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Review

Measures of global and central obesity as predictors of cardiovascular risk. Their utility in clinical practice

M. N. Moreira-Andrés[1,*] and F. J. del Cañizo-Gómez[2]

[1]Department of Endocrinology, Hospital Universitario 12 de Octubre, [2]Endocrine Unit, Hospital Universitario Infanta Leonor, Madrid, Spain

ABSTRACT

Measures of central obesity, such as waist circumference, waist to hip ratio and waist to height ratio, have been suggested to be more closely associated with subsequent chronic diseases and cardiovascular risk (CVR) than the body mass index (BMI = Kg/m^2), measure of global obesity. Over the past two decades several hundred studies have compared anthropometric parameters of obesity to evaluate which of them is the best in detecting adverse CVR profile. The purpose of this review is to provide an overview of the current evidence focused on the association between measures of global and abdominal obesity and several CVR factors, such as high blood pressure, type 2 diabetes mellitus and dyslipidemia, and to summarize results from recent prospective studies on the body size measures as predictors of cardiovascular disease outcomes. An overview of performance of these associations and cut-off values to predict CVR within and between different ethnical populations was also provided. The clinical utility of abdominal measures in clinical practice for the effective management of obese patients in resource poor-settings and in feasible routine biochemical testing was discussed.

KEYWORDS: anthropometric measures, cardiovascular risk, obesity, type 2 diabetes, hypertension, dyslipidemia

*Corresponding address: M. N. Moreira-Andrés,
Trav. Mare Nostrum nº 23,
28221 Majadahonda, Madrid, Spain.
manamoan@hotmail.com

ABBREVIATIONS

BMI, body mass index (Kg/m^2)
CAC, coronary artery calcification
CI, confidence interval
CT, computed tomography
CVD, cardio vascular disease
CVR, cardio vascular risk
DL, dyslipidemia
DXA, dual energy X- ray absorptiometry
HBP, high blood pressure
HDL-Ch, high density lipoprotein cholesterol
MI, myocardial infarction
OAC, Obesity in Asia Collaboration
SD, standard deviation
T2DM, type 2 diabetes mellitus
WC, waist circumference
WHO, World Health Organization
WHR, waist-to-hip ratio
WHtR, waist- to- height ratio

INTRODUCTION

Overweight and obesity are associated with a wide spectrum of chronic diseases, including type 2 diabetes mellitus (T2DM) high blood pressure (HBP) and dyslipidemia (DL), that are in turn cardiovascular risk (CVR) factors for increased cardiovascular disease (CVD) and mortality [1-7]. Traditionally, body mass index (BMI = Kg/m^2) has been the most widely used method to define excess body weight in epidemiological studies as well as in clinical practice. The World Health Organization (WHO) recommends the BMI as universal criterion of overweight (≥25) and obesity (≥30) [8-9]. A recent report from the Prospective Studies Collaboration [7] estimated that optimal survival is achieved at a BMI of 22,5-25 Kg/m^2 with reductions of life expectancy of 3 and 10 years in individuals with moderate (BMI 30-35) and extreme obesity (BMI 40-50). However, the clinical importance of abdominal obesity as a CVR factor has been well recognized the last decades [10], since prospective epidemiological studies have shown increased abdominal fat accumulation to be an independent risk factor for T2DM and other CVR conditions, CVD and death [11-13], and measures of abdominal fat accumulation have been reported to be better predictors of CVR than BMI [11-15]. Therefore, alternative measures of obesity, such as waist circumference (WC) [16-20], waist to hip ratio(WHR) [21, 22] and waist to height ratio (WHtR) [23-27], which reflect central adiposity, have been suggested to be more closely associated with subsequent chronic diseases and CVR than BMI. Measurements of WC are included in clinical guidelines on the management of overweight and obesity in adults [28].

Over the past two decades a large number of studies have been performed to address the question of what is the most appropriate anthropometric measure to define excess of body weight on the bases of which of them is more strongly associated with CVR factors or better predicts CVD outcomes. The purpose of this review was to provide an overview of the current evidence focusing on several questions: Are measures of abdominal obesity more strongly associated with CVR factors, such as T2DM, HBP, DL, or better predictors of CVD than BMI? Which abdominal measure is best associated with CVR or with CVD outcomes? Are there notable differences in the performance of these parameters and in their cut-off values to predict CVR within and between diverse ethnic groups? What is the utility of abdominal measures in clinical practice for the effective management of obese patients?

Metabolic disturbances associated with abdominal fat

Abdominal adipose tissue is important in understanding the relation of obesity with disturbances in glucose and lipid metabolism, including decreased glucose tolerance, reduced insulin sensitivity, hyperinsulinemia, HBP and adverse lipoprotein-lipid levels, [29-31]. Abdominal obesity is related to alterations in plasma concentrations of lipids, particularly low high density lipoprotein cholesterol (HDL-Ch), which is a strong predictor of risk of CVD [32], and increased plasma triglyceride concentrations, in relation to the association of insulin resistance with lipid and lipoprotein abnormalities, as risk factors for ischemic heart disease [33-36]. The mechanism linking the metabolic abnormalities related with abdominal fat are complexes and not yet clearly elucidated [31, 36, 37]. Accumulation of visceral fat has been considered the main determinant of these metabolic disturbances, since it is associated with increased secretion of free fatty acids, hyperinsulinemia, insulin resistance, HBP and DL [31, 38, 39]. However, subcutaneous fat may also play a role in metabolic derangement given its association with insulin resistance independently of visceral fat [40-42].

Measurements of abdominal fat

Computed tomography (CT) is the gold standard measure of intra-abdominal fat, but its use is limited. Therefore clinical measures, such as anthropometric parameters and technical measures, such as dual X ray absorptiometry (DXA), have been compared in their prediction of abdominal fat measured by CT.

Among proposed anthropometric parameters, WC [43-46], WHR [21, 47] and WHtR [24], to measure abdominal obesity as useful alternatives to direct abdominal fat measurements, WC has more commonly been accepted because of its simplicity [48] and strong association with visceral adipose tissue measured by CT [43]. However, the WHtR has been reported to be a better predictor of intra-abdominal fat than WHR and WC [24] generating some controversy on which is the best abdominal measure to estimate abdominal adiposity [49-51]. Although DXA derived abdominal regions of interest correlate well with visceral adipose tissue as measured by CT they are no better than WC or WHtR; neither DXA nor anthropometric measures are able to accurately distinguish between high and low levels of visceral fat between population groups [52].

Association between anthropometric parameters and CVR factors

The prevalence of CVR factors is increasing globally. Over the last decades much interest have been focused on the association between different measures of body size and one or other CVR factor. We summarize findings, either from large meta-analysis or from recent studies, on the association between measures of global and abdominal obesity and T2 DM, HBP and DL.

Association between anthropometric parameters and T2DM

Data from several meta-analysis that examined the association between measures of body size and T2 DM are conflicting. Vazquez *et al.* [53] conducted a meta-analysis of 33 cohort studies, in Caucasian and Asian populations, that evaluated the association between BMI, WC, and WHR and risk of incident T2DM. The pooled relative risk estimates [95% confidence interval (CI)] for incident T2DM associated with a one standard deviation (SD) increment in BMI, WC and WHR were 1.87 (1.67-2.10), 1.87 (1.58-2.20) and 1.88 (1.61-2.19) respectively, showing that the measures of global and abdominal obesity studied had similar associations with incident T2 DM. However, findings from the Obesity in Asia Collaboration (OAC), an individual participant data meta-analysis from 21 cross-sectional studies (n >263 000, 73% Asian), indicated that, with the exception of Caucasian men, WC and WHR were more strongly associated with prevalent T2DM than BMI [54]: A 0.5 SD increment in BMI was associated with a 20-30% prevalent odds ratio of T2DM, whereas for WC and WHR the same SD increment was associated with about 40% risk of T2DM. In contradiction with this finding, the DECODA study [55], a comparable meta-analysis in 16 cross-sectional studies in Asia, found little difference between BMI, WC and WHR association with T2DM, but WHtR in men and WC and WHtR in women showed a slightly stronger association with T2DM: age-adjusted odds ratios for T2DM in men (women) for one SD increment in BMI, WC, WHR and WHtR were 1.52 (1.59), 1.54 (1.70), 1.53 (1.50) and 1.62 (1.70) respectively. Several cross-sectional studies in different populations also found a slightly better association of WHtR than other anthropometric parameters with T2DM [56-61]. Furthermore, in a cross-sectional study including 958 T2DM patients WHtR was the best anthropometric measure associated with adverse cardio-renal outcomes [62].

Association between anthropometric parameters and HBP

There is no evidence from large meta-analysis that measures of abdominal obesity are more strongly associated with HBP than BMI. In the above mentioned meta-analysis from the OAC [54], the strength of the association of BMI, WC and WHR with HBP was similar across the three anthropometric measures for both men and women. Data from DECODA [55] also indicated that there was little evidence that measures of central obesity were more strongly associated with HBP than BMI: the prevalent odds ratio for HBP in men (women) were 1.68 (1.55), 1.66 (1.51), 1.45 (1.28), and 1.63 (1.50) for BMI, WC, WHR and WHtR respectively. However, findings from recent studies in different populations are conflictive: In Korean adults (2 327 men and 3 102 women) WHtR predicted HBP better than WC and BMI in both men and women [60], whereas according to studies in fourteen Chinese general populations (13 558 men and 15 521 women) the best indicator for HBP was WHtR in men but BMI in women [63]. Also in the INTERHEART study [27] BMI best predicted HBP as assessed from physicians records. The ATICA study [64] evaluated the effect of anthropometric indices in the 5 year incidence of HBP in a sample of cardiovascular disease- free European adults (1 514 men and 1 528 women), WC was the best predictor of the incidence of HBP, followed by BMI. Other findings from this study were that for every 1 cm difference in baseline measurements of WC a 2% higher risk of HBP was observed, and presence of obesity at baseline examination was associated with a 2.4 fold (95% CI 1.62-3.79) of the risk of HBP.

Association between anthropometric parameters and DL

DL is an important CVR factor, however the association between measures of body size with DL and with its individual lipid fractions has been less widely studied than with other risk factors. A clinical study, to compare anthropometric parameters as predictors of serum lipids, in 166 normal weight and obese premenopausal Spanish women, showed that classification of women by BMI, as indicator of body fatness, or by WC, as indicator of body fat distribution, did not make differences in mean serum lipid concentrations; besides, compared with WC, WHR and WHtR did not provide substantial information on the concentration of serum lipid components in women who needed weight management [65]. A clinical epidemiological cross-sectional study in adult European primary care population (2 016 men and 3 361 women) found some indications that WC or WHtR may predict DL better than BMI and WHR even though differences were small [59]. In Korean adult men (n = 2 327) WC was reported as the best parameter predictor for low HDL-Ch [60]. Lee *et al.* [66] conducted a meta-analysis involving 10 studies (9 were cross-sectional) over 88.000 individuals, to determine which of the four measures, BMI,WC,WHR and WHtR, was the best discriminator of major CVR factors: HBP, T2DM and DL. They concluded that, in both men and women, measures of central obesity tended to be superior to BMI as discriminatory of CVR factors, although the differences were very small and likely without clinical relevance. Barzi *et al.* [67] have recently published the results from the most comprehensive series of analyses to date of the relationships between BMI,WC,WHR and WHtR, with DL and its individual lipid components in 18 studies from ethnically diverse populations (n = 222 975) of the Asia Pacific regions. They reported that no single anthropometric measure was superior at discriminating those individuals at increased risk of dyslipidaemia, and that the magnitude of the associations between measures of body size and lipids were broadly similar between Asians and non-Asians.

Association between anthropometric parameters and CVD outcomes

There are few prospective studies conducted to discriminate which parameter has better prediction power of CVD events. Published data indicate that there is no clear agreement as to whether measures of central obesity are more strongly associated with CVD outcomes compared with BMI: differences found between anthropometric measures as predictors of CVD events are either contradictory or small, and likely without clinical significance. In a subgroup from the Asia Pacific Cohort Studies Collaboration [68] (n = 45 998, coronary heart disease events: 601, stroke: 346) the associations with increase of CVD events tended to be stronger for WC and WHR than for BMI [one SD increase in BMI, WC and WHR was associated with an increase in risk of coronary events (95% CI) of 17% (7-27), 27% (14-40) and 36% (21-52) respectively], but there was no clear association between any of the anthropometric measures with stroke outcomes. However, in a prospective study of predominantly non obese Chinese women, aged 40 to 70 years (n = 74 942, follow up: 7.5 y. stroke: 2 403) increased measures of general or abdominal obesity consistently predicted increased risk of stroke [hazard ratios (95% CI) for stroke comparing the highest versus lowest quintiles of BMI, WC, WHR and WHtR were 1.71 (1.49-1.97), 1.77 (1.53-2.05) 1.59 (1.37-1.85), 1.91 (1.61-2.27) respectively] [69]. In the INTERHEART [15], a large case control study involving >12 000 cases of myocardial infarction (MI) and 14 000 controls of varying ethnicity from 52 countries, BMI was positively and linearly associated with MI, such that individuals in the top quintile of the BMI had an 40% greater risk of MI compared with those in the lowest quintile [odds ratio 1.44 (95% CI) 1.32-1.57], after adjusting for WHR the risk of MI was reduced to approximately 10% [odds ratio comparing highest with the lowest quintile of BMI 1.12 (95% CI: 1.03-1.22)]. In this study, WC and WHR were also strongly and linearly associated with risk of MI [odds ratio for MI comparing the top with the lowest quintiles for WHR and WC were 1.75 and 1.33 (both p-values <0.001)], but the relationships were relatively unaffected after adjustment for BMI, indicating the independence of measures of central obesity in predicting risk of MI. This findings contrast with those from Gelber *et al.* [70] over studies in men (n = 16 332, follow up: 14.2 y., CVD: 1 505) and women (n = 32 700, follow up 5.5 y., CVD: 414), which also explored the issue of whether the effects of BMI on CVR are independent of central obesity. The magnitude of the linear and positive association between self reported anthropometric measures (BMI,WC,WHR,WHtR) and CVD risk was broadly similar across the measures, although the association tended to be stronger for WHtR. However after adjusting for BMI the relationship was attenuated, but remained statistically significant, suggesting that some of the risk associated with central obesity is mediated in part by BMI. They concluded that WHtR tended to be more strongly associated with CVD than the other parameters although, differences in CVR assessment comparing BMI with other measures was small. In a prospective study including Iranian adult population (n = 1 614 men and 2 006 women, follow-up: 7.6 y., CVD: 333) the risk factor adjusted hazard ratios for CVD events was similar and significant (all p-values <0.05) for all anthropometric variables in males (1.19, 1.24, 1.21, 1.24 for BMI,WC,WHR and WHtR respectively) and for WHR in females (1.27) [71]. In the PRIME [72], a prospective study in middle aged European men (n = 10 602, follow up: 10 y. CVD: 659), WHtR identified coronary risk more strongly than WC,WHR or BMI, though the differences were marginal [after adjustment for BMI, the relative risks (95% CI) for CVD were 1.30 (0.99-1.71, p = 0.06), 0.99 (0.76-1-30, p = 0.5) 1.22 (0.93-1.60, p = 0.1) and 1.53 (1.16-2.01, p = 0.03) for BMI,WC,WHR and WHtR respectively]. The WHtR has also been reported as the preferred clinical measure of obesity for predicting mortality [20, 73].

Ethnical differences in the association between parameters of body size and CVR

There is increasing prevalence of T2DM and CVD in Asian countries occurring at levels of BMI much lower than the WHO cut off point of overweight (25.0) and at lower BMI levels than in Caucasian populations [74]. Possible explanations for these findings may be that, for a given BMI, adiposity can be greater in Asian compared with Caucasian individuals and also that ethnical differences may exist in the strength of the associations between body size measures and adiposity and BMI have been found even within Asian populations. For a given BMI adiposity was greater in Hong Kong Chinese, Indonesians, Singaporeans and urban Thailand than in Europeans, whereas subjects from Northern China and rural Thailand had similar values to Europeans [75]. With respect to ethnical differences in the strength of the relationships between body size measures and CVR, findings are contradictory: Bell *et al.* [76] reported a stronger association between BMI and HBP in Chinese than in Caucasians and in non-Hispanic blacks compared with Caucasians and Mexican Americans. However, according to data from a large meta-analysis, including multiethnic studies in the Asia Pacific region, the association between body size measures and HBP was stronger in Caucasians compared with non- Caucasians: A 0.5 SD increment in each measure was associated with a 40% risk of prevalent HBP in Caucasian men compared with only a 30% risk in non-Caucasian men [54]. Despite the often considerable differences in body size and fat distribution between different ethnic groups, there was no clear evidence of any significant differences in the strength of associations between BMI,WC or WHR with T2DM across the sex and ethnic groups [54].

Coronary artery calcification (CAC), as indicator of subclinical disease, can be used to predict risk of coronary heart disease. Studies conducted in different ethnic groups from the United States found racial differences in the prevalence and severity of CAC: it was higher in whites compared to African Americans and other ethnic groups, indicating a higher prevalence of subclinical coronary heart disease in whites than in the other ethnic groups; these differences were more pronounced in men and in the elderly [77]. There is also a recent report of greater intra-abdominal adipose tissue in white than in African American women associated with higher levels of markers of inflammation, whereas African Americans had lower insulin sensitivity independently of obesity, fat distribution and markers of inflammation [78].

Cut-off optimal points of anthropometric parameters to predict CVR in different ethnic populations

The WHO recommends measurement of BMI as a universal criteria of overweight (≥25)and obesity (≥ 30) and recognizes that WC 94-102 cm in men and 80-88 cm in women and WHR ≥ 0.9 in men and ≥ 0.8 in women correspond with the overweight range (BMI: 25-30) [8]. These estimates are derived from predominantly Caucasian populations, and the applicability of these cut-off points in non Caucasian populations is questioned [9]. As above mentioned, central adiposity is a growing problem, particularly among Asian populations, where individuals may have a normal BMI but disproportionally large WC. In a cross-sectional study including four community Chinese centers (n 3 704 men and 6 392 women, aged 18-85 y.) the WC was the best predictor, among the measures studied (BMI,WC,WHR and WHtR), for ≥ 2 metabolic CVR factors in both genders; optimal cut-off points were 89 cm in men while, in women was different depending on age: 89.5 cm in > 60 years, 82.5 cm in 40-60 years and 80.5 cm in < 40 years. [79]. Two extensive meta-analysis including studies in Asian and non-Asian subjects determined that WHR cut-off points of 0.8 in women and 0.9 in men, in both sexes, were applicable across Asians and non-Asians for the optimal discrimination of individuals with prevalent T2DM, HBP or any form of DL [54, 67]. A recent clinical study evaluated presence of vascular changes in 100 adult European never smoking subjects (71 women and 29 men), findings were that association of central obesity with early carotid intima-media thickening is independent of that from other risk factors, and the proposed cut-off points of body size measures to indicate vascular and metabolic risk factors were: BMI ≥ 25 kg/m^2 in both genders, WC≥ 88 and 102 cm and WHR≥ 0.8 and 0.9 in women and men respectively and WHtR ≥ 0. 50 in both sexes [80]. However, in the above mentioned prospective study in Iranian adult population [71] cut-off values for prediction of CVD tended to be higher in females and in males: BMI 29.2 and 26.9 kg/m^2, WC 95.5 and 95.5 cm, WHR 0.90 and 0.95, and WHtR 0.62 and 0.55 respectively. A WHtR of approximately 0.55 best predicted metabolic risk factors in European primary care patients [59] and in an adult Spanish general population [61]. However, a lower WHtR cut-off level, 0.50, is proposed as indicator of weight management in Caucasian [26] and in Asian populations [23, 81-84]. The cut-off value of 0.50 for WHtR was also found to be appropriated to separate subjects with increased CVR and evidence of subclinical vascular disease according to the above mentioned study [80]. In the same line, in a clinical study from the United States, in 639 young normal weight black and white adults (75% white, and 36% men), subjects with WHtR ≥ 0.50 had greater prevalence of DL, HBP, insulin resistance, hyperuricemia and elevated C-reactive protein and greater carotid intima-media thickness than those with WHtR < 0.50 [85].

Limitations of studies on the relationship between anthropometric parameters and CVR

Most of the data on the relationship between anthropometric parameters and CVR are from cross-sectional studies, which examine the temporal nature of the association between measures of excess weight and CVR factors. However, the development of T2DM, HBP or DL may influence body size. Besides, a survivor bias cannot be ruled out, it is possible that older persons with highest risk had died who could not be studied. It has also to be considered that these data only show the association with present risk factor conditions but do not directly predict the future risk of cardiovascular events, for which prospective studies are necessary.

Several differences between studies, such as study design (case control vs. cross sectional), subject population (general population vs. primary care patients), definition of risk conditions (newly diagnosed vs. all patients with risk conditions), may lead to different results. Also, methods of measurement of anthropometric parameters (WC: the smallest circumference vs. midway between the lowest rib and pelvis; hip circumference: at the widest hip circumference vs. at the great trochanters), and personnel who performed them (trained personnel vs. personnel according to written, standardized instructions or even, self reported measurements). Presence of other diseases among the controls, in the case control studies, might have possibly led to potential bias. Finally, different statistical methods (adjustment for different variables) may contribute, among other factors, to different or even contradictory findings.

Clinical utility of anthropometric measurements

Provide evidence on which of the anthropometric measures of body size is most strongly associated with CVR, either within or between different ethnic groups and on what are their cut-off values is a key requirement for defining prevention strategies for the weight-related morbidity and mortality within and between populations. Besides, in a clinical setting in poor populations, where laboratory assessment is not available, the use of appropriated anthropometric measures and optimal cut-off values is important to separate individuals who need further attention. In a study in 689 participants aged 40-59 years and without CVD, a risk algorithm based on non –laboratory data from a single primary care consultation, (including age, sex, WHtR, present smoking, prevalent T2DM or HBP at base line and family history of CVD) predicted long term CVD events as accurately as an elaborate laboratory- based method [86]. Although anthropometric parameters used in daily clinical practice have a predictive value of CVR [59, 86], a possible superior discriminatory capability for prediction CVR factors of any of the parameters has no practical usefulness in the physician´s daily management of obesity in clinical settings where blood glucose and serum lipids are usually measured in obese patients; in this situation, obesity and the associated abnormalities are treated concomitantly. Besides, as Huxley *et al.* [87] concluded after a recent review of the literature on anthropometric parameters as predictors of CVR, given the general consistency in associations between measures of body size and CVR, there was limited evidence to support the superior discriminatory capability of any of the measures. Furthermore, the differences in discriminatory capability that were reported were too small to be of any clinical relevance.

There is no consensus on which anthropometric parameter is of more utility in daily clinical practice for the definition of obesity and for the follow-up of obese patients. WC has some advantages over BMI because it is a simple measurement, easier to understand for lay persons: no need to use square terms and to do any calculation, less clothes need to be removed for measurement and, as WHtR, is more sensitive to diet and exercise than the BMI, because increase in muscle mass might lead to little change in BMI but clear changes in WC and WHtR. The National Cholesterol Education Program has adopted the upper WC levels (WC >102 cm in men and >88 cm in women) to define abdominal obesity as criteria of the term metabolic syndrome [88] and the International Diabetes Foundation proposed a new definition of metabolic syndrome using adapted WCs for different ethnic groups [89]. The WHR is not only more complicated to assess than WC but it has also been criticized for masking accumulation of abdominal fat if the hip circumference is also increased [90]. WhtR has the advantage over WC that takes into account differences in body height; it would make sense to correct WC for height, in the same way as measures of body weight necessitate adjustment for height. However, it has been reported that height has limited influence on the WC in obese adults [91]. WHtR has shown to be better than other parameters especially to predict metabolic derangement in children and adolescents [92, 93] and it has been proposed as the best measure to be used in clinical practice (26; although, according to a recent report a BMI ≥ 25 was as reliable as a WHtR ≥ 0.5 in determining metabolic and vascular abnormalities of risk in adult subjects [80]. Abdominal measures would be of utility in daily clinical practice to separate normal weight subjects, which may present abdominal obesity in spite of BMI in normal range. There are reports that abdominal fat is related to increased risk of CVD even in normal weight subjects [94, 95]. A WHtR ≥ 0.5 in these subjects might alert prevalent metabolic and vascular derangement [85].

SUMMARY

Data from large meta-analysis of studies in adult populations do not provide evidence to indicate which of the commonly used measures of global and central obesity is better predictor of CVR. For T2DM there was some evidence to indicate that measures of central obesity were more strongly associated with risk compared with BMI; however for HBP and for DL the relationships with BMI, WC and WHR were broadly similar. Some recent studies suggest better relationship for WHtR than for the other parameters of body size with CVR factors and with CVD outcomes but, in general, differences were small and probably without clinical relevance. Future meta-analysis are needed to obtain solid scientific bases on the superiority of this parameter in relation with CVR. Most studies are cross-sectional therefore, they do not directly predict the future risk of cardiovascular events. To elucidate which anthropometric parameter is the best predictor of future cardiovascular events or mortality, more prospective studies are necessary; standardized methodological instructions to perform the studies would allow better to compare results.

There was little evidence to indicate that the strength of the associations between measures of body size and subsequent CVR was consistently different across the ethnic groups. Ethnical differences were found in cut-off values of anthropometric parameters to predict CVR. Finally, it is not clearly established which measure, if any, of central obesity is best to use in clinical practice for the management of obese patients; although WC is the simplest one and more widely introduced, WHtR might be more adequate mainly in children and adolescents. It has also been suggested the utility of WHtR in detecting central obesity and related CVR among normal weight young adults.

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