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ARE HEALTH RISKS BETTER DISCRIMINATED BY GENERALIZED OBESITY OR CENTRAL OBESITY- A REPORTED RELATIONSHIP

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Abstract

Obesity is a well-documented risk factor for morbidity and mortality; they are also a major public health problem in many developing and developed countries. However, the association between body fat and pathology has not been fully elucidated. However, measures like body mass index (BMI), Waist height ratio (WHR), waist circumference (WC), waist height ratio (WHtR) and their differential association with excess body fat is still a debate. BMI is the most widely used traditional measure of describing general obesity, in recent years measures of central obesity like WC, WHR and WHtR have been suggested to more accurately describe the distribution of body fat and more closely associated to mortality and morbidity than BMI. There exist uncertainty about how these measures perform across diverse ethnic groups; most of the previous evidences and the cut off values of all these measures related to it associations with excess body fat and many non communicable illness has been chiefly derived from Caucasian populations. Hence, it remains unclear whether their relationships are consistent with non Caucasian populations. The purpose of this review is therefore to explore and narratively synthesize current evidences focusing on anthropometric measures and their health related predictive power, notable ethnic discriminations in their associations with conditions.

Keywords: Central obesity, Waist circumference, BMI, Diabetes mellitus.

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Introduction

It is a known fact that being overweight is a major risk factor for a wide range of chronic diseases[1]. One in every 3 adults in the world was overweight and 1 in every 9 was obese in 2008. Beyond this global average, at least 1 in 5 women were obese in 117 countries and at least 1 in 5 men were obese in 73 countries. Notably, the increase in the prevalence of obesity has accelerated in the last decade compared to the 1980s and 1990s[2]. The prevalence of obesity will continue to rise at an alarming rate. This recent trend of global increase in mean BMI had made obesity related works an active research area because obesity is a major driver of many Non communicable diseases[3]. The growing prevalence of type 2 diabetes, hypertension, cardiovascular disease, and some cancers is tied to excess weight[4]. The burden of these diseases is particularly high in the middle-income countries of Eastern Europe, Latin America, northern Africa and Asia, where obesity

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is the fifth-most-common cause of the disease burden ranking just below underweight[5, 6]. Number of people with diabetes worldwide is projected to increase from 171 million in 2000 to 366 million by 2030. This increase will be most noticeable in developing countries, where the number of people with diabetes is expected to increase from 84 million to 228 million[7, 8]. The high risk of both diabetes and cardiovascular disease associated with obesity in Asians may be due to a predisposition to abdominal obesity, which can lead to the metabolic syndrome and impaired glucose tolerance [9, 10].

Measures of adiposity such as BMI, waist circumference (WC), waist-to-hip ratio (WHR), and waist-to-height ratio (WHtR) have been shown to correlate differently with many Non-Communicable diseases (NCD); at the same time these measures also vary widely in their threshold based on race and diverse ethnicity[11-14]. Many studies have suggested that duration of general adiposity or central obesity also substantially increases the risk of acquiring coronary artery diseases and diabetes[15]. Central obesity (also known as abdominal obesity, central adiposity) means that most of the excess fat is located in the abdominal area[16]. Increased body mass index (BMI) (calculated as (weight [kg]/height^2 [m])) is still considered has a surrogate for total body fat, which is not always true. For an instance, someone who is muscular may have a higher weight and BMI which will eventually be categorized as overweight or obesity indicating higher proportion of fat mass[17-19]. Alternative measure such as waist circumference (WC), waist to height ratio (WHtR) and waist hip ratio (WHR) is a surrogate for abdominal subcutaneous and visceral fat stores are suggested to be superior predictors of some diseases. Both BMI and measure of central adiposity differentially correlates with numerous Non-Communicable diseases (NCD), including type 2 diabetes, cardio vascular diseases, stroke, cancer and mortality[20].

The utility of BMI and WC in predicting obesity related health risk has been recognized by the National Heart, Lung, and Blood Institute of the National Institutes of Health (NIH; 2). The NIH guidelines indicate that the health risk increases in a graded fashion when moving from the normal-weight through obese BMI categories, and that within each BMI category men and women with high WC values are at a greater health risk than are those with normal WC values. Both BMI and WC may have independent effects on obesity related co-morbidity[21]. In most occasions, addition of WC to BMI had predicted a greater variance in health risk than BMI alone, whether the reverse is true is still unclear[22]. That is, for a given WC value or WC category (e.g., normal or high), it is not known whether higher BMI values indicate a greater health risk than do lower BMI values. However, it has been shown that WC and hip or thigh circumferences have independent and opposite effects on metabolic health risk. WC is positively associated with health risk, whereas hip and thigh circumferences are negatively associated with health risk. This implies a protective effect of a large hip or thigh circumference (or both), which could be due to a greater lean mass in the non abdominal regions. Indeed, lean body mass is negatively associated with all-cause mortality[23-27].

WHO in its 2008-2013 action plan on interventions to prevent NCDs had mentioned an objective to develop simple strategies to identify those at risk. As the glucose test is invasive, relatively expensive, time consuming and not easy to apply to mass screening programmes, several other diagnostic tools, including obesity indicators such as waist circumference (WC) and body mass index (BMI), have been proposed and applied[28-29]. Moreover it is controversial that which measure of obesity and what cut off values in particular is strongly associated with NCD's. The purpose of this review article is to locate and narratively synthesize evidences in recent literatures focusing on anthropometric measures and their health related predictive power, notable ethnic discriminations in their associations with conditions.

Data source and method

Inclusion criteria for articles

Research articles with aim of finding the association between health risks and measures of obesity, comparing the predictive power of BMI, WC, WHR, WHtR were included. Articles on measure of obesity, exploring and defining cut offs values were also reviewed.

Exclusion criteria

Studies those using unstandardized methodology were excluded. Published articles related to these

titles were searched from 1985 onwards. The results of 15 prospective studies and 31 cross sectional studies is reviewed, summarized and presented.

Measure of generalized obesity (BMI)

WHO and IDF recommended cut offs for BMI or generalized obesity is 18.5-24.5 kg/m^2 for normal, 25.0-29.9 kg/m^2 for overweight and > 30 kg/m^2 for obesity[30]. But some authors suggest that these cut-offs are based on morbidity and mortality data from Caucasian populations, hence may not be applicable to all ethnic groups. Some ethnic groups pose higher percentage of body fat, central adiposity at lower BMI levels (Table 1).

They also recommended Normal BMI: 18.0-2.9 kg/m^2, Overweight: 23.0-24.9 kg/m^2, Obesity: >25 kg/m^2 and some Asian authors had recommended BMI cut off's corresponding to cut off percentage of body fat using DEXA scan[31, 32]. WHO experts panel recommended potential BMI categories for public health action in people of Asian descent (i.e., underweight <18.5 kg/m^2, increasing but acceptable risk 18.5 to <23 kg/m^2, increased risk 23 to <27.5 kg/m^2, and high risk ≥27.5 kg/m^2) is in line with many studies. In most of the Asian studies BMI cut-offs ranged from 22-25 kg/m^2 (Table 2)[31].

The ethnic-specific incidence of diabetes varied markedly across BMI categories. For the equivalent incidence rate of diabetes at BMI 30 kg/m^2 in white subjects, Some studies shows lower BMI cut-offs points for South Asian (24 kg/m^2), Chinese (25 kg/m^2), and black (26 kg/m^2) subjects, thus supporting the need for lower BMI cut-offs values for diabetes screening and lower ideal target body weights in non-white populations (Table 3)[33]. The diagnostic and predictive value of BMI versus percent body fat were diversified with over all sensitivity ranging from 50% in Asians to 80% is Hispanics. A World Health Organization (WHO) expert consultation also concluded recently that a substantial proportion of Asians with BMIs lower than the existing WHO cut-offs for overweight (BMI >25) are at high risk of type 2 diabetes and cardiovascular disease[34, 35].

Measures of central obesity

WHO recommended WC is between 94.0–101.9 cm in men and 80.0–87.9 cm in women, and WHR 0.8 and 0.9 in women and men respectively[36, 37]. Measures of central obesity such as waist circumference (WC), waist-to-hip ratio (WHR), and waist-to-height ratio (WHtR) have been shown to correlate differently with health risks[38, 39]. In a comparable meta-analysis from the Diabetes Epidemiology: Collaborative Analysis of Diagnostic Criteria in Asia Study (DECODA, 2008)[40], which involved the collation of data from 16 cross-sectional studies, an examination of the strength of association between BMI, WC, WHR and WHtR with type II diabetes suggested little difference between the first of the three measures but a slightly stronger association with WHtR in both men and women: age-adjusted odds ratios for diabetes in men (women) for one standard deviation increment were 1.52 (1.59), 1.54 (1.70), 1.53 (1.50) and 1.62 (1.7), respectively[41, 42].

For hypertension, the findings from DECODA were comparable with those from the OAC such that there was little evidence that measures of central obesity were more strongly associated with hypertension: the prevalent odds ratios for hypertension were 1.68 (1.55), 1.66 (1.51), 1.45 (1.28) and 1.63 (1.5)[40]. The International Day for Evaluation of Abdominal obesity (IDEA) was a large, international, non interventional, cross sectional study to evaluate abdominal adiposity (WC) measured by a standardized protocol in 168 000 primary care patients in 63 countries showed (Table 1) a wide distribution of WCs within each region, with median WCs higher in men than in women (Overall, the median WC (quartiles) was 95 (86 to 104) cm for men and 88 (78 to 98) cm for women. According to the NCEP criteria (WC≥102/88 cm for men/women), 29% of men and 48% of women had abdominal adiposity; with the IDF Caucasian criteria (WC ≥ 94/80 cm for men/women), these frequencies increased to more than half of the population (men 56%; women 71%) [32].

The Asia Pacific Cohort Studies Collaboration (Asia Pacific Cohort Studies Collaboration 2006) comprises data from 440 cohort studies within the Asia-Pacific region. Of these studies, 33 cohorts (n = 3, 10,000 individuals) had information on BMI and cardiovascular events but only six cohorts (n =

45 998) had information on waist and HC. In this subgroup analysis, which was based on 601 coronary heart disease events and 346 strokes, a one standard deviation increase in BMI, WC, HC and WHR was associated with an increase in risk of CHD of 17% (95% CI: 7–27%), 27% (95% CI: 14–40%), 10% (95% CI: 1–20%) and 36% (95% CI:21–52%), respectively[43]. In (IDEA) a Study of Waist Circumference, Cardiovascular Disease, and Diabetes Mellitus in 168 000 Primary Care Patients in 63 Countries, A statistically significant graded increase existed in the frequency of CVD and diabetes mellitus with both BMI and WC, with a stronger relationship for WC than for BMI across regions for both genders. This relationship between WC, CVD, and particularly diabetes mellitus was seen even in lean patients (BMI< 25 kg/m^2)[32].

The OAC reports on the ability of BMI, WC and WHR to discriminate those individuals with prevalent diabetes or hypertension and showed that the area under the receiver operating characteristic curves ranged from 0.63 to 0.71 in men and from 0.66 to 0.80 in women with little statistically significant evidence of any consistent difference between the three measures across the sex and ethnic groups.

Lee et al. (2008) conducted a meta-analysis involving 10 studies (nine of which were cross-sectional) and over 88 000 individuals, to determine which of the four indices (BMI, WC, WHR and WHtR) is the best discriminator of major cardiovascular risk factors: hypertension, type II diabetes and dyslipidaemia. In both men and women, measures of central obesity were superior to BMI as discriminators of cardiovascular risk factors, although the differences were small and unlikely to be of clinical relevance (Table 5). Further, the study showed that combining BMI with any measure of central obesity did not improve the discriminatory capability of the individual measures[44-48].

Ethnic difference in measures of central obesity and its association with health risks

The review did confirm that the optimal cut-off points for indicators of overweight and obesity, and measures of abdominal adiposity, vary across different ethnicities and population groups. Asian Indians appear to have higher morbidity at lower cut-off for WC than do White Caucasians. In a study by Misra et al. WC cut-offs, 72 cm in women (sensitivity: 68.7%, specificity: 71.8%) and 78 cm in men (sensitivity: 74.3%, specificity: 68.0%) were observed to be optimum for identifying those with presence of at least one cardiovascular risk factor. WC cut-offs of = 90 cm in men and = 80 cm in women identified high odds ratio (4.2 & 2.2, respectively) for cardiovascular risk factors and those with a BMI < 25 kg/m^2. Distinct ethnic groups may have significantly different visceral adipose tissue distributions and different cardio-metabolic risk profiles[31]. Therefore, the identification of risk sby using WC is population specific and depends on levels of obesity and other risk factors for cardiovascular disease and type 2 diabetes mellitus. The WC cut points generally recommended for the Caucasian adults are inferred from a Dutch population. The demographic characteristics of the Dutch people are not likely to represent those of other ethnic groups. Therefore, population specific WC cut-off values should be established and used to better estimate the presence of metabolic syndrome and the risk of cardiovascular diseases[49].

Conclusion

Many research papers have been published so far in order to report specific WC cut-off points in different populations. However, the results of these studies significantly differ, even within the same ethnic groups. Our review summarizes the evidence to indicate which measure of obesity like BMI, WC, WHtR, and WHR is strongly associated with CVD, hypertension and T2DM. There were strong evidences to suggest that measures of central obesity are more strongly associated with risk than BMI. However, again, the evidence is largely cross-sectional and requires confirmation from prospective studies.

Table No. 01: Characteristics of patient in different regions

			Mean BMI, kg/m^2(SD)		Mean waist circumference, cm (SD)	
	Number of patients	Mean age, y (SD)	Men	Women	Men	Women
North western Europe	29 582	51.7 (16.4)	27.2 (4.6)	26.4 (5.6)	97.8 (13.5)	88.3 (14.8)
Southern Europe	31 289	53.0 (15.8)	28.2 (4.5)	27.9 (5.6)	99.4 (12.9)	91.3 (14.7)
Eastern Europe	30 375	50.2 (15.9)	27.5 (4.8)	27.6 (6.0)	96.9 (13.7)	89.7 (15.7)
Northern Africa	5 028	43.1 (14.7)	26.6 (5.4)	28.3 (6.4)	93.6 (15.3)	93.1 (16.2)
Southern Africa	2 492	42.0 (13.8)	26.9 (5.6)	28.9 (7.2)	93.6 (15.5)	89.8 (16.4)
Middle East	5 457	41.9 (13.9)	28.2 (5.4)	28.7 (6.9)	98.2 (14.2)	93.4 (16.5)
Eastern Asia	11 402	48.4 (15.9)	24.4 (4.0)	23.9 (4.1)	86.4 (10.7)	80.2 (10.7)
Southern Asia	19 381	43.3 (14.7)	24.7 (4.8)	25.0 (5.6)	89.3 (13.4)	84.1 (13.9)
Australia	1 846	49.3 (16.7)	28.0 (5.2)	27.5 (6.3)	99.1 (14.9)	89.0 (15.9)
Canada	3 062	51.9 (15.7)	29.2 (5.7)	28.9 (6.9)	101.4 (15.2)	92.2 (16.2)
Latin America	28 245	44.1 (15.5)	27.8 (4.9)	27.6 (5.7)	96.4 (13.4)	89.7 (13.8)

Adapted from Beverley Balkau et al.,(2008).

Table No. 02: Cut-offs of BMI corresponding to Cut-offs of percentage body fat

Authors	Location	BMI cut off [kg/m^2]	Sensitivity (%)	Specificity (%)
Snehalatha et al. 2003	South Asian	Male 22	74.7	79.7
Mishra et al. 2006		Female 22.1	85.7	62.5
Vikram et al 2003	South Asian	Male 22	81.0	62.0
		Female 23	84.3	76.9
Mohan et al. 2007	South Asian	23	--	---
Singh et al. 2008	South Asian	Over wt 23.85	70.2	87.5
		Obese 24.38	90.0	81.2
Bhansali et al 2006	South Asian	Male 25	92	-----
		Female 23.9	84	------
Ishor Sharma 2013	Nepal	23.5	86.9	90.0
Rachmad Soegih 2004	Indonesia	24.67	62	72
Francisco de et al. 2010	Brazil	Male27	73.7	72.5
		Female 25	76.3	100.0

Table No. 03: Ethnic-specific BMI cut off for equivalent incidence rate of diabetes

ETHNIC GROUP	Whites	Blacks	Chinese	South Asian
BMI	≥30 kg/m^2	≥26 kg/m^2	≥25 kg/m^2	≥24 kg/m^2

Adapted from Maria Chiu et al. (2011)

Table No. 04: WHO & IDF recommended waist circumference cut off for different ethnic groups

WC (cm)	Europid	South Asians	Chinese	Japan	South & Central America	Sub Saharan Africa	Arabs
Male	94	90	90	85	90*	94*	94*
Female	80	80	80	90	80*	80*	80*

***WC-Waist circumference, *** *Cut-off points to be used until more specific data are available*

Table No. 05: Comparison of the discriminatory power (pooled AUC score) for three cardiovascular risk factors between measurements of obesity (BMI, WC, WHR, WHtR) stratified by gender (Lee et al., 2008)

CV risk factors	HT		T2DM		Dyslipidaemia	
Measurement	Men	Women	Men	Women	Men	Women
BMI	0.64	0.69	0.67	0.69	0.65	0.64
WC	0.67	0.71	0.70	0.74	0.64	0.66
WHR	0.67	0.71	0.72	0.75	0.64	0.66
WHtR	0.68	0.73	0.73	0.76	0.67	0.68

CV-cardiovascular, HT-Hypertension, T2DM-Type II diabetes

Abbreviations
AUC: Areas under the ROC curves
BMI: Body Mass Index
CHD: Coronary artery diseases
CI: Confidence Interval
CVD: Cardio-Vascular Diseases
DEXA: Dual Energy X-Ray Absorptiometry
HC: Hip Circumference
HT: Hypertension
IDEA: International Day for the Evaluation of Abdominal obesity
IDF: International Diabetes Federation
NCD's: Non-Communicable Disease's
NCEP: National Cholesterol Education Program
OAC: Obesity Action Coalition
T2DM: Type II Diabetes Mellitus
WC: Waist Circumference
WHR: Waist to Hip Ratio
WHtR: Waist to Height Ratio

Conflict of Interests
There are no financial or other contractual agreements that might cause conflict of interests.

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