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Comparison of BMI and anthropometric measures among South Asian Indians using standard and modified criteria

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Abstract

Objective: To compare the prevalence rates of obesity based on BMI/anthropometric measures, using WHO standard and ethnicity-specific criteria, the National Cholesterol Education Program–Adult Treatment Panel III (NCEP-ATPIII) and the International Diabetes Federation (IDF) definitions, among a migrant South Asian Indian population.

Design: Cross-sectional study conducted in October 2007.

Subjects: A total of 213 participants of South Asian descent over the age of 18 years. Measures included a questionnaire with basic demographic information and self-reported histories of diabetes, coronary artery disease and/or hypercholesterolaemia. Height, weight, waist and hip circumference and blood pressure measurements were obtained.

Setting: Houston and surrounding suburbs.

Results: WHO-modified (WHO-mod) BMI and IDF waist circumference (WC) criteria independently identified higher numbers of overweight/obese participants; however, when the WHO-mod BMI or IDF WC criteria were applied, nearly 75 % of participants were categorized as overweight/obese – a proven risk factor for the future development of metabolic syndrome.

Conclusions: Obesity is likely under-diagnosed using the standard WHO and NCEP-ATPIII guidelines. Stressing the use of modified criteria more universally to classify obesity among South Asian Indians may be optimal to identify obesity and help appropriately risk stratify for intervention to prevent chronic diseases.

Keywords
South Asian Indians
Obesity
WHO modified BMI
IDF waist circumference

Obesity is increasing with epidemic proportions globally, with more than 1·1 billion adults overweight and 312 million of them obese[1]. This is a major predisposing factor for CVD, metabolic syndrome and glucose impairment. The identification of obesity is not always straightforward and the most commonly relied on measure, BMI alone, using standard criteria may be inadequate to identify obesity, high risk of CVD and metabolic syndrome, because of the lack of detection of central obesity in individuals with normal BMI. Hence, waist circumference (WC) and waist-to-hip ratios (WHR) are found to be better indicators of obesity and risk of CVD than BMI alone[2]. Metabolic syndrome, as defined by the National Cholesterol Education Program–Adult Treatment Panel III (NCEP-ATPIII), refers to a cluster of central obesity, high blood pressure, insulin resistance/glucose intolerance and dyslipidaemia predisposing to the future development of diabetes mellitus (DM) – a significant and rapidly growing public health challenge affecting about 5 % of adults worldwide. The WHO projects that 300 million people will be affected by type 2 diabetes by the year 2025 and half of this population will be Asians and Pacific Islanders.

Risk factors for obesity and metabolic syndrome include non-modifiable factors such as gender, age, ethnicity and genetic predisposition. Studies have shown that South Asian Indians have a higher predisposition to developing metabolic syndrome and DM[3–5], possibly a genetic predisposition at smaller body sizes to higher percentages of central adiposity in the presence of a lower BMI, thus increasing their risk of developing CVD, metabolic syndrome and diabetes, even at lower BMI levels[6–13]. The NCEP-ATPIII definition of central obesity may be inadequate to identify many South Asians at risk of morbidity; hence, the International Diabetes Federation (IDF) recommended ethnicity-specific lower WC criteria for diagnosing central obesity in this population (Table 1)[6–9]. In addition, WHO has proposed modified

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BMI cut-off points of ≥23·0 kg/m^2 for overweight in Asian-specific populations compared with the standard cut-off of ≥25·0 kg/m^2 for Caucasians (Table 1), on the basis of higher morbidity risk at lower BMI levels[8–10,14].

Asian Indians are now considered the third largest and fastest growing Asian-American group in the USA, with the recent census report (2000) showing that there are currently 1·6 million Asian Indians in the USA. There is a paucity of studies on the South Asian population in the USA to estimate the prevalence or burden of obesity and metabolic syndrome in this group. In addition, studies that have included South Asians have grouped them with other Asian ethnicities and used the WHO standard BMI cut-offs, which may underestimate the prevalence of obesity in this population as not all Asians have equal body fat/BMI distribution[10]. The aim of the present study was to compare the prevalence rates of obesity based on BMI/anthropometric measures, using standard WHO and ethnicity-specific criteria, NCEP-ATPIII and IDF definitions, among a South Asian-Indian population.

Methods

Participants and selection

Study participants were drawn from a convenience sample of South Asian Indians present at a local community health fair held in a temple in Houston, TX, USA, in October 2007. Permission and approval was obtained from the authorities at the temple and from the Institutional Review Board of the University of Texas Houston Medical School. Most of the participants at the fair were South Asian Indians with only a few people of other origins in attendance. This is an annual fair with a large representation of all sects of South Asian Indians in Houston and surrounding suburbs, hence the reason for selection of this event to obtain a good sample population for our study. All persons present at the fair were approached individually for possible participation in the study. Persons who volunteered to take part were then screened for eligibility on the basis of the criteria of being of South Asian-Indian descent and over 18 years of age, and were then recruited. Information sheets to educate participants on the procedures and intent of the study were distributed and all eligible persons then completed study procedures. We had a recruitment rate of about 90 % of all participants at the fair who were approached for the study.

Measures

Measures included a questionnaire on basic demographic information such as age and gender, as well as self-reported histories of diabetes, coronary artery disease (CAD) and/or high cholesterol. Trained and designated personnel measured the height, weight, waist and hip circumferences of each participant in light clothing without shoes. Height and weight were measured using a non-stretchable tape and a calibrated digital machine, respectively, and BMI was calculated using the formula: weight (kg)/height (m^2). WC was measured at the horizontal girth between the lowest costal margin and the iliac crest at minimal respiration using a non-stretchable fibre measuring tape with the participant standing erect in a relaxed position with feet together on a flat surface. Hip circumference was taken as the greatest circumference at the level of the greater trochanter on both sides. Both measurements were made to the nearest centimetre and used to calculate the WHR (see Table 1 for all the definitions of obesity based on BMI and WC). Two sitting measurements of blood pressure were taken on the right arm using a manual inflation monitor (Omron Corporation, Kyoto, Japan) and were measured to the nearest mmHg, with the average of the two readings taken for data analysis.

Data analysis

Data analysis was carried out using the Statistical Package for the Social Sciences statistical software package version 10·0 (SPSS Inc., Chicago, IL, USA) and descriptive statistics-derived means and SD for continuous variables such as age, BMI, WC and blood pressure measurements, and

Table 1 Guidelines for classification of obesity

Category	WHO definitions*	Proposed WHO-modified definitions for Asians
BMI (kg/m^2)*		
Normal	18·5–24·9	18·5–22·9
Overweight	25·0–29·9	23·0–24·9
Obese	≥30·0	≥25·0
WHR		
Men	>1·0	>0·89
Women	>0·9	>0·81
	NCEP-ATPIII*	IDF*
WC (for abdominal obesity; cm)		
Men	≥102	≥90
Women	≥88	≥80

WHR, waist-to-hip ratio; NCEP-ATPIII, National Cholesterol Education Program–Adult Treatment Panel III; IDF, International Diabetes Federation; WC, waist circumference.
*WHO definitions refer to those that are currently standard or generally applicable.

percentages for ordinal or categorical variables such as the presence of diabetes, CAD or high cholesterol. Further analysis was carried out by categorising BMI and WC using the various classification methods of WHO standard and modified criteria for BMI[8,9] and IDF and NCEP-ATPIII criteria for WC[8,14]. On the basis of the various criteria, participants were classified as normal weight or overweight/obese. The overweight and obese groups were grouped together because of the small numbers that qualified under the obese category, and grouping overweight and obese persons allowed for comparison between those in the normal category and those in the 'high-risk' overweight/obese group. Results from these classifications were compared using χ^2 and Fisher's exact tests. Comparisons were also made by stratifying according to gender and age groups; regression analysis was carried out after adjusting for age and gender as well.

Results

A total of 213 participants aged between 18 and 79 years took part in the survey; the mean age was 47 (SD 15) years, with 56 % of participants being male (Table 2). Data showed that 14·6 % had a history of diabetes, 10·3 % had CAD and 21 % had hypercholesterolaemia. As listed in Table 2, the average BMI was 24·5 (SD 3·6) kg/m^2, WC was 91·2 (SD 10·2) cm for male and 85·5 (SD 11·4) cm for female participants and WHR was 0·92 (SD 0·06) for male and 0·88 (SD 0·08) for female participants. Nearly half of the participants were available to obtain interpretable blood pressure measurements, and they had a mean of 128 (SD 18·3) mmHg and 75 (SD 9·7) mmHg for systolic and diastolic blood pressure (SBP and DBP), respectively.

For the purpose of the present study, standard WHO criteria will be referred to as WHO-std and the modified criteria will be WHO-mod.

BMI classification

As shown in Table 3, WHO-mod criteria identified a significantly higher proportion (67 %) of the total cohort to be overweight/obese as compared with the WHO-std criteria (42 %; $P \leq 0·005$), with a higher percentage among both genders found to be overweight/obese using WHO-mod criteria (male: 71 % *v.* 42 %; female: 61 % *v.* 42 %; $P < 0·005$).

Central obesity classification

The IDF criteria for WC identified 57·5 % of participants (male: 53 %; female: 63 %; $P < 0·005$) as having central obesity, compared with 25 % (male: 13 %; female: 41 %; $P < 0·005$) by the NCEP-ATPIII criteria; a significantly higher number in both genders (Table 3). Similarly, the WHR-mod criteria identified 75·4 % of people as being overweight/obese compared with 19·9 % using the WHR-std ($P \leq 0·005$). In all, 70·3 % of male participants were found to be overweight/obese using WHR-mod criteria as opposed to only 6·8 % using WHR-std criteria ($P = 0·103$). The same findings were mirrored in women, with WHR-mod finding 81·7 % of women to be overweight/obese compared with only 36·6 % by the WHR-std criteria ($P = 0·001$).

Table 2 Demographic distribution of South Asian-Indian participants

Variables	Frequency	%	Mean	SD	Range
Age (years)	213		47·0	14·5	18–79
Gender	213				
Male	120	56·34			
Female	93	43·66			
History of diabetes	213				
Yes	31	14·55			
No	182	85·45			
History of CAD	213				
Yes	22	10·33			
No	191	89·67			
History of high cholesterol	210				
Yes	44	20·95			
No	166	79·05			
BMI (kg/m^2)	213		24·5	3·6	13·5–40·4
WC (cm)	212				
Male	119		91·2	10·2	53·3–121·9
Female	93		85·5	11·4	61·0–109·2
WHR	211				
Male	118		0·92	0·06	0·57–1·09
Female	93		0·88	0·08	0·73–1·12
SBP (mmHg)	97		128·1	18·3	94–192
DBP (mmHg)	97		75·1	9·7	55–101

CAD, coronary artery disease; WC, waist circumference; WHR, waist-to-hip ratio; SBP, systolic blood pressure; DBP, diastolic blood pressure.
Missing data pertinent to various parameters were excluded from the analysis; hence, the number of participants may differ between variables. All variables with mean and SD (range) indicate that the mean, SD and range were documented per continuous variable. All variables with frequency (%) indicate the number of responses in each category and the percentage of response per categorical variable.

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Table 3 Distribution of BMI and WC according to gender in the study population

	Total			Gender					
				Male			Female		
Individual criteria	*n*	%	*P*	*n*	%	*P*	*n*	%	*P*
BMI WHO-std*	213		**<0·005**	120		**<0·005**	93		**<0·005**
Not overweight	124	58·2		70	58·3		54	58·1	
Overweight/obese	89	41·8		50	41·7		39	41·9	
BMI WHO-mod†	213			120			93		
Not overweight	71	33·3		35	29·2		36	38·7	
Overweight/obese	**142**	**66·7**		**85**	**70·8**		**57**	**61·3**	
WC IDF‡	212		**<0·005**	119		**<0·005**	93		**<0·005**
Not overweight	90	42·5		56	47·1		34	36·6	
Overweight/obese	**122**	**57·5**		**63**	**52·9**		**59**	**63·4**	
WC NCEP§	212			119			93		
Not overweight	159	75·0		104	87·4		55	59·1	
Overweight/obese	53	25·0		15	12·6		38	40·9	
WHR-std‖	211		**<0·005**	118		0·103	93		**0·001**
Not overweight	169	80·1		110	93·2		59	63·4	
Overweight/obese	4	19·9		8	6·8		34	36·6	
WHR-mod¶	211			118			93		
Not overweight	52	24·6		35	29·7		17	18·3	
Overweight/obese	**159**	**75·4**		83	70·3		**76**	**81·7**	

WC, waist circumference; IDF, International Diabetes Federation; NCEP, National Cholesterol Education Program; WHR, waist-to-hip ratio.
Values in bold are statistically significant.
*BMI WHO-std refers to the currently used WHO BMI definitions that are generally applicable. Not overweight, BMI < 25·0 kg/m^2; overweight/obese, BMI ≥ 25·0 kg/m^2.
†BMI WHO-mod refers to the proposed WHO-modified BMI definitions for Asians. Not overweight, BMI < 23·0 kg/m^2; overweight/obese, BMI ≥ 23·0 kg/m^2.
‡Not overweight: male, WC IDF < 90 cm; female, WC IDF < 80 cm. Overweight/obese: male, WC IDF ≥ 90 cm; female, WC IDF ≥ 80 cm.
§Not overweight: male, WC NCEP < 102 cm; female, WC NCEP < 88 cm. Overweight/obese: male, WC NCEP ≥ 102 cm; female, WC NCEP ≥ 88 cm.
‖WHR-std refers to the cut-off values being used for all races. Not overweight: male, WHR < 1·0; female, WHR < 0·9. Overweight/obese: male, WHR ≥ 1·0; female, WHR ≥ 0·9.
¶WHR-mod refers to ethnicity-specific cut-off values for Asian-Indian adults[7]. Not overweight: male, WHR < 0·89; female, WHR < 0·81. Overweight/obese: male, WHR ≥ 0·89; female, WHR ≥ 0·81.

Table 4 Comparison of various combinations of obesity criteria (BMI and WC indices) according to gender in the study population

	Total			Gender					
				Male			Female		
Combined criteria	*n*	%	*P*	*n*	%	*P*	*n*	%	*P*
BMI WHO-std and WC IDF	213		**<0·005**	120		**<0·005**	93		**<0·005**
Not overweight	135	63·3		76	63·3		59	63·4	
Overweight/obese*	78	36·7		44	36·7		34	36·6	
BMI WHO-std and WC NCEP	213			120			93		
Not overweight	173	81·2		107	89·2		66	71·0	
Overweight/obese*	40	18·8		13	10·8		27	29·0	
BMI WHO-mod and WC IDF	213			120			93		
Not overweight	111	52·1		65	54·2		46	49·5	
Overweight/obese*	**102**	**49·9**		**55**	**45·8**		**47**	**50·5**	
BMI WHO-mod and WC NCEP	213			120			93		
Not overweight	167	78·4		107	89·2		60	64·5	
Overweight/obese*	46	21·6		13	10·8		33	35·5	
BMI WHO-mod or WC IDF	213		**<0·005**	120		**<0·005**	93		**<0·005**
Not overweight	51	23·9		27	22·5		24	25·8	
Overweight/obese†	**162**	**76·1**		**93**	**77·5**		**69**	**74·2**	
BMI WHO-mod or WC NCEP	213			120			93		
Not overweight	64	30·0		33	27·5		31	33·3	
Overweight/obese†	149	70·0		87	72·5		62	66·7	

WC, waist circumference; IDF, International Diabetes Federation; NCEP, National Cholesterol Education Program.
See footnotes in Table 3 for explanations of the obesity criteria and their cut-offs.
Values in bold are statistically significant.
*In order to be grouped as overweight/obese, the participant had to be classified as being overweight/obese by both criteria.
†In order to be grouped as overweight/obese, the participant had to be classified as being overweight/obese by either of the criteria.

Combination criteria and classification

In order to determine the sensitivity of these criteria in identifying overweight/obesity and to identify any non-overlap (i.e. participants identified as obese by one test but not the other), we explored six combinations of standard and modified BMI and WC criteria (Table 4).

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Not surprisingly, the combination of WHO-mod for BMI and IDF criteria for WC identified nearly half of the participants (49·9 % in total, 46 % of male and 51 % of female participants) as overweight/obese, which was significantly higher than when other criterion combinations ($P < 0·005$) or WHO-std BMI alone was used (Tables 3 and 4). This remained statistically significant even when the cohort was stratified for gender. Interestingly, fewer cases of obesity were detected when using this combination of BMI WHO-mod and WC IDF than when using BMI WHO-mod alone ($P \leq 0·005$) or WC IDF ($P \leq 0·005$), implying that the two tests identify slightly different subjects as overweight/obese. On using the combination BMI WHO-mod or WC IDF, 76 % of participants were identified as overweight/obese (male: 77·5 %; female: 74 %; $P < 0·005$), and this was significantly more than when the other combinations were used across genders.

As shown in Table 5, 14·5 % of participants reported a history of diabetes (male: 19 %; female: 9 %; OR = 2·52, $P = 0·034$), 10 % reported CAD (male: 10 %; female: 11 %; OR = 0·92; $P = 0·858$) and 21 % reported hypercholesterolaemia (male: 21 %; female: 21 %; OR = 1·03, $P = 0·925$). Among the participants with history of diabetes, CAD and hypercholesterolaemia, BMI WHO-mod and the combination BMI WHO-mod or WC IDF categorized a higher number of people as overweight/obese, as indicated by the higher odds ratios, than BMI WHO-std. This was observed in the crude rates and after adjusting for gender and age. On the basis of the definitions of the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC-7), 19·6 % of participants had high SBP, whereas 10·3 % had high DBP[15]. Significantly more male participants than female participants had high SBP (male: 27·3 %; female: 9·5 %; OR = 3·56, $P = 0·036$). There was also a higher number of participants with high DBP categorized as being overweight/obese when using BMI WHO-mod and BMI WHO-mod or WC IDF combination compared with BMI WHO-std.

Table 5 Correlation of histories of diabetes, coronary artery disease, high cholesterol and blood pressure levels with gender and age, and comparisons of various BMI criteria using crude and age/gender-adjusted measures

	Total				BMI WHO-std*		BMI WHO-mod†		BMI WHO-mod or WC IDF‡	
Variables	*n*	%	Gender§	Age (years)	Unadjusted	Adjusted‖	Unadjusted	Adjusted‖	Unadjusted	Adjusted‖
Hx of DM	213									
Yes	31	14·5								
No	182	85·5								
OR			**2·52**	**1·05**	1·00	0·94	1·26	1·21	1·75	1·70
95 % CI			**1·07, 5·92**	**1·02, 1·08**	0·47, 2·18	0·42, 2·11	0·55, 2·91	0·50, 2·90	0·64, 4·85	0·59, 4·92
P			**0·034**	**<0·005**	0·985	0·876	0·583	0·674	0·275	0·326
Hx of CAD	213									
Yes	22	10·3								
No	191	89·7								
OR			0·92	**1·05**	0·96	0·82	1·38	1·41	2·13	2·00
95 % CI			0·38, 2·23	**1·02, 1·09**	0·39, 2·36	0·32, 2·10	0·51, 3·68	0·51, 3·91	0·60, 7·50	0·55, 7·30
P			0·858	**0·001**	0·930	0·686	0·526	0·509	0·241	0·293
Hx of hi Chol	210									
Yes	44	21·0								
No	166	79·0								
OR			1·03	**1·04**	1·10	1·00	1·25	1·27	1·84	1·79
95 % CI			0·53, 2·01	**1·02, 1·07**	0·56, 2·14	0·50, 2·01	0·61, 2·57	0·60, 2·69	0·77, 4·45	0·72, 4·42
P			0·925	**<0·005**	0·791	0·996	0·549	0·532	0·171	0·209
SBP (mmHg)¶	97									
Normal (≤139)	78	80·4								
High (>140)	19	19·6								
OR			**3·56**	**1·06**	2·36	2·84	1·66	1·70	1·72	1·68
95 % CI			**1·08, 11·7**	**1·02, 1·10**	0·85, 6·52	0·90, 9·02	0·54, 5·08	0·50, 5·73	0·45, 6·54	0·39, 7·23
P			**0·036**	**0·004**	0·099	0·076	0·377	0·395	0·428	0·487
DBP (mmHg)¶	97									
Normal (≤89)	87	89·7								
High (>90)	10	10·3								
OR			1·16	1·01	1·90	1·91	2·33	2·31	2·86	2·81
95 % CI			0·31, 4·42	0·97, 1·05	0·51, 7·08	0·50, 7·32	0·47, 11·64	0·46, 11·62	0·34, 23·94	0·33, 23·70
P			0·824	0·691	0·339	0·344	0·304	0·310	0·332	0·343

WC, waist circumference; IDF, International Diabetes Federation; Hx of DM, past history/diagnosis of diabetes mellitus; Hx of CAD, past history/diagnosis of coronary artery disease; Hx of hi Chol, past history/diagnosis of high cholesterol; SBP, systolic blood pressure; DBP, diastolic blood pressure.
Values in bold are statistically significant.
*BMI WHO-std refers to the currently used WHO BMI definitions.
†BMI WHO-mod refers to the proposed WHO-modified BMI parameters for Asians.
‡BMI WHO-mod or WC IDF refers to those who were classified as being overweight/obese by either the BMI WHO-mod or the WC IDF criterion.
§Male is the comparison group.
‖Comparisons were made after adjusting for age and gender.
¶Classification according to definitions of the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC 7)[21]. Both SBP and DBP are collapsed into two categories of normal and high blood pressure.

In summary, BMI WHO-mod and WC IDF independently identified higher numbers of overweight/obese participants, but when the BMI WHO-mod or WC IDF combination was applied nearly 75 % of participants were categorized as overweight/obese – a proven risk factor for the future development of metabolic syndrome[8–10,14].

Discussion

Migrant Asian Indians are reported to have high rates of DM, metabolic syndrome, CVD and its related complications in the USA, with insulin resistance identified as playing a pivotal role in this group. Central adiposity is a very strong indicator of insulin resistance and marked variations in the prevalence of insulin resistance syndrome could be accounted for by different methodologies used for the assessment of insulin resistance, different age groups, socio-economic status and variations in diet and exercise. Ethnicity and inclusion of disparate ethnic groups having ancestral origins from several countries in South Asia also account for the variability seen in the rates of insulin resistance[16]. Studies on South Asian Indians have estimated the prevalence of obesity in adults to be 23·2 %, 18·3 % and 25·8 % according to the WHO, ATPIII and IDF definitions[8]. It has also been documented that there is an increase in the prevalence of obesity, CVD and diabetes in South Asian immigrants to the USA, attributed to Westernization, change in diet and lifestyle, but there is no documentation of the exact increase in these figures[8,17]. Limited studies conducted in India and the Western world have shown a higher prevalence of adiposity and metabolic syndrome when Asian-specific cut-off points for BMI and WC measurements were used[18,19].

BMI cut-off, waist circumference and classification of obesity

Our results, as indicated above, did show a statistically significant difference in rates of obesity, with the WHO-mod BMI criteria identifying 67 % of the population as overweight/obese. This supported our hypothesis that standard WHO guidelines for obesity diagnosis are inadequate among South Asian Indians given their high prevalence rates of diabetes, metabolic syndrome and early CAD at lower anthropometric measures. The current cut-off points for BMI recommended by WHO are largely based on morbidity and mortality data from the white Caucasian population and may not be applicable across all ethnic groups. Diagnosis of obesity based on BMI alone may be inadequate and the disparity may be more pronounced with the presence of certain variables such as age, gender, genetic predisposition and ethnicity. Differences in body composition are observed in different ethnic groups, with Asian Indians having less skeletal muscle mass, low bone mineral content and excess body fat for a given BMI, and this has a direct impact on the determination of cut-off points for diagnosing overweight/obesity[8,9].

The present results compare favourably with those from prior studies of BMI and abdominal obesity criteria based on morbidity data and body fat determination, as discussed below. Several studies have investigated the BMI value which corresponds to the cut-off points of percentage body fat (25 % in male and 30 % in female participants) that indicate obesity, finding that the BMI corresponding to the cut-off of percentage body fat is lower for Asian Indians from various parts of India[20]. In a study conducted in North India by Misra *et al.*[21] (*n* 2000), a BMI cut-off of $>21 \cdot 0\,\text{kg/m}^2$ was observed to be optimum in identifying individuals with at least one risk factor (type 2 DM, hypertension, hypertriacylglycerolaemia and low HDL cholesterol) and the sensitivity and specificity improved when modified criteria for BMI were used. Limited studies conducted in Western countries have shown that, in comparison with a European cohort, the South Asian group had higher mean WHR, trunk skinfolds, blood pressure levels, fasting and post-glucose serum insulin concentrations, plasma TAG, lower HDL cholesterol and a higher prevalence of diabetes (19 % *v.* 4 %), indicating a higher predisposition to develop insulin resistance with a pronounced tendency to central obesity in this group[22]. A recent study in the USA conducted by Misra *et al.*[21] on the prevalence of diabetes, metabolic syndrome and cardiovascular risk factors in US Asian Indians (*n* 1038) showed that the mean BMI was 25·4 (SD 3·7) kg/m^2 and there was a significant difference in overweight and obesity prevalence depending on classification criterion, with respectively 38 % and 11 % overweight and obese using standard criteria whereas 25 % and 49 % were overweight and obese using modified WHO criteria[23]. Our study reproduced the above findings, with the average BMI in our study being 24·5 (SD 3·6) kg/m^2. Thus, 58 % of the patients (*n* 213) were classified as normal weight using the WHO-std criteria.

Abdominal obesity assessed by measuring WC and WHR is increasingly being recognized as an important cardiovascular risk factor[24]. Experts during a workshop on anthropometry sponsored by the Centers for Disease Control and Prevention (Atlanta, GA, USA) concluded that, because of heterogeneity in average levels of measurements of obesity in different populations, the currently recommended cut-off points might not apply to all populations[21]. The currently recommended cut-off for WC by NCEP-ATPIII may not be applicable to all ethnic groups and hence IDF has recommended using lower cut-off points for WC to diagnose abdominal obesity and as an inclusion criterion for metabolic syndrome among the South Asian ethnic group; and this has been supported by the American Heart Association. A recent national study of Asian Indians in the USA showed the age-adjusted prevalence of abdominal obesity to be 12·8 % and 56·4 % for male and 36·3 % and 68·0 % for female participants using the NCEP-ATPIII and IDF criteria[23]. Using data from the 1998 Singapore National Health Survey it was found that, in Asians, decreasing the WC cut-off (>80 cm in female and >90 cm in male participants) increased the crude prevalence of metabolic syndrome from 12·2 % to 17·9 %, indicating that applying the NCEP-ATPIII criteria to an Asian population will likely underestimate the proportion at risk[6]. A study conducted in India (*n* 4500) also reproduced the above findings, with the rates of metabolic syndrome increasing when Asian WC cut-off points were used (male: 26·9–32·5 %; female: 18·4–23·9 %)[9]. A study conducted in Canada, to evaluate whether BMI and anthropometric indices for visceral obesity vary by ethnic group and their relationship to metabolic abnormalities, showed that uniform cut-off points for the classification of obesity using the above indices resulted in marked variations in the levels of glucose-metabolic abnormalities between ethnic groups[25]. Our study showed statistically significant higher rates of abdominal obesity using the IDF criteria (male: 53 %; female: 63 %; $P < 0.005$) compared with the NCEP-ATPIII criteria (male: 13 %; female: 41 %). Our study showed that using the combination WHO-mod for BMI and IDF for WC resulted in significantly higher rates of identifying overweight/obese people in comparison with the WHO-std BMI, NCEP-ATPIII WC and other combination criteria (Table 4). Further, our data indicated that meeting either the WHO-mod BMI or IDF WC criteria identified nearly 75 % of participants as overweight/obese. Although classifications need to be validated by actual risk of subsequent disease, it may be important in this ethnic group to use both WHO-mod BMI and IDF WC as screening tools, with either criterion being used to determine a high-risk group for early intervention (Tables 4 and 5). Our study also showed that when WHO-mod BMI criteria were used, more participants with a history of diabetes, diastolic hypertension, CAD and hypercholesterolaemia were categorized as overweight/obese, indicating that there is a possible disease–risk association that may not persist when corrected for age; this needs further evaluation (Table 5). As our data and the limited studies suggest, the current standard WHO and NCEP-ATPIII recommended cut-off points for BMI and WC under-diagnose obesity in South Asian Indians. It is very important that the modified ethnicity-specific criteria be universally accepted. There needs to be a consensus that this information be disseminated to appropriate health-care personnel in order to aid the early identification and management of obesity, an under-diagnosed epidemic in this ethnic group.

Limitations

The limitations of the present study include a convenience sample with small size that may or may not be representative of all Asian Indians in Houston. Recall bias may also be a limitation, as participants were asked to provide self-reported data regarding their health status with no laboratory data for verification. In addition, about 46 % of participants had blood pressure data collected and we are unclear whether this is an accurate representation of the entire cohort. We also recognize that by simply altering the definition of obesity there is a possibility that we would increase prevalence in a given population; hence, future studies are needed to show that this increase in prevalence is predictive of subsequent disease.

Conclusion

Our study showed that obesity is likely under-diagnosed using the standard WHO criteria for BMI and the NCEP-ATPII guidelines for WC, indicating that these definitions may not be satisfactory for risk prediction. Stressing the use of modified criteria more universally to classify obesity among South Asian Indians may be an optimal means to identify obesity and help appropriate risk stratification in interventions to prevent chronic diseases. Limited studies in this ethnic group and these data provide a firm basis for the need of future intervention trials in this rapidly increasing subgroup in the US population.

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