Obesity, defined as excess fat (adipose) tissue accumulation that may impair health, is a highly prevalent and serious public health problem. Roughly 35.7% of American adults are obese. High rates of obesity are not limited to the United States or even to other highly developed countries. The prevalence of obesity in Mexico, for example, is comparable to that in the United States. Not surprisingly, rates of obesity-related illnesses including cardiovascular disease (CVD) are rising quickly worldwide. More than 25 million American adults have been diagnosed with diabetes mellitus. India is projected to have >100 million diabetic people by the year 2030. CVD is the number 1 cause of death worldwide. These grim statistics highlight the need for accurate identification of overweight and obese adults who are at high risk for obesity-related illnesses. Accurate identification of such people allows healthcare professionals, policymakers, and others to target prevention and treatment programs to those at the highest risk of morbidity and mortality. Unfortunately, the tools and measures currently available to identify obesity and associated risks are either impractical, inaccurate, or both. For example, the body mass index (BMI) is easy to calculate, and established cutoffs that define overweight (25 kg/m²) and obesity (30 kg/m²) are readily available and well known. The application of such cutoffs to a diverse population, as will be discussed, however, leads to misclassification of a large number of people. Many people with a normal BMI have high levels of adiposity and also are at high risk for obesity-related illness. Others with a high BMI have relatively normal levels of adiposity and are metabolically healthy. The problem of misclassification is especially important for racial and ethnic minorities, who make up nearly 40% of the American population today and will make up more than half of the population by the year 2050.

The purpose of this scientific statement is to describe the limitations of current simple measures, such as the use of BMI with standard thresholds to identify overweight and obesity, as applied to racial and ethnic minorities. The statement also addresses potential alternatives, as well as the diagnosis of obesity based on multiple risk factors, including race and ethnicity. On the basis of our extensive, systematic review of current literature and in collaboration with the American Heart Association’s Obesity Committee of the Council on Lifestyle and Cardiometabolic Health, we have also made some key recommendations for clinical practice, research, and public health for improved identification of obesity and cardiovascular risks in a racially and ethnically diverse population.

This statement is focused on racial and ethnic groups within the United States, although many of our conclusions are either drawn from or applicable to related populations around the world. We use the standard US Census Bureau classification of Hispanic origin and race. Although our statement is intended to encompass the full racial and ethnic diversity of the United States, many people with a normal BMI have high levels of adiposity and also are at high risk for obesity-related illness. Others with a high BMI have relatively normal levels of adiposity and are metabolically healthy. The problem of misclassification is especially important for racial and ethnic minorities, who make up nearly 40% of the American population today and will make up more than half of the population by the year 2050.

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States, we acknowledge that specific groups make up a large or growing segment of the population and also suffer disproportionately from obesity and CVD. Groups that are the focus of the discussion that follows include the following: (1) Blacks, non-Hispanic blacks, and those who identify as such and have primary or partial ancestry in sub-Saharan Africa. This group represents 42 million Americans (13.6% of the population).7 (2) Hispanic or Latinos (eg, people of Puerto Rican, Mexican, or Dominican origin), a group of diverse racial and ethnic origins that includes >50 million Americans (16.3% of the total population). Among Hispanics, Mexican-Americans, a group that includes those who identify as having primary or partial ancestry in the Republic of Mexico, represent 31.8 million Americans (10.0% of the American population). This group grew by 11.2 million people between 2000 and 2010 and now represents 63% of the US Hispanic population.10 (3) Asian Americans (10.0% of the American population). This group includes East Asian Americans (people of part or whole Chinese, Korean, Japanese, Filipino, Vietnamese or other Southeast Asian ancestry) and South Asian Americans (people of part or whole Indian, Nepali, Pakistani, Bangladeshi, or Sri Lankan origin).

This statement is intended to provide practical guidance for clinicians and therefore emphasizes simple anthropometric measures, including BMI, waist circumference (WC), and waist-hip ratio (WHR), alone or in combination with other measures of overall cardiovascular risk. However, we do briefly also describe the accuracy of currently less practical methods such as imaging and related methods for identification of adiposity in racial and ethnic minorities. The accuracy of anthropometric measures has been assessed on the basis of comparison to more reliable measures of adiposity (such as dual-energy X-ray absorptiometry [DEXA] scanning), as well as on the ability of such measures to distinguish between people with and without cardiovascular risks (eg, diabetes mellitus and other components of the metabolic syndrome). In some studies, the ability of anthropometric measures to predict cardiovascular or all-cause mortality has been estimated. For our purposes, we consider all 3 of these standards for evaluation of the value of anthropometric measures to be valid and important.

We searched the PubMed database for English-language articles published between 1998 and 2013. As noted, our focus was racial and ethnic minority populations living in the United States. We limited our search to these populations and closely related populations from other parts of the world (eg, people of South Asian background living in India or the United Kingdom). Our search was limited to adults only. We used a variety of search terms in various combinations, including the following: obesity, adiposity, measurement, diagnosis, accuracy, race, ethnicity, blacks, Hispanics, Asians, Native Americans, south Asians, Indians, Chinese, BMI, WC, WHR, cardiovascular risk, and Framingham risk score. We considered both review articles and cross-sectional studies. The abstracts of all retrieved citations were reviewed for relevance. Relevant articles were shared and discussed by all authors. We also reviewed the reference lists of all reviewed articles to identify additional relevant studies. Members of the writing group who knew of relevant consensus guidelines, scientific statements, and articles not indexed in PubMed shared and reviewed these with other group members.

Nature of the Problem

Applying Common Anthropometric Measures With Uniform Standards to Minority Populations

Body Mass Index

BMI was developed as a measure of body fatness (adiposity) nearly 200 years ago by Adolphe Quetelet.12 BMI is the most widely used measure to identify overweight and obesity in research studies and is recommended in clinical settings as well. Cutoff points of 25 and 30 kg/m2 define overweight and obesity, respectively, according to both the National Institutes of Health (NIH) and World Health Organization (WHO).1,13 These cutoffs have been recommended for use in all populations and for both men and women. BMI is easy to calculate, and having uniform cutoffs in different populations greatly simplifies identification of overweight and obesity. As a diagnostic tool, however, using the BMI with these cutoffs is problematic for several reasons. As pointed out by Kuczmarski and Flegal,14 the origin of the current recommended cutoffs is not entirely straightforward. BMI cutoff points have evolved considerably over the past 30 years. At times, cutoffs were based on a reference standard, which means that cutoffs separated population segments based on the overall distribution of BMI. The recommended BMI cutoffs of 27.8 kg/m2 for men and 27.3 kg/m2 for women recommended by the NIH in 1985, for example, represented the 85th percentile for adults aged 20 to 29 years in the population.15 The current BMI cutoffs of 25 and 30 kg/m2 were based loosely on a criterion standard, which means that cutoffs were selected to reflect morbidity and mortality. Recent evidence, however, calls this rationale into question. There is some evidence, for example, that a BMI between 25 and 30 kg/m2 is associated with lower mortality than normal weight (BMI of 20–25 kg/m2) and that a BMI of 30 to 35 kg/m2 is not associated with increased mortality compared with normal weight.16 There is also evidence that current BMI cutoffs do not accurately predict the presence of cardiovascular risk factors or the incidence of heart disease in diverse populations.17,18

Visceral adipose tissue (VAT) may better predict cardiovascular risk than BMI. VAT likely serves as the site of dysfunctional, hypertrophic adipocytes that promote inflammation, oxidative stress, and production of cytokines and adipokines.19,20 Consistent with the evidence of its metabolic activity, VAT has also been shown to predict CVD burden and incident cardiovascular events independent of other cardiometabolic risk factors.21–24 Additionally, VAT appears to improve cardiovascular risk prediction over BMI.18 Unfortunately, data describing the relationship between VAT and CVD in racially and ethnically diverse populations are extremely limited.25

As a criterion standard for identifying people at high risk for cardiovascular morbidity, as well as cardiovascular and all-cause mortality, BMI with current cutoffs alone is of limited usefulness. An ideal tool for identifying overweight and obesity would be able to distinguish not only between people at
lower and higher risk of cardiovascular events, cardiovascular morbidity, and cardiovascular and all-cause mortality but also between those with low and high levels of adiposity in general. Clearly, CVD and related mortality represent extremely serious consequences of obesity, but excess body fat has a much broader impact, for example, on the musculoskeletal system, sleep, the incidence of cancer, and a wide range of psychosocial issues. Can BMI with current cutoffs at least be used to identify people with excess adiposity? Adiposity can be accurately measured by a number of different techniques, including DEXA (“Nonanthropometric Imaging and Other Measures”). Unfortunately, even as a simple measure of adiposity, the current BMI cutoffs are inaccurate across the general population. The WHO reference standards for percent body fat (%BF) used to define obesity are 25% for men and 35% for women. Romero-Corral et al26 found that a BMI of 30 kg/m² in a diverse sample of US adults had a high specificity (95% for men, 99% for women) to detect obesity defined by %BF but very poor sensitivity (36% for men, 49% for women). The inaccuracy of BMI in predicting adiposity across the general population has been confirmed by others.27

The accuracy of BMI with standard, uniform thresholds as a measure of adiposity or cardiovascular risk is especially problematic in ethnic and racial minorities. Several studies have documented the poor sensitivity of BMI in Asian populations and the need for lower BMI thresholds. In a study of Japanese Americans, for example, in which elevated cardiovascular risk was defined as the presence of ≥ 2 risk factors (among them, high-density lipoprotein cholesterol [HDL-C] <40 mg/dL for men or <50 mg/dL for women; triglycerides >150 mg/dL; blood pressure >130/85 mm Hg or taking antihypertensive medication; or fasting plasma glucose >100 mg/dL, 2-hour oral glucose tolerance test >140 mg/dL, or use of glucose-lowering medications), the optimal BMI for identifying people at elevated risk was estimated at just 23.3 kg/m² for women and 25.3 kg/m² for men.28 BMI is also a poor measure of adiposity among Asians and Asian Americans.29 Just 7% of Asian American men and women have a BMI ≥30 kg/m².29 According to one estimate, 25-year-old women of Chinese origin, for example, with a %BF of 35% (WHO threshold for obesity among women) have a BMI on the average of just 24.3 kg/m², far below the cutoff of 21.7 kg/m² for white women.29

The ability of BMI to predict cardiovascular risk and the associated optimal BMI cutoff values varies considerably in other racial and ethnic groups and between men and women. For example, the BMI cutoff with the maximum sensitivity and specificity for predicting diabetes mellitus among Mexican American men has been estimated at >27.8 kg/m² compared with 29.5 kg/m² among non-Hispanic white men. By contrast, the optimal cutoff among Mexican American women has been estimated at 30.4 kg/m², higher than the cutoff of 27.7 kg/m² among white women. Other estimates from Mexico itself are available that substantiate the need for lower cutoffs for predicting diabetes mellitus among men of Mexican origin compared with non-Hispanic white men. Data from the 2000 Encuesta Nacional de Salud (ENSA), or Mexican National Health Survey, which enrolled 11 730 men and 26 647 women, were used to calculate optimal BMI cutoffs for predicting type 2 diabetes mellitus and hypertension in Mexican men and women. Optimal BMI cutoffs for predicting type 2 diabetes mellitus were 26.3 to 27.4 kg/m² in men and 27.7 to 28.9 kg/m² in women. Optimal cutoffs for predicting hypertension were 26.2 to 27.0 kg/m² in men and 27.7 to 28.5 kg/m² in women.22

Another study of optimal cutoffs for predicting ≥1 of 3 risk factors (glucose >125 mg/dL or use of diabetes mellitus medication, blood pressure >140 mm Hg or use of antihypertensive medication, and low-density lipoprotein cholesterol >160 mg/dL, HDL-C <35 mg/dL for men/<45 mg/dL for women, or use of cholesterol-lowering medication) estimated comparable cutoffs of 23.9 kg/m² for Mexican American men and 23.6 kg/m² for white men.23 Optimal cutoffs differed significantly between Mexican American women (23.5 kg/m²) and white women (21.7 kg/m²). The optimal BMI cutoff value predictive of having >1 of 3 CVD risk factors for black men was estimated at 23.0 kg/m², comparable to that among white men (23.6 kg/m²). In the same study, the optimal BMI cutoff among black women was 23.0 kg/m², significantly higher than the cutoff of 21.7 kg/m² among white women.17

As among Asians, BMI with standard thresholds provides a poor estimate of adiposity among other racial and ethnic groups. Analysis of data and derivation of estimates from the National Health and Nutrition Examination Surveys (NHANES) by Heo et al33 revealed that non-Hispanic white men aged 18 to 84 years with a BMI of 30 kg/m² have a %BF in the range of 29.8% to 32.3% depending on age, well above the WHO threshold for obesity. Non-Hispanic white men with a BMI of 25 kg/m² have between 24.9% and 28.0% body fat depending on age, which suggests that a BMI threshold of 25 kg/m² may be more appropriate for defining obesity in this group. BMI cutoffs of 25 and 30 kg/m² also underestimate body fat among Mexican American men. Mexican-American men with a BMI of 25 kg/m² have between 25.6% and 27.5% body fat, Mexican-American men with a BMI of 30 kg/m² have between 30.1% and 31.9% body fat.

Non-Hispanic black men have significantly lower %BF at BMI values of 25 and 30 kg/m² than their white or Mexican-American counterparts. Non-Hispanic black men with a BMI of 25 kg/m² have %BF in the range of 22.6% to 25.6% depending on age, and those with a BMI of 30 kg/m² have %BF in the range of 27.5% to 30.0%. Among women with a BMI of 30 kg/m², both non-Hispanic whites and Mexican-Americans have body fat percentages well above the WHO standard of 35%, with a range of 41.8% to 44.0%. As in the case of non-Hispanic black men, standard BMI cutoffs among non-Hispanic black women more closely correlate with the 35% body fat standard than for women of other backgrounds. Non-Hispanic black women have a %BF in the range of 35% to 37.7% at a BMI of 25 kg/m² and 39.9% to 42.3% at a BMI of 30 kg/m².24 On the basis of these estimates, Rahman and Berenson24 report that the sensitivity of BMI ≥30 kg/m² for %BF >35% is greater among non-Hispanic black women (75% sensitive) than among non-Hispanic white (47.8% sensitive) and Hispanic (53.9% sensitive) women.

The differences in body fat percentages described above may be associated with significant differences among different racial and ethnic groups in both skeletal and muscle mass. On average, non-Hispanic black men and women have greater...
skeletal and muscle mass than their non-Hispanic white counterparts, who in turn have greater skeletal and muscle mass than men and women of Asian origin.\textsuperscript{35–37} Skeletal and muscle mass in Hispanic men and women approximates that in non-Hispanic white men and women.\textsuperscript{27} In conclusion, BMI with standard cutoffs for overweight and obesity does not reliably predict cardiovascular risk, cardiovascular morbidity, cardiovascular and all cause-mortality, or adiposity among men or women of different ethnic and racial backgrounds in the US population. The accuracy of BMI cutoffs in predicting adiposity is somewhat better among non-Hispanic blacks than among other groups.

**Waist Circumference**

Elevated WC and WHR are associated with increased cardiovascular risk and premature death independent of BMI.\textsuperscript{38,39} Like BMI, both measures are correlated with overall adiposity, but they are more appropriately used as measures of abdominal obesity, which correlates with the amount of VAT, which in turn is strongly associated with cardiovascular risk.\textsuperscript{40,41} The mechanisms through which VAT leads to adverse metabolic effects are not well understood. Possible mechanisms include more labile release of fatty acids from VAT than from other adipose tissue and possibly a higher release of inflammatory molecules from VAT.\textsuperscript{42} Of the 2 measures, WC is easier to measure in a clinical setting because it requires only 1 measurement and has been more thoroughly studied. To assess obesity, the 2013 Guideline for the Management of Overweight and Obesity in Adults from the AHA, American College of Cardiology, and the Obesity Society recommends measurement of WC at least annually in all adults using cut points from either the NIH/National Heart, Lung, and Blood Institute (NHLBI) or WHO/International Diabetes Federation.\textsuperscript{43} Unfortunately, roughly half of primary care physicians seldom or never measure WC.\textsuperscript{44,45} Furthermore, errors in measurement and inconsistency of technique are common.\textsuperscript{46,47} The NIH/NHLBI cut points that distinguish between people at higher and lower cardiovascular risk are \( > 102 \text{ cm} \) (\( 40"\)) for men and \( > 88 \text{ cm} \) (\( 35"\)) for women.\textsuperscript{48} On the basis of a large random sample of people from the Netherlands, the WHO recommends cut points of \( > 94 \text{ cm} \) for men and \( > 80 \text{ cm} \) for women to identify those with increased risk of metabolic complications and \( > 102 \text{ cm} \) for men and \( > 88 \text{ cm} \) for women to identify those with substantially increased risk of metabolic complications.\textsuperscript{49} The International Diabetes Federation has established different cut points for populations of European (\( > 94 \text{ cm} \) for men and \( > 80 \text{ cm} \) for women) and Asian (\( > 90 \text{ cm} \) for men and \( > 80 \text{ cm} \) for women) origin.\textsuperscript{50}

There is considerable evidence that use of the NIH/NHLBI cut points in racial and ethnic minorities greatly underestimates the presence of metabolic abnormalities and cardiovascular risk. This is especially true in both South Asian and East Asian populations. For example, based on a cross-sectional sample of 15,239 Chinese adults aged 35 to 74 years, Wildman et al\textsuperscript{51} calculated WC cutoffs associated with the presence of \( \geq 2 \) cardiovascular risk factors (among hypertension, dyslipidemia, and diabetes mellitus). A cutoff of 100 cm for men (slightly below the 102-cm NHLBI cutoff) had a sensitivity of just 8.5%, which means that >90% of men with \( \geq 2 \) risk factors would be missed. Cutoffs of 85 and 90 cm in women had sensitivities of just 45.7% and 26.1%, respectively. Even the International Diabetes Federation’s more conservative cutoffs for Asian populations of 90 cm for men and 80 cm for women had sensitivities of just 32.8% and 61.6%, respectively. These results are consistent with other studies reviewed by Lear et al\textsuperscript{52} that indicated significant cardiovascular risk among both East and South Asian populations at much lower values of WC than among Europeans. The poor performance of the NIH/NHLBI cutoffs also applies to other populations in the United States. Zhu et al\textsuperscript{17} calculated WC cutoffs for the presence of \( \geq 1 \) cardiovascular abnormalities (among hypertension, diabetes mellitus, or dyslipidemia, defined by standard criteria) based on data from the third NHANES. A cutoff of 101 cm had a sensitivity of just 37.4% (specificity 85.8%) among non-Hispanic black men and 40.6% (specificity 84.3%) among Mexican American men. The sensitivity was only slightly better (47.7%) among non-Hispanic white men. A cutoff of 89 cm had much better sensitivities of 74.0%, 81.4%, and 85.9% among non-Hispanic black, Mexican American, and non-Hispanic white men, respectively, although at the expense of specificity. Cutoffs of 83 cm and 94 cm had sensitivities of 84.2% and 57.5%, 83.2% and 57.9%, and 78.5% and 49.2% among non-Hispanic black, Mexican-American, and non-Hispanic white women, respectively. Additional data from the ENSA survey in Mexico estimated optimal cutoffs for predicting diabetes mellitus as 93 to 98 cm in men and 94 to 99 cm in women. Optimal cutoffs for predicting hypertension in the same study were 92 to 96 cm in men and 93 to 96 cm in women.\textsuperscript{23} The WHO, NIH, and International Diabetes Federation all recommend higher WC cutoffs for men and women. It is curious, therefore, that as is the case for BMI, optimal WC cutoffs for women of Mexican origin are higher than those for men of Mexican origin.

**Waist-Hip Ratio**

The WHO recommends cutoffs for WHR of \( \geq 0.90 \) for men and \( \geq 0.85 \) for women.\textsuperscript{21} Corresponding cutoffs from the US Department of Agriculture and US Department of Health and Human Services are \( \geq 0.95 \) for men and \( \geq 0.80 \) for women.\textsuperscript{53} WHR cutoffs have been thoroughly studied among Asian populations. A limited number of studies in other populations have recommended widely varying WHR cutoffs. On the basis of their review of available evidence, Lear et al\textsuperscript{52} recommend cutoffs of 0.90 and 0.80 for Asian men and women, respectively, the WHO cutoff for men and the US Department of Agriculture/US Department of Health and Human Services cutoff for women.

**Waist-Height Ratio**

Waist-height ratio (WHtR) was proposed as a measure of central adiposity and a marker for future cardiovascular risk nearly 20 years ago.\textsuperscript{24} On the basis of a meta-analysis of 10 studies that included roughly 88,000 people, Lee et al\textsuperscript{55} concluded that adiposity indices that included a measure of central adiposity (WC, WHR, or WHtR) were superior to BMI in predicting cardiovascular risk, although no single measure that incorporated WC was superior to the others. Furthermore, combining BMI with a measure of central obesity did not improve the discriminatory value.\textsuperscript{35} A systematic review of 65 studies
by Browning et al\textsuperscript{56} concluded that WHtR is superior to BMI for predicting CVD and diabetes mellitus. Unfortunately, subsequent studies from a number of countries including India, Iran, China, and Korea and from diverse populations within the United Kingdom, among others, have shown inconsistent results, which leaves the value of WHtR compared with other waist-based measures and BMI in question.\textsuperscript{57–60}

In summary, the universal NIH/NHLBI cutoffs for WC perform poorly as predictors of cardiovascular risk/metabolic abnormalities, especially in Asian populations. Cutoffs recommended by the WHO and the International Diabetes Federation perform slightly better. WHR has been less thoroughly studied, but based on available evidence, cutoffs recommended by the WHO and the US Department of Agriculture and US Department of Health and Human Services more accurately identify cardiovascular risk in diverse populations. Given, however, that WC is infrequently measured, it is unlikely that WHR, which requires 2 measurements and calculation of their ratio, is as practical a tool for most clinical settings. The value of the WHtR compared with BMI and other measures that incorporate WC is uncertain.

**What Are the Consequences of Misclassification?**

**Missing Obesity in Large Numbers of People**

Reliance on current, standard, or universal anthropometric standards to diagnose obesity (BMI threshold of 30 kg/m\textsuperscript{2}) may lead to missing excess adiposity in large numbers of people. This problem is especially relevant for populations of East Asian and South Asian origin. On the basis of the National Health Interview Survey, Oza-Frank et al\textsuperscript{61} reported that using the current BMI thresholds of overweight at 25 kg/m\textsuperscript{2} and obesity at 30 kg/m\textsuperscript{2}, the proportions of Asian Americans who met the criteria for overweight and obese were just 29% and 7%, respectively, significantly lower than the US population as a whole. As discussed above, however, Asians and Asian Americans have substantially higher levels of adiposity at the same BMI as non-Hispanic whites, and they also develop cardiovascular risks at lower levels of BMI.\textsuperscript{62} For these reasons, a WHO Expert Consultation recommended lower BMI thresholds for overweight and obesity among Asians. A comparison of these lower thresholds to the current US standards provides an estimate of the proportion of overweight and obesity that is missed if the thresholds of 25 and 30 kg/m\textsuperscript{2} are applied to different Asian groups\textsuperscript{61} (Table 1).

**Overdiagnosis of Obesity in Some Groups**

People who are muscular but do not have excess adiposity have higher BMI, which allows a number of people to be inappropriately diagnosed as obese. Ode et al\textsuperscript{63} demonstrated in their study of athletes and nonathletes that the specificity of elevated BMI to diagnose excess adiposity in male varsity athletes, who have higher muscle mass, was only 27%.

Using NHANES III data, Burkhauser and Cawley\textsuperscript{64} compared BMI with total body fat and \%BF measured through bioelectrical impedance. On average, black females had 3.6 kg more fat-free mass (such as muscle, bone, and fluid) than white females, and black males had 1.3 kg more fat-free mass than white males (both differences were statistically significant). Black women also had on average 3.2 kg more total body fat, but their additional fat-free mass offset that, so their \%BF was only 0.8% greater than that of white females, a non-significant difference. Black men were found not only to have more fat-free mass on average but also to have on average 2.3 kg less total body fat than white men. As a result, their average \%BF was 2.9% lower than that of white men, a statistically significant difference. When \%BF, instead of BMI, was used to define obesity, the race/ethnic gap in obesity between black and white women decreased significantly (with black women still significantly more likely to be obese). Using BMI criteria, 34% of black women were classified as obese, compared with 26% when \%BF criteria were used. Similarly, for black males, the 19% classified as obese as defined by BMI cutoffs dropped to 13% when \%BF was used (Table 2).

**Missed Obesity and Assessment of Cardiovascular Risk**

**Underestimation in Asian and Asian American Populations**

Palaniappan et al\textsuperscript{65} have shown that the prevalence of metabolic syndrome among non-Hispanic whites with a BMI of 25 kg/m\textsuperscript{2} is comparable to the prevalence of metabolic syndrome among Asians with a BMI of just 20 kg/m\textsuperscript{2}. Asians with a BMI of 24 kg/m\textsuperscript{2} have a prevalence of metabolic syndrome comparable to non-Hispanic whites with a BMI of 30 kg/m\textsuperscript{2}. In addition, among Filipino American women, the prevalence of CVD risk factors such as hypertension, reduced HDL-C levels, elevated triglyceride and high-sensitivity C-reactive protein levels, and diabetes mellitus increases significantly beginning

| Table 1. Proportion of Overweight/Obesity According to Different BMI Thresholds |
|---------------------------------|------|------|------|------|------|
| % Overweight (WHO Asian BMI standard: 23.0–27.4 kg/m\textsuperscript{2}) | Asian Indian | Chinese | Filipino | Other Asian | Asian (All) |
| % Overweight (general BMI standard: 25.0–29.9 kg/m\textsuperscript{2}) | 46.7 | 38.2 | 46.5 | 40.7 | 43.0 |
| Missed % overweight with use of general BMI standard | 34.1 | 20.6 | 34.5 | 25.9 | 28.8 |
| % Obese (WHO Asian BMI standard: >27.5 kg/m\textsuperscript{2}) | 12.6 | 17.6 | 17.6 | 14.8 | 14.3 |
| % Obese (general BMI standard: >30.0 kg/m\textsuperscript{2}) | 16.6 | 8.8 | 20.8 | 14.5 | 15.2 |
| Missed % obese with use of general BMI standard | 6.7 | 4.2 | 10.2 | 7.3 | 7.1 |

BMI indicates body mass index; and WHO, World Health Organization.

Modified from Oza-Frank et al\textsuperscript{61} by permission of the American Diabetes Association. Copyright © 2009, the American Diabetes Association.
at a BMI in the range of 23 to 24.9 kg/m$^2$. Furthermore, the relationship between increasing BMI and the presence of metabolic disorders appears to be stronger among Asians than among US whites or blacks. Pan et al$^46$ showed that for most BMI values, Taiwanese had higher prevalences of hypertension, diabetes mellitus, and hyperuricemia than US whites. In the BMI range of 30 to 40 kg/m$^2$, the differences between the Taiwanese and the other groups in the prevalences of hypertension and hyperuricemia were as great as $>$20 percentage points. Additional studies have found that the lowest all-cause mortality among Chinese, Korean, and Japanese populations is found in the BMI range of 23.0 to 24.9 kg/m$^2$ compared with $\approx$27 kg/m$^2$ in the US population as a whole.$^46-71$

Multiple studies have shown high rates of CVD risk factors among Asians at BMI cut points even lower than the WHO obesity standards for Asians. For example, Li et al$^72$ found that the prevalence of risk factors among Chinese began increasing at a BMI of just 21 kg/m$^2$. The risk of hypertension and hypertriglyceridemia doubled at a BMI of 23.0 to 24.9 kg/m$^2$ and tripled at a BMI of 25.0 to 26.9 kg/m$^2$. A meta-analysis of 239,972 adults from China and Taiwan found that when those whose BMI $\geq$28 kg/m$^2$ were compared with those with BMI $<20$ kg/m$^2$, the prevalence of hypertension was 4 to 5 times greater in women and men, respectively; high fasting blood glucose was 3 times greater; high serum total cholesterol was 2 times greater; and low HDL-C was 2 to 3 times greater.$^73$ Women with a BMI $>24$ kg/m$^2$ and men with a BMI $>23$ kg/m$^2$ had a 2.5 times higher risk of stroke than men and women with a BMI $<19$ kg/m$^2$. Two studies by Razak et al$^{74,75}$ showed Asians had higher CVD risk than non-Hispanic whites at any given BMI value. Of 28 studies in a 2009 meta-analysis, all but 1 supported lowering BMI cut points for Asian populations based on increased prevalence of CVD risk factors, other obesity-related disorders, or all-cause mortality.$^{76}$

**Overestimation in Black Populations**

The validity of the NHLBI-WHO definition of overweight (25.0 $\leq$ BMI $\geq$ 29.9) is less clear for blacks than for non-Hispanic whites. Stevens et al,$^77$ however, found no relationship between normal BMI (18.5 and 25 kg/m$^2$) and low overall mortality among black women. Furthermore, Fontaine et al$^78$ estimated that the BMI range associated with greatest longevity in black men and women was between 23 and 30 kg/m$^2$. After adjustment for smoking status, years of life lost secondary to obesity did not occur in black men until BMI reached 32 kg/m$^2$. For black women, years of life lost secondary to obesity did not occur until BMI reached 38 kg/m$^2$. These findings aside, blacks still experience higher CVD mortality than non-Hispanic whites, as well as a higher prevalence of cardiovascular risks. Among black women, in particular, the higher observed 30-day mortality after myocardial infarction and greater overall cardiovascular mortality rates may be related to the disproportionate number of black women with class III obesity (BMI $\geq$40 kg/m$^2$).$^{79,80}$

**Inaccurate Self-Perception of Weight Status (eg, an Asian American With a BMI of 24 kg/m$^2$ May Consider Himself/Herself to Be at a Healthy Weight)**

Self-perceptions of weight status are heavily influenced by culture, personal preferences, and other factors. Reliance on BMI, however, by people to assess their own weight status may be misleading. The relatively low prevalence of BMI $\geq$25 kg/m$^2$ among most Asian groups but the high rates of metabolic abnormalities and high %BF in these same groups at BMI values well below 25 kg/m$^2$, for example, may lead a person of Asian background with a BMI of 24 kg/m$^2$ to falsely assume that he or she is neither overweight nor obese, nor at risk of metabolic abnormalities.

**Failure to Offer Appropriate Screening for Obesity-Related Conditions and Treatments for Obesity in Specific Populations**

Although there is much evidence to support lower BMI thresholds for overweight and obesity in Asians, there is a lack of studies that show the consequences on healthcare delivery of having the same BMI classifications across all races/ethnicities. Current practice guidelines, however, indicate that many Asians would fail to be screened for obesity-related conditions and treatments for obesity. Both Healthy People 2010 and Healthy People 2020, for example, which include goals and strategies for screening, treatment, and health promotion for a wide variety of obesity-related and other conditions, rely on standard BMI thresholds. One of the nutrition and weight status objectives of Healthy People 2020 is to “increase the proportion of adults who are at a healthy weight.”$^{81}$ The definition of healthy weight is a BMI of $\geq$18.5 to $<$ 25 kg/m$^2$, a range that would obviously include many Asian Americans at high risk for obesity-related conditions. A diagnosis of obesity has been shown to predict obesity-related counseling (eg, nutrition, physical activity) and obesity-related treatment in primary care.$^{82,83}$ A diagnosis solely based on a BMI of $\geq$20 kg/m$^2$ makes Asian Americans much less likely to receive services from which they can benefit.

In summary, reliance on current BMI cutoffs for the diagnosis of obesity and recommendations to provide counseling and other treatment based on these cutoffs make
it less likely that Asian Americans in particular will be diagnosed with obesity despite high rates of adiposity and metabolic abnormalities, and less likely to receive obesity-related services.

**Alternative Anthropometric Standards for Ethnic and Racial Minorities**

The preceding discussion makes it clear that current anthropometric standards for BMI and WC are likely to lead to misclassification with significant consequences of obesity, based on both adiposity and cardiovascular risk among a significant proportion of racial and ethnic minorities. The most obvious solution is to modify anthropometric standards for minority groups. This undoubtedly introduces some complexity in identification of obesity compared with the use of a single standard for all people (e.g., BMI of 30 kg/m² for diagnosis of obesity). The problem is compounded by the fact that race and ethnicity are not always obvious or well defined and that many people have more than 1 racial or ethnic background or identity. For example, on average, European ancestry makes up roughly 20% of the genetic background of blacks. In other cases, the umbrella term used to describe race and ethnicity is so broad that it includes groups with widely divergent origins. For example, for US Census purposes, Asians and Pacific Islanders are grouped together. There is substantial evidence, however, that for a given BMI, Pacific Islanders have lower body fat than both Asians and whites. Similarly, the diverse ethnic category of Hispanic includes Cuban Americans, the vast majority of whom have predominantly European ancestry. These complexities aside, several organizations have put forth anthropometric standards for overweight and obesity for specific ethnic and racial groups. The WHO, for example, has proposed BMI thresholds to prevent ill health and premature death called public health action points that are different for white European and Asian populations and encompass the categories “underweight,” “increasing but acceptable risk,” “increased risk,” and “high risk.” Similarly, a number of organizations have put forth thresholds for WC for identifying abdominal obesity for specific ethnic or racial groups (Table 3).

Are modified thresholds more accurate for diagnosis of obesity? A large number of studies support the use of lower BMI and WC thresholds for Asian populations. These studies have used a variety of methods and outcomes to identify optimal cutoffs. For example, Wildman et al studied data from a large sample of adults in China to estimate optimal BMI and WC cutoffs for identifying people with ≥2 cardiovascular risk factors. Receiver operating characteristic calculations were used to find cutoffs with maximal sensitivity and specificity. Their results support a BMI cutoff of 24 kg/m² and a WC cutoff of 80 cm for both men and women. Razak et al studied a diverse Canadian population that included 289 South Asians, 281 Chinese, 207 Aboriginals (Native Americans), and 301 white Europeans. Using principal components factor analysis and linear regression, they identified appropriate BMI cutoffs associated with abnormal blood glucose, lipids, and blood pressure. The cut point to define obesity based on distribution of glucose and lipids was estimated at 24 kg/m² in the non-European groups, or 6 kg/m² lower than among the Europeans.

More recently, Cheong et al, using receiver operating characteristic curves, estimated optimal BMI cutoffs in a multiethnic Malaysian population that included people of Malay, Chinese, and Indian origins; their recommended cutoffs were 23.0 and 24.0 kg/m² for Asian men and women, respectively. Even more recently, Park et al used Cox proportional hazards models to estimate mortality among Asian Americans in different BMI categories. Data were pooled from previously published prospective cohort studies. No increase in mortality was found in the BMI range of 20 to 25 kg/m², which does not support the use of BMI cutoffs lower than 25 kg/m². As noted previously, however, mortality is only 1 of many important outcomes of overweight and obesity. In general, the preponderance of evidence supports the use of lower BMI cutoffs for populations of South and East Asian origin for greater sensitivity in detecting obesity-related cardiovascular risks. As discussed above, the accuracy of standard BMI cutoffs in other populations is also poor. There is, however, insufficient evidence to support different BMI cutoffs in non-Asian populations. Furthermore, the serious problem of missed diagnosis of obesity is greatest in Asian populations.

In an extensive systematic review, Lear et al concluded that there is possible evidence that Asians should also have lower WC cutoffs than Europeans (85 cm for men, 80 cm for women), as well as WHR cutoffs of 0.90 for men and 0.80 for women, and that there is insufficient evidence for specific cutoffs for African-Americans, Hispanics, and other populations. Studies reviewed were primarily cross-sectional in design and used a variety of measurement techniques and outcomes, which makes comparisons difficult.

**Nonanthropometric Imaging and Other Measures**

In addition to the anthropometric measures of obesity described above, several other methods may be used to identify excess adiposity in different populations. Imaging modalities such as computed tomography (CT), magnetic resonance imaging (MRI), and ultrasonography may be used to measure both overall body composition and adipose tissue distribution, including distinguishing subcutaneous adipose tissue from VAT, which, as noted, is closely linked to CVD risk. Additionally, modalities such as DEXA, bioelectrical impedance analysis (BIA), and air displacement plethysmography (ADP) may be used to assess body composition. These tools measure %BF, which, although not as closely linked to CVD risk as VAT, is still a useful marker of cardiovascular risk.

A detailed discussion of the various tools available to assess excess adiposity can be found in the AHA scientific statement on “Assessing Adiposity” by Cornier et al. What follows is a brief discussion of the accuracy of each of these methods, including specific considerations about optimal technique, followed by a discussion of considerations when applied to racial and ethnic minorities. We acknowledge that at this point in time, such nonanthropometric methods are often expensive, time-consuming, and not widely available; however, because the availability and affordability of several of these methods are increasing, they will have increased importance and practicality in clinical practice in the near future and are worth reviewing here.
MRI and CT
MRI and CT are the current “gold standards” for assessing body composition (ie, %BF) and adipose tissue distribution (ie, VAT and subcutaneous adipose tissue volume).95 CT can be performed quickly but involves exposure to ionizing radiation. MRI has the benefit of being radiation free but is time consuming.96

The efficiency of CT and MRI can be improved by limiting the scan to a small region of the abdomen and using a single sagittal abdominal slice to estimate total VAT volume.97 It is not clear, however, exactly which sagittal slice best correlates with total VAT volume and CVD risk factors.98 Commonly, a sagittal slice obtained at the L4-L5 level is used to approximate VAT volume98; however, Shen et al99 studied an ethnically and racially diverse group of people and found that different abdominal levels are more predictive of VAT volume than the L4-L5 level. Among men, a single slice at 10 cm above L4-L5 was most predictive of VAT volume; among women, 5 cm above L4-L5 was most predictive.99 Similarly, when different racial and ethnic groups are studied, the optimum level at which to obtain a single sagittal slice for the estimation of VAT volume appears to vary. In a Chinese sample, Liu et al100 determined that a single slice at L4-L5 best correlated with cardiovascular risk factors;99 Demerath et al100 compared VAT distribution in non-Hispanic white and black adults and determined that maximum VAT area generally occurred 5 to 10 cm above L4-L5 in non-Hispanic white men but 1 to 4 cm above L4-L5 in black men and in both black and non-Hispanic white women.

As described above, the sagittal abdominal slice most predictive of cardiovascular risk may vary among different groups. Many groups, including Hispanics, have not been studied. Although CT and MRI are useful for measuring VAT volume because it correlates highly with CVD risk, VAT volume may not be the best single measurement for predicting CVD risk. A recent study indicated that sagittal abdominal diameter as determined by MRI was more predictive of metabolic syndrome than VAT.102 There are also studies that have shown that anthropometric measures, when adjusted for other factors, may be as predictive of CVD risks as MRI- or CT-obtained measures of adipose tissue.103 Furthermore, although CT and MRI may accurately quantify VAT and %BF, there are no agreed upon cut points to define people as high risk versus lower risk for CVD. Thus, it is difficult to interpret and act on data from CT and MRI in a clinical setting.

In summary, CT and MRI may be highly accurate in quantifying both total body fat and VAT. Unfortunately, in addition to their high cost and impracticality for most clinical settings, standards regarding which sagittal level is optimal in different ethnic and racial groups and standards for classifying people as high or low risk based on results have not yet been established.

Table 3. Thresholds for Abdominal Obesity

<table>
<thead>
<tr>
<th>Source</th>
<th>Waist Circumference, cm</th>
<th>Waist-to-Hip Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Men</td>
<td>Women</td>
</tr>
<tr>
<td>NCEP (2001)</td>
<td>102</td>
<td>88</td>
</tr>
<tr>
<td>NHLBI Obesity Education Initiative Expert Panel (1998)</td>
<td>102</td>
<td>88</td>
</tr>
<tr>
<td>WHO/IASO/IOTF classification for Asians (2000)</td>
<td>90</td>
<td>80</td>
</tr>
<tr>
<td>IDF (for defining metabolic syndrome) (IDF, 2006)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Europids</td>
<td>94</td>
<td>80</td>
</tr>
<tr>
<td>Asians (South Asians, Chinese, Japanese)</td>
<td>90</td>
<td>80</td>
</tr>
<tr>
<td>Ethnic South and Central Americans</td>
<td>90</td>
<td>80</td>
</tr>
<tr>
<td>Sub-Saharan Africans</td>
<td>94</td>
<td>80</td>
</tr>
<tr>
<td>Eastern Mediterranean and Middle East</td>
<td>94</td>
<td>80</td>
</tr>
<tr>
<td>Canadian clinical practice guidelines (2007)</td>
<td>94</td>
<td>80</td>
</tr>
<tr>
<td>European</td>
<td>90</td>
<td>80</td>
</tr>
<tr>
<td>Asians (South Asians, Chinese)</td>
<td>85</td>
<td>90</td>
</tr>
<tr>
<td>Japanese</td>
<td>90</td>
<td>80</td>
</tr>
<tr>
<td>Ethnic South and Central Americans</td>
<td>94</td>
<td>80</td>
</tr>
<tr>
<td>Sub-Saharan Africans</td>
<td>94</td>
<td>80</td>
</tr>
<tr>
<td>Eastern Mediterranean and Middle East</td>
<td>94</td>
<td>80</td>
</tr>
<tr>
<td>US Department of Agriculture and US Department of Health and Human Services</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

IASO/IOTF indicates International Association for the Study of Obesity/International Obesity Task Force; IDF, International Diabetes Federation; N/A, not applicable; NCEP, National Cholesterol Education Program; NHLBI, National Heart, Lung, and Blood Institute; and WHO, World Health Organization.

Reprinted with permission from Lear et al.52

Imaging Modalities

MRI and CT
MRI and CT are the current “gold standards” for assessing body composition (ie, %BF) and adipose tissue distribution (ie, VAT and subcutaneous adipose tissue volume). CT can be performed quickly but involves exposure to ionizing radiation. MRI has the benefit of being radiation free but is time consuming. The efficiency of CT and MRI can be improved by limiting the scan to a small region of the abdomen and using a single sagittal abdominal slice to estimate total VAT volume. It is not clear, however, exactly which sagittal slice best correlates with total VAT volume and CVD risk factors. Commonly, a sagittal slice obtained at the L4-L5 level is used to approximate VAT volume; however, Shen et al studied an ethnically and racially diverse group of people and found that different abdominal levels are more predictive of VAT volume than the L4-L5 level. Among men, a single slice at 10 cm above L4-L5 was most predictive of VAT volume; among women, 5 cm above L4-L5 was most predictive.99 Similarly, when different racial and ethnic groups are studied, the optimum level at which to obtain a single sagittal slice for the estimation of VAT volume appears to vary. In a Chinese sample, Liu et al determined that a single slice at L4-L5 best correlated with cardiovascular risk in men, whereas a slice at the lower costal margin correlated best with cardiovascular risk in women. In both men and women, the slice at the lower costal margin correlated most closely with VAT volume. In a study of Japanese men, a single MRI slice taken 5 to 6 cm above L4-L5 correlated better with cardiovascular risk factors.99 Demerath et al100 compared VAT distribution in non-Hispanic white and black adults and determined that maximum VAT area generally occurred 5 to 10 cm above L4-L5 in non-Hispanic white men but 1 to 4 cm above L4-L5 in black men and in both black and non-Hispanic white women.

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In summary, CT and MRI may be highly accurate in quantifying both total body fat and VAT. Unfortunately, in addition to their high cost and impracticality for most clinical settings, standards regarding which sagittal level is optimal in different ethnic and racial groups and standards for classifying people as high or low risk based on results have not yet been established.
**Ultrasonography**

Ultrasonography is not as widely used as CT or MRI for determination of body composition and adipose distribution in the research setting. Nevertheless, ultrasonography estimates of VAT correlate well with CT measurements and MRI single-slice estimates.\(^{104,105}\) In addition to measuring VAT, ultrasonography has also been used to measure mesenteric fat thickness. In a Chinese population, ultrasonography measurement of mesenteric fat thickness showed higher association with CVD risk factors than MRI-measured VAT, and mesenteric fat thickness was an independent predictor of the metabolic syndrome.\(^{106,107}\) We did not identify studies of the accuracy of ultrasonography as a measure of VAT or for the prediction of cardiovascular risk in blacks, Hispanic Americans, or Asian Americans.

Despite its accuracy and ability to predict CVD risk factors, ultrasonography is also prone to significant limitations. Although portable ultrasonography machines are now available and are used routinely in some ambulatory offices, ultrasonography accuracy depends on adequate user training. Compared with anthropometric measurements, ultrasonography is time consuming and relatively expensive and thus does not lend itself well to routine clinical use.

**Dual-Energy X-Ray Absorptiometry**

DEXA is increasingly used to assess body composition.\(^{108}\) Multiple studies have shown good correlation between DEXA-measured and CT-measured VAT mass. Gradmark et al,\(^{104}\) for example, found a strong correlation between VAT measured by DEXA compared with CT (\(r=0.70, P<0.001\)) in a Swedish population. Micklefield et al\(^{109}\) found that DEXA was comparable to CT at L4-L5 for estimating VAT in both black and white South African women. In this population, DEXA better estimated VAT than a linear regression model that included anthropometric measurements and demographic characteristics. However, when Browning et al\(^{110}\) compared DEXA measurements of VAT to MRI measurements, they did not find a strong correlation. They did observe a strong correlation between DEXA measurements and MRI measurements of total abdominal adipose tissue. In summary, although DEXA appears to correlate highly with CT measurements of VAT in multiple studies, it did not correlate with MRI measurements of VAT in the single study that we identified.

Although we identified many studies that used DEXA to compare racial and ethnic differences in body composition and adipose tissue distribution, we found no studies that explored whether the accuracy of DEXA measurements varies in different racial and ethnic populations. DEXA has the advantage of being less expensive than CT, MRI, and ultrasonography. Also, DEXA involves less ionizing radiation than CT. Unfortunately, because of its lack of availability and other practical considerations, its use in clinical settings is currently limited.

**Other Modalities**

**Air Displacement Plethysmography**

ADP was developed as a more convenient alternative to hydrostatic weighing. Early air displacement methods were unreliable, but newer devices, including the BOD POD, have generally been found to be as accurate and reliable as hydrostatic weighing and other accurate methods.\(^{101,111}\) This is true in several minority populations. For instance, in a population of Japanese men, the BOD POD was found to be comparable to DEXA for estimation of change in %BF.\(^{112}\) Meanwhile, a study of Mexican men and women found the BOD POD was equivalent to the accurate methods of deuterium oxide dilution and infrared spectroscopy for measurement of fat mass.\(^{113}\) In another study, however, the BOD POD systematically overestimated %BF in black men by 1.9% compared with hydrostatic weighing and by 1.6% compared with DEXA.\(^{114}\) The clinical significance of these overestimates, however, is questionable. ADP is quick and involves no radiation exposure. It is available in many health systems and fitness centers, but its widespread availability in most clinical settings remains limited. Furthermore, the relationship between %BF measured by ADP and cardiovascular risk has not been studied.

**Bioelectrical Impedance Analysis**

BIA is widely used because of its convenience, portability, and low cost. There are, however, significant concerns about accuracy for specific adiposity variables. The AB-140 BIA device, for example, was found to provide an accurate measurement of total abdominal adipose tissue but not VAT compared with MRI.\(^{115}\) Similarly, measurements with the ViScan BIA device correlated well with MRI measurements of total abdominal adipose tissue and subcutaneous abdominal adipose tissue but not intra-abdominal adipose tissue.\(^{116}\) Another study compared foot-to-foot BIA with the BOD POD in a population of South Asian adults. Compared with BOD POD, BIA underestimated %BF by an average (and substantial) 4.3%.\(^{117}\) The ability of BIA to predict cardiovascular risk has not been studied.

In summary, CT and MRI remain the gold standards for measuring adiposity, but their clinical use is limited because of cost, time, and radiation exposure concerns. They are accurate in measuring adiposity and adipose tissue distribution in the minority populations in which they have been studied. Standards for the optimal sagittal slice for approximating VAT volume, which varies among different populations, have not been established. Similarly, ultrasonography and DEXA are accurate for measurement of adiposity but are also impractical in clinical settings. The accuracy of these methods in specific minority populations is less well studied than CT and MRI. The BOD POD ADP device accurately measures body composition in several minority populations, although its use is limited by availability. BIA is the least accurate method of measuring body composition despite its ease of use.

**Cardiovascular Risk Assessment Tools With and Without Anthropometric Measures**

Anthropometric measures are not the only tools available for assessment of cardiovascular risk. A number of risk assessment tools are available and have been evaluated in ethnically and racially diverse populations. The integration of anthropometric measures with other measures of cardiovascular risk would appear to be a rational strategy for better prediction of cardiovascular morbidity and mortality. Unfortunately, to date, few cardiovascular risk prediction models have incorporated anthropometric measures. There are also unresolved questions about the value of this approach. For example, it is unclear whether cardiovascular risk prediction can be improved with the addition of anthropometric measures to risk assessments that already incorporate blood lipid measurements.\(^{118,119}\) On the basis of data
from >200,000 people in 17 countries, neither BMI, WHR, or WC improved cardiovascular risk prediction above total cholesterol and HDL-C. These considerations aside, we reviewed the following: (1) The very commonly used Framingham Risk Score (FRS), as applied to ethnically and racially diverse populations; (2) the limited number of other tools derived from populations that include non-Europeans; and (3) tools that combine anthropometric measures such as BMI with other cardiovascular risks.

The accuracy of cardiovascular risk prediction tools is often expressed with sensitivity, specificity, area under receiver operating characteristic curves, or the C statistic. The C statistic is a function of both sensitivity and specificity and provides an estimate for the probability that a case (ie, a person who develops a cardiovascular outcome) will have a higher score than a noncase. For example, a C statistic of 0.80 means that a person with a cardiovascular outcome will have a higher score than a noncase. Scores between 0.70 and 0.8 are acceptable, and scores >0.8 are excellent.

**Framingham Risk Score**

The Framingham Heart Study was among the first studies to identify that multiple factors jointly influence cardiovascular risk. The original FRS was developed for calculation of the 10-year risk of developing coronary heart disease in people without established CVD by use of age, sex, total cholesterol, systolic blood pressure, HDL-C, smoking exposure, and presence of type 2 diabetes mellitus. The score has been used widely to estimate the likelihood of current and future coronary heart disease both in clinical and research settings. The FRS was developed in a non-Hispanic white population with a mean age of 49 years (range 30–74 years). Tzoulaki et al recently evaluated the use of the FRS in the scientific literature from the original publication of the FRS in 1998 to April 2011 in 375 articles. The majority of articles used the score to quantify cardiovascular risk in populations distinct from the Framingham cohort population and assessed outcomes distinct from those for which the FRS was developed. The authors concluded that the FRS is frequently used for purposes for which it was not originally intended and has not been validated. Nevertheless, the diagnostic performance of the FRS to predict 10-year risk of coronary heart disease has been assessed in a small number of studies of nonwhite patients (Table 4). There is evidence that among non-Hispanic black men and women, Chinese men and women, US Hispanic men, Japanese-American men, Japanese men, South Asians, Malay, and Native American populations, the FRS appears to provide accurate measurements of CVD risk. The FRS appears less accurate, however, in Mexicans and a composite group of New Zealanders of South Asian and Pacific Island origin who were combined because they are believed to be at high risk. In a relatively small cohort of Mexicans, the FRS overestimated the risk of myocardial infarction among men. In the composite group of nonwhite New Zealanders, the FRS underestimated risk by 1.1% to 1.2% in those classified as having 5-year risk <15% and overestimated risk by 2.4% to 4.1% in those classified as having 5-year risk ≥15%. The reasons for the overestimates and underestimates in these populations are unclear.

**Other Risk Scoring Tools**

We identified a total of 6 scores that have been derived in diverse populations or account for race/ethnicity in cardiovascular risk prediction (or both) and that estimate risk for future cardiovascular events in people without existing CVD (Table 5). The Strong Heart Study Calculator was based on a Native American population. Two scores were derived from Chinese samples. The QRISK2 (QResearch, Cardiovascular Risk Disease Calculator) and UKPDS

<table>
<thead>
<tr>
<th>Authors</th>
<th>Ethnic/Racial Group</th>
<th>Geographic Location</th>
<th>Accuracy of FRS in Predicting Cardiovascular Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>D’Agostino et al</td>
<td>Non-Hispanic blacks</td>
<td>United States</td>
<td>C statistic = 0.70 (men), 0.85 (women)</td>
</tr>
<tr>
<td>Liu et al</td>
<td>Chinese</td>
<td>China</td>
<td>AUROCs = 0.705 (95% CI, 0.665–0.746) for men and 0.742 (95% CI, 0.686–0.798) for women</td>
</tr>
<tr>
<td>D’Agostino et al</td>
<td>Hispanic men</td>
<td>United States</td>
<td>C statistic = 0.72</td>
</tr>
<tr>
<td>Suka et al</td>
<td>Japanese men</td>
<td>Japan</td>
<td>AUROC = 0.71, specificity = 0.74, sensitivity = 0.59</td>
</tr>
<tr>
<td>D’Agostino et al</td>
<td>Japanese men</td>
<td>United States</td>
<td>C statistic = 0.74</td>
</tr>
<tr>
<td>D’Agostino et al</td>
<td>Native American</td>
<td>United States</td>
<td>C statistic = 0.77 (men), 0.86 (women)</td>
</tr>
<tr>
<td>Lee et al</td>
<td>Malay, Chinese, South Asian</td>
<td>Singapore</td>
<td>AUROCs = 0.85 for men and 0.92 for women</td>
</tr>
<tr>
<td>Bhopal et al</td>
<td>South Asian</td>
<td>United Kingdom</td>
<td>FRS for men predicted SMRs of 122 and 71 (reference = 100 for people of European origin) for CHD and stroke, respectively. Actual SMRs among South Asian men were 142 and 155 for CHD and stroke, respectively. Among women, FRS predicted SMRs of 146 and 95 compared with actual SMRs of 145 and 141, respectively.</td>
</tr>
<tr>
<td>Jiménez-Corona et al</td>
<td>Mexican men and women</td>
<td>Mexico</td>
<td>FRS overestimated the observed number of total CHD cases in both men and women. Overall ratio of predicted/observed was 1.68 for CHD and 1.36 for MI.</td>
</tr>
<tr>
<td>Riddell et al</td>
<td>Maori, Pacific, and Indian combined</td>
<td>New Zealand</td>
<td>Underestimated risk by 1.1%–2.2% in those classified below the 15% 5-y predicted risk. Overestimated risk by 2.4%–4.1% in those classified above the 15% 5-y predicted risk.</td>
</tr>
</tbody>
</table>

AUROC indicates area under the receiver operating characteristic curve; CHD, coronary heart disease; CI, confidence interval; FRS, Framingham Risk Score; MI, myocardial infarction; and SMR, standardized 10-year mortality ratio.
Table 5. Additional Scoring Tools

<table>
<thead>
<tr>
<th>Authors</th>
<th>Name of Score/Study</th>
<th>Population</th>
<th>Components</th>
<th>Primary Outcome</th>
<th>Accuracy</th>
<th>Web site</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lee et al133</td>
<td>Strong Heart Risk Calculator</td>
<td>13 US Native American tribes</td>
<td>Systolic BP, LDL-C, HDL-C, hypertension medication, diabetes mellitus, smoking status, microalbuminuria and macroalbuminuria</td>
<td>10-y risk of CHD</td>
<td>C statistic 0.70 for men, 0.73 for women</td>
<td><a href="http://strongheart.ouhsc.edu/CHDcalculator/calculator.html">http://strongheart.ouhsc.edu/CHDcalculator/calculator.html</a></td>
</tr>
<tr>
<td>Zhang et al134</td>
<td>...</td>
<td>Chinese men</td>
<td>Age, BP, total cholesterol, BMI, smoking status</td>
<td>10-y risk of CHD and ischemic and hemorrhagic stroke</td>
<td>AUROC 0.76</td>
<td>...</td>
</tr>
<tr>
<td>Tillin T et al135</td>
<td>QRISK2</td>
<td>White, South Asian, black, Chinese/other Asian</td>
<td>Age, sex, ethnicity, smoking status, diabetes mellitus, family history, chronic kidney disease, atrial fibrillation, BP medication, rheumatoid arthritis, cholesterol/HDL ratio, systolic BP, BMI, Townsend deprivation score*</td>
<td>10-y risk for CVD event</td>
<td>Overall AUROC 0.792 for men, 0.817 for women.</td>
<td><a href="http://www.qrisk.org">http://www.qrisk.org</a></td>
</tr>
<tr>
<td>Guzder et al136</td>
<td>UKPDS Risk Engine</td>
<td>Diabetics; nearly entirely white, with very small ethnic minority</td>
<td>Age, duration of diabetes mellitus, sex, HbA1c%, smoking status, systolic BP, total cholesterol, HDL-C, atrial fibrillation</td>
<td>10-y risk of CHD</td>
<td>C statistic 0.673 for men, 0.618 for women</td>
<td><a href="http://www.dtu.ox.ac.uk/riskengine/">http://www.dtu.ox.ac.uk/riskengine/</a></td>
</tr>
<tr>
<td>Liu et al137</td>
<td>Chinese Multi-Provincial Cohort Study</td>
<td>Mainland Chinese</td>
<td>Age, BP, smoking status, diabetes mellitus, TC, HDL-C</td>
<td>10-y risk of coronary death or MI</td>
<td>AUROC 0.736 for men, 0.759 for women</td>
<td>...</td>
</tr>
<tr>
<td>Goff et al137</td>
<td>ACC/AHA ASCVD Risk Estimator</td>
<td>Whites and non-Hispanic black</td>
<td>Age, sex, race (white, non-Hispanic black, other), smoking status, total cholesterol, HDL-C, systolic BP, BP medication, diabetes mellitus</td>
<td>10-y risk of coronary death or MI</td>
<td>C statistic 0.66–0.77 among non-Hispanic black women; 0.56–0.77 among non-Hispanic black men (comparable to 0.66–0.71 and 0.59–0.70 among non-Hispanic white women and men, respectively)</td>
<td><a href="http://tools.cardiosource.org/ASCVD-Risk-Estimator/">http://tools.cardiosource.org/ASCVD-Risk-Estimator/</a></td>
</tr>
</tbody>
</table>

ACC indicates American College of Cardiology; AHA, American Heart Association; ASCVD, Atherosclerotic Cardiovascular Disease; AUROC, area under the receiver operating characteristic curve; BMI, body mass index; BP, blood pressure; CHD, coronary heart disease; CVD, cardiovascular disease; HbA1c, percent hemoglobin A1c; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; MI, myocardial infarction; QRISK2, QResearch Cardiovascular Risk Disease Calculator; TC, total cholesterol; and UKPDS, United Kingdom Prospective Diabetes Study.

*A measure of economic deprivation based on postal code of residence within the United Kingdom.

(United Kingdom Prospective Diabetes Study) Risk Engine were both derived from ethnically heterogeneous samples from the United Kingdom.135,136 The American College of Cardiology/AHA Atherosclerotic Cardiovascular Disease (ASCVD) Risk Estimator was derived from pooled data from 5 large cohorts that included white and non-Hispanic black men and women.137 Scores vary in the number and type of components. Most include age, sex, smoking status, lipid levels, and blood pressure.

QRISK2, the UKPDS Risk Engine score, and the ASCVD Risk Estimator are the only ones to include race or ethnicity as a component in the risk determination. The QRISK2 and the score described by Zhang et al134 both incorporate BMI. The accuracies of these cardiovascular risk prediction scores were similar (Table 5).

Conclusions, Recommendations, and Research and Public Health Priorities

The writing group met together with the entire Obesity Committee of the AHA’s Council on Lifestyle and Cardiometabolic Health to discuss the results of our review of the evidence and to discuss and agree on the conclusions, recommendations, and research and public health priorities described below.

Conclusions and Recommendations

1. BMI alone, even with lower thresholds, is a useful but not an ideal tool for identification of obesity or assessment of cardiovascular risk in Asian populations because of its lack of sensitivity. The value of BMI is also questionable in other populations, including blacks, Hispanics, and Pacific Islanders.

2. In combination with BMI, we recommend that WC be measured annually in all people by use of a standardized technique, such as that recommended by the NHLBI,48 to better gauge cardiovascular risk in diverse populations.

3. WHO recommended thresholds for WC should be used to gauge cardiovascular risk in diverse populations.49

4. Imaging and other noninvasive methods cannot be recommended at this time for the routine assessment of obesity or cardiovascular risk.

5. The FRS has been shown to provide a reasonably accurate estimate of cardiovascular risk in a number of different ethnic and racial minority groups.
6. There are a very small number of other risk assessment tools that take account of race or ethnicity or BMI. The American College of Cardiology/AHA ASCVD Risk Estimator is useful for risk assessment in non-Hispanic blacks. Without further validation, we cannot recommend the use of any of these tools for other racial or ethnic minorities living in the United States.

Research and Public Health Priorities
The writing group and the Obesity Committee call for the following:

1. More education about the importance of WC as a measure of cardiovascular risk among the general public and healthcare professionals.

2. Given the infrequency of WC measurement in clinical practice, more training for healthcare professionals on correct standard measurement technique.

3. More research on the usefulness of emerging imaging or other noninvasive techniques for anthropometric measurements in racially or ethnically diverse populations.

4. More research on the usefulness of incorporating standard and emerging anthropometric measures into cardiovascular risk prediction models for diverse populations.

5. This statement includes assessment in adults only. Research evidence for children and adolescents is scarce. The writing group and Obesity Committee call for more research on the accurate assessment of obesity and cardiovascular risk in children and adolescents of diverse ethnic and racial backgrounds.

Disclosures

Writing Group Disclosures

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<thead>
<tr>
<th>Writing Group Member</th>
<th>Employment</th>
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<th>Other Research Support</th>
<th>Speakers’ Bureau/Honoraria</th>
<th>Expert Witness</th>
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*Significant.

Reviewer Disclosures

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*Modest.
References


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**KEY WORDS:** AHA Scientific Statements ■ African Continental Ancestry Group ■ Asian Americans ■ body mass index ■ cardiovascular diseases ■ Hispanic Americans ■ obesity ■ waist circumference
Identification of Obesity and Cardiovascular Risk in Ethnically and Racially Diverse Populations: A Scientific Statement From the American Heart Association
Goutham Rao, Tiffany M. Powell-Wiley, Irma Ancheta, Kristen Hairston, Katherine Kirley, Scott A. Lear, Kari E. North, Latha Palaniappan and Milagros C. Rosal

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