diabetes using a simple indicator such as BMI is an important step toward reducing the burden of diabetes in Indo-Guyanese communities. Identification of individuals with pre-diabetes, a precursor to type 2 diabetes is particularly important, given that lifestyle and pharmacological interventions can effectively stop or delay the progression into diabetes [13]. The objective of this study is to identify the BMI cut-off that is associated with diabetes and more inclusive glucose abnormality (diabetes, pre-diabetes and borderline diabetes combined) among Indo-Guyanese adults in a U.S. urban community.

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Methods

Data source

Data for this study were obtained from a cross-sectional health survey of adults conducted in Schenectady, New York. Eligibility of respondents was being at least 18 years of age and a current resident of Schenectady. Using venue-based quota sampling technique, respondents were recruited at 36 community locations and events. A small number of respondents were also recruited through referrals from community members and door-to-door visits. The age–sex distribution of respondents was closely monitored, and recruitment strategies were adjusted to ensure that the sample had a similar age–sex distribution of the city's adult population.

Respondents filled out a 42-item health questionnaire written at a 6th grade level in English. Trained members of the research team provided assistance in completing the questionnaire, if requested by the respondent. The survey questionnaire was pilot-tested with a sample of Schenectady residents (n=12) and found perfect test-retest agreement (prevalence-adjusted bias-adjusted kappa or PABAK>1.0) in 9 key variables including age, sex, diagnosis of diabetes, and family history of diabetes, and excellent agreement (PABAK>0.8) in all other health-related variables. A total of 792 respondents were in the original data set. This study used the unweighted subset of the survey data containing only respondents with Indo-Guyanese ethnicity (N=333). The institutional review boards of Ellis Hospital in Schenectady and University at Albany reviewed and approved the human subject protection protocol.

Measurement

Two questions "Has a health professional ever told you that you have diabetes?" and "Has a health professional ever told you that you have pre-diabetes or borderline diabetes?" were used to derive diabetes (yes to the first question) and abnormal blood glucose (yes to any of the two). BMI was computed from body weight in pounds and height without shoes in inches. Seventeen individuals provided no body weight and/or height information so their BMIs were unavailable. Since no significant differences (P<0.01) in age, sex, and diagnosis of diabetes were found between the respondents with and without BMI, the latter group was excluded from analysis. Age, sex, diagnoses of high blood pressure and high blood cholesterol (ever told by a health professional), and family history of diabetes (specific to mother, father, sisters or brothers) were also reported by respondents. The sample size of the analysis data set was 316.

Assessing accuracy of self-reported diabetes status

Because the Indo-Guyanese are mostly medically underserved, some individuals may not be aware of their elevated glucose status. An auxiliary study was conducted to examine whether those who reported not having diabetes or pre-diabetes were truly so. Data from a free community glucose screening event held in Schenectady were linked to the survey data, and found 13 matched participants. In this screening event, individuals who had been diagnosed with diabetes were not invited. The American Diabetes Association's guidelines were used to determine diabetes risks into 3 categories: Low risk (non-fasting plasma glucose < 140 mg/dl), medium risk (140 mg/dl – 199 mg/dl), and high risk (≥ 200 mg/dl) [2]. All of those who had reported not having been diagnosed with diabetes, pre-diabetes, or borderline diabetes in the survey (N=9) were in the low risk group (range: 89 mg/dl to 128 mg/dl), with a mean of 107.6 mg/dl (SD 11.5). Individuals who had reported having pre-diabetes or borderline diabetes (N=4) had non-fasting plasma glucose values all above 140 mg/dl (range: 143 mg/dl to 279 mg/dl), with a mean of 210.3mg/dl (SD 57.8). The pre-diabetes group's mean glucose value was significantly higher (p<0.01) than the disease-free group's mean glucose value. These results suggested accuracy of self-reported disease-free status in this population. In addition, respondents who reported having been diagnosed with diabetes were probed for their diabetes-related health conditions and medical care in the survey, and all their responses were consistent with their diseased status.

Analysis

Diabetes is relatively common in the Indo-Guyanese, affecting about a third of the adult population [11,12]. When the outcome measure is not uncommon, the odds ratio overestimates the effect of exposure [14]. As a better alternative, Poisson regression models were fitted to directly estimate the prevalence ratio of diabetes and glucose abnormality [15]. First, unadjusted prevalence, prevalence ratio, and its 95% confidence intervals were obtained for BMI cut-offs of every 1 kg/m^2 increment from 21.0 kg/m^2 to 31.0 kg/m^2, where there were at least 10 respondents for each BMI category. Then, adjusted Poisson regression models were analyzed for BMI cut-offs for 21.0 kg/m^2 to 28.0 kg/m^2. BMI of 28.0 kg/m^2 was the threshold at which the confidence intervals of unadjusted prevalence ratio were no longer entirely above the null. Covariates in the adjusted models were age (in years), sex, and three commonly assessed clinical variables that had significant (P<0.01) bivariate associations with BMI and/or glucose abnormality, including high blood pressure, high blood cholesterol, and family history of diabetes. The prevalence ratio and 95% confidence intervals were reported. All analyses were conducted using SAS ver. 9.3 (SAS Institute, Inc. Cary, North Carolina).

Results

Characteristics of respondents in the sample are summarized in Table 1. The ages of respondents ranged from 18 to 82 years, with a mean of 45.1 years (SD 14.4). Slightly more than a half of respondents (54.4%) were female, and great majorities (97.2%) were born in Guyana. BMI had a range of 16.9 kg/m^2 to 45.2 kg/m^2, and a mean of 26.7 kg/m^2 (SD 4.1). Gender difference in BMI was very small and non-significant (P>0.01), with a mean of 26.9 kg/m^2 (SD 4.1) for females and 26.6 kg/m^2 (SD 4.0) for males. Approximately two thirds of respondents had a BMI higher than 25.0 kg/m^2. Ninety-five individuals (30.1%) reported diagnosed diabetes, and additional 15 (4.7%) reported diagnosed pre-diabetes or borderline diabetes. Together, 34.8% of the sample was classified as having glucose abnormality.

Results of the Poisson regression analyses are shown in Table 2. The unadjusted prevalence ratio of diabetes was highest at the BMI cut-off of 23.0 kg/m^2 (PR 3.34, 95% CI 1.68, 6.63). As BMI cut-off values increased, the prevalence ratios decreased incrementally toward the null. The prevalence ratio of diabetes was attenuated after adjustment for age, sex, high blood pressure, high blood cholesterol, and family history of diabetes, but it was also highest at the BMI cut off of 23.0 kg/m^2 (PR 1.83, 95% CI 1.01, 3.33). Table 2 also shows similar but slightly more robust results for glucose abnormality. Both

Table 1: Characteristics of Indo-Guyanese adult sample in Schenectady, NY.

Characteristic (total n=316)	n or mean	% or SD
Age (n, %)		
18-29	55	17.4
30-44	90	28.5
45-59	116	36.7
60+	55	17.4
Age (mean, SD)	45.1	14.4
Sex (n, %)		
Female	172	54.4
Male	144	45.6
BMI (n, %)		
< 18.5	6	1.9
18.5 – 24.9	99	31.3
25.0 – 29.9	136	43.0
≥ 30.0	75	23.7
BMI (mean, SD)	26.7	4.1
Place of birth (n, %)		
Guyana	307	97.2
U.S.	9	2.8
Diabetes outcome (n, %)		
Diabetes	95	30.1
Pre-diabetes or borderline diabetes	15	4.7
Other health status (n, %)		
High blood pressure	99	31.3
High blood cholesterol	107	33.9
Family history of diabetes	188	59.5

unadjusted and adjusted prevalence ratios of glucose abnormality were highest at the BMI cut-off of 23.0 kg/m^2 (unadjusted PR 3.90, 95% CI 1.97, 7.71; adjusted PR 2.28, 95% CI 1.24, 4.17).

Discussion

The present study is the first to explore appropriate BMI cut-offs for diabetes and glucose abnormality among Indo-Guyanese adults in a U.S. community. Poisson regression analyses of health survey data found that the BMI cut-off of 23.0 kg/m^2 was associated with the highest unadjusted and adjusted prevalence ratio for both diabetes and glucose abnormality in the Indo-Guyanese. It is reasonable to conclude that BMI 23.0 kg/m^2 is the threshold at which the likelihood of having glucose abnormality including diabetes and pre-diabetes is elevated among the Indo-Guyanese. The strengths of this study include the use of community-based data, assessment of the accuracy of self-reported glucose status, having two diabetes outcome measures, and application of Poisson regression to directly estimate the prevalence ratio.

The findings of this study are consistent with earlier research that examined BMI cut-offs associated with diabetes in various South Asian populations. Two large cross-sectional studies of diabetes from Indian cities reported BMI cut-offs of 23.1 kg/m^2 for males and 23.8 kg/m^2 for females in one study [7], and 23.0 kg/m^2 for both sexes in the other [5]. A nationwide population-based cross-sectional study conducted in Pakistan found that diabetes was associated with BMI cut-offs of 22.1 kg/m^2 for males and 22.9 kg/m^2 for females [6]. A prospective cohort study from Canada, which analyzed diabetes incidence rates using Cox proportional hazards models, found that a BMI cut-off of 24.0 kg/m^2 was appropriate for South Asians [4].

There are fewer studies that investigated BMI cut-offs for pre-diabetes in South Asian populations, but their results are also generally consistent with the findings of this study. The previously cited urban Indian study found that pre-diabetes was associated with BMI of 23.2 kg/m^2 for males and 23.5 kg/m^2 for females [7]. It was also found that the optimal BMI cut-offs for diabetes, pre-diabetes, and indicators of metabolic syndrome were very close or identical to one another within the South Asian study samples [7,16].

In addition, the participants in the urban Indian studies had a lower mean BMI at baseline (from 22.4 to 23.6 kg/m^2) [5,7] compared to participants in the Canadian studies (from 24.6 to 26.1 kg/m^2) [4,16]. The Indo-Guyanese participants in this study had a mean BMI of 26.7 kg/m^2, which is consistent with heavier body weight status for South Asians living in North America. Despite differences in baseline weights and living environments, South Asian populations around the world appear to have similar diabetes-related risks at a BMI below 25.0 kg/m^2. It has been known that South Asians have higher

Table 2: Unadjusted and adjusted prevalence ratio for diabetes and glucose abnormality: Indo-Guyanese adults in Schenectady, NY.

	Diabetes					**Glucose Abnormality***			
	Unadjusted		Adjusted**			Unadjusted		Adjusted**	
BMI cut-off (kg/m^2)	PR	95% CI	PR	95% CI		PR	95% CI	PR	95% CI
21.0	2.75	1.04, 7.27	1.22	0.53, 2.82		3.20	1.21, 8.47	1.56	0.67, 3.66
22.0	2.34	1.16, 4.69	1.38	0.76, 2.50		2.73	1.36, 5.47	1.68	0.91, 3.08
23.0	**3.34**	**1.68, 6.63**	**1.83**	**1.01, 3.33**		**3.90**	**1.97, 7.71**	**2.28**	**1.24, 4.17**
24.0	2.31	1.39, 3.82	1.36	0.88, 2.11		2.49	1.53, 4.04	1.55	1.01, 2.39
25.0	2.28	1.48, 3.53	1.61	1.11, 2.33		2.38	1.58, 3.60	1.71	1.19, 2.45
26.0	1.71	1.19, 2.45	1.25	0.92, 1.70		1.57	1.12, 2.19	1.19	0.89, 1.59
27.0	1.60	1.13, 2.26	1.43	1.06, 1.91		1.48	1.07, 2.05	1.33	1.01, 1.76
28.0	1.37	0.97, 1.93	1.26	0.94, 1.69		1.28	0.93, 1.76	1.19	0.90, 1.57

* Diabetes and pre-/borderline diabetes combined.

** Poisson model adjusted for age, sex, family history of diabetes, high blood pressure, and high blood cholesterol.

proportions of overall body fat and visceral fat compared to Whites or Blacks with identical BMI [3]. Therefore individuals with South Asian genetic traits, including the Indo-Guyanese, can be "metabolically obese" while their BMI is still below 25.0 kg/m^2 [17].

Limitations exist in this study. Selection bias due to the healthy volunteer effect may have affected this study. The authors compared the study population with clinical data from the previously published Indo-Guyanese study in Schenectady [11]. It was found that an age-matched subset from this study was not significantly different (P>0.01) in mean BMI, prevalence of diabetes, hypertension, and hyperlipidemia compared to the clinical population. Type of diabetes was not assessed in this study. The same clinical data indicate that type 1 diabetes is very rare among Indo-Guyanese adults [11]. The adjusted analyses did not include measures for physical activity, diet, and current medication use that may influence the association between BMI and glucose status. Finally, cross-section design could not estimate the relative risk of diabetes and glucose abnormality.

Conclusion

Diabetes and pre-diabetes are major health concerns in Indo-Guyanese communities, and identifying individuals associated with these conditions using a simple BMI cut-off can be an effective public health approach. This study demonstrated that both diabetes and glucose abnormality are associated with BMI of 23.0 kg/m^2. Although this study alone does not provide sufficient evidence to make glucose screening recommendations, public health and medical professionals should be aware of the elevated likelihood of having diabetes and pre-diabetes in Indo-Guyanese adults whose BMI are below the overweight range.

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