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Preventing Diabetes and Atherosclerosis in Sub-Saharan Africa: Should the Metabolic Syndrome Have a Role?

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Abstract

Obesity, hypertension, atherosclerosis, and type 2 diabetes mellitus are increasing in all regions of sub-Saharan Africa. The metabolic syndrome is a valuable tool in predicting atherosclerosis and type 2 diabetes in populations in Europe and North America. However, the applicability of the metabolic syndrome to African populations has not been studied. Prior to investing scarce funds into diagnosing and treating the metabolic syndrome, primary research needs to be designed to determine the prevalence of the metabolic syndrome and its ability to detect early, treatable disease in Africa. Assessment of these data should make it possible to determine if it is more effective to focus on the metabolic syndrome as a whole or on obesity, hypertension, atherosclerosis, and type 2 diabetes as individual conditions. This article is an overview of the presentation of metabolic syndrome variables in the Eastern, Western, and Southern regions of sub-Saharan Africa.

Introduction

Sub-Saharan Africa is experiencing an epidemiologic transition in which the prevalence of infectious diseases is giving way to growing rates of noncommunicable chronic diseases of urbanization, specifically type 2 diabetes mellitus (T2DM) and atherosclerosis [1•–3•]. With the environmental and social changes that accompany urbanization, Africans have increased consumption of processed foods and decreased participation in physical activity; consequently, the metabolic health of Africans has declined. Epidemiologists predict that 70% of Africans will live in cities by 2025, which will dramatically increase the number of Africans at risk for the diseases of urbanization [1•].

Because T2DM usually occurs after the onset of obesity and atherosclerosis begins in the prediabetic state, obesity, T2DM, and atherosclerosis are intertwined [4]. T2DM causes blindness, renal failure, and the need for lower extremity amputations. Atherosclerosis leads to myocardial infarction, heart failure, and stroke. Therefore, the economic and social costs of T2DM and atherosclerosis are enormous and are likely to worsen. In 2006, the International Diabetes Federation (IDF) estimated that 10.8 million sub-Saharan Africans had T2DM [1•]. IDF predicts that there will be 18.7 million diabetics in Africa by 2025, which represents an 80% increase and is much greater than the 55% increase in T2DM expected worldwide [1•].

Due to the triple burden of obesity, T2DM, and atherosclerosis, it is essential that effective strategies for prevention be identified. In North America and Europe, the metabolic

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syndrome (MetSyn) carries a fivefold risk of T2DM and a twofold risk of atherosclerosis [5•]. Therefore, the American Heart Association, IDF, and World Health Organization (WHO) have engaged in a worldwide movement to use MetSyn as a global tool to guide the institution of preventive therapy programs [5•,6,7]. However, MetSyn was not developed or tested in people of African descent. Furthermore, evidence is emerging that MetSyn is under-diagnosed in African Americans [8]. Part of the reason lies in the fact that current MetSyn thresholds for both waist circumference and triglycerides (TG) do not identify high-risk African Americans; the former leads to overdiagnosis and the latter to underdiagnosis [9•,10•]. Because MetSyn thresholds appear not to be valid for African Americans, the question immediately arises as to whether MetSyn criteria are applicable to Africans.

As the prevalence of T2DM and atherosclerosis rises in Africa, it is essential to know the relevance of MetSyn to African populations, particularly if MetSyn is used to guide health policy. The MetSyn has five parameters: central obesity, hypertension, fasting hyperglycemia, low high-density lipoprotein (HDL) levels, and hypertriglyceridemia [5•]. According to the National Cholesterol Education Panel's Adult Treatment Panel III (NCEP-ATPIII), the diagnosis of MetSyn requires any three of the five parameters be present [5•]. For the IDF definition of MetSyn, central obesity must be present, along with any two of the remaining four criteria [5•]. Because there are few data on the prevalence of MetSyn in Africa, this review does not enter into the debate about whether the NCEP-ATPIII or IDF definition of MetSyn is superior; instead we concentrate on the five parameters of MetSyn.

Sub-Saharan Africa has four distinct regions: Western, Eastern, Middle, and Southern Africa (Table 1). The fact that Middle Africa has only one country (Cameroon) whose official language is English limited our ability to assess health data in that region. Therefore, we focus on Western, Eastern, and Southern Africa. We recognize that in each of these regions there are varying degrees of social and political instability that make the collection of data regarding chronic disease problematic. Nevertheless, we believe it is important to analyze data related to chronic disease in these regions. Africans with T2DM, uncontrolled hypertension, and atherosclerosis are especially vulnerable if the resources needed to take care of them are not available.

A major challenge associated with this review is that African countries do not have population-based national studies such as the National Health and Nutrition Examination Survey or prospective cohort studies equivalent to the Framingham Heart Study. Therefore, we extensively reviewed the literature, and in this article we report on English-language articles we thought were most representative of the population studied.

Obesity

Obesity is a risk factor for T2DM and atherosclerosis as well as gallbladder disease, arthritis, cancer, and countless other diseases. Therefore, with its rapidly rising prevalence, obesity has become a challenge to the lives and economies of African nations. Obesity in MetSyn is measured by waist circumference, a measure of central obesity [5•]. However, the emphasis in obesity research in Africa is on overall obesity rather than central obesity. Driven by the availability of data, we too focus on overall obesity.

To understand the scope and consequences of obesity in Africa, three issues must be considered: rural–urban differences, sex differences, and the cultural view of female beauty. In general, urban dwellers are three times more likely to be obese than their rural counterparts [11•]. Many factors contribute to this rural–urban difference. Rural occupations such as farming are physically rigorous. In addition, walking long distances is often required to obtain potable water, reach worksites, or attend school. Locally grown foods tend to be high in fiber and low in caloric density. In contrast, urbanites are more

likely to be sedentary, drive cars, use public transportation, watch television, drink soda, and eat processed, energy-dense food [12]. In urban regions, homes are often small with poorly equipped cooking spaces that have minimal access to clean water. Together, these living conditions promote the consumption of unhealthy street foods, physical inactivity, and ultimately obesity [13•].

Obesity is three times more common in African women than men [11••]. Cultural attitudes toward obesity may be partly responsible. Throughout much of Africa, obesity is considered a sign of wealth and a characteristic of beautiful women [12,14]. Consequently, prosperous, educated African women are more likely to be obese whereas poor African women are not.

Western Africa

The Western African countries of Nigeria, Ghana, and Benin exemplify the African trend of rising rates of obesity. The risk of obesity is greater in women than men and higher in urban than rural areas. Four decades ago, in a study of more than 900 Nigerians, the prevalence of obesity was 3% in urban men and 15% in urban women [15]. By 2003, the prevalence of obesity in urban Nigerian men and women had increased to 5% and 21%, respectively [11••]. In addition, the prevalence of obesity is 50% higher in urban than rural women. Interestingly, the prevalence of obesity in rural and urban men was similar [11••]. Similar to Nigerians, the rate of obesity in Ghana is increasing. In a 10-year period, the prevalence of obesity rose from less than 1% to 14% [12]. When examined by region and sex, the rate of obesity in 4700 Ghanaians was reported to be 6% and 23% for urban men and women and 2% and 16% for rural men and women, respectively [12]. Benin, a smaller, less prosperous country, is also experiencing urban obesity. In a study of 200 urbanites, the prevalence of obesity was 8% for men and 28% for women [14].

Eastern Africa

Overall the prevalence of obesity in the Eastern African countries of Malawi, Tanzania, and Kenya appears to be lower than the rates observed in Western African countries. In a study of about 1000 urban Malawians published in 2000, the prevalence of obesity was 11% in women and less than 1% in men [16]. In a 1993 study of 8500 rural Tanzanian men and women, the rate of obesity was less than 2% [17]. By 2000, the rate of obesity in rural Tanzanian men remained negligible but had increased to 4% in rural women [18]. In contrast, urban Tanzanians have a higher prevalence of obesity, with rates of 7% for men and 20% for women [18]. The rate of obesity in rural and urban areas of Kenya in a 2008 study was 5% for men and 16% for women [19].

Southern Africa

Most research on obesity in Southern Africa originates from the Republic of South Africa. Obesity in South Africa differs from other regions of Africa for two reasons. First, the rate of obesity in South African women is higher than anywhere else in Africa and, second, the rate of obesity is similar in urban and rural women. In some rural and urban areas of South Africa, the prevalence of obesity in women is as high as 34% [20]. The issue of obesity in South African women is complex. In addition to the belief that a large body is beautiful, black South African women report the fear that losing weight will lead others to believe they have AIDS [21]. For South African men, the prevalence of obesity is less than 10% [20].

Hypertension

Hypertension, which is highly prevalent in every region of Africa, causes debilitating strokes, heart disease, and renal failure. Hypertension is also a MetSyn criterion. For MetSyn, hypertension is diagnosed if systolic BP is ≥ 130 mm Hg or diastolic BP is ≥ 85

mm Hg [5•]. Surveys of blood pressure in Africa usually use much higher threshold values to diagnose hypertension; typically they are $\geq 160/95$ or $\geq 140/90$ mm Hg. Obviously, the systolic and diastolic thresholds used to diagnose hypertension have a major impact on prevalence data. In 1999, the WHO officially lowered the definition of hypertension from $\geq 160/95$ to $\geq 140/90$ mm Hg, and with that change the prevalence of hypertension in many African populations doubled [22–24].

A lack of a universal definition of high blood pressure is not the only challenge for hypertension research in Africa. There is an absence of population-based studies and no universal standards for data collection [3••]. Recognizing these limitations and using the diagnostic threshold of $\geq 140/90$ mm Hg, the prevalence of hypertension in some areas of Africa exceeds 30% [3••].

To understand the implications of hypertension for African societies, it is necessary to examine rural–urban differences, sex differences, and compliance with diagnostic and treatment regimens. Historically in Africa, the prevalence of hypertension is higher in urban than rural areas [25•]. Recent evidence suggests that this difference is disappearing [26]. As modernization progresses, rural villages are changing and a new social construct has been created: the “semi-urban” village [27]. Semi-urban villages often have a main water supply and electricity. Residents of semi-urban villages have higher rates of hypertension than their rural counterparts, demonstrating that even modest urbanization is associated with an enhancement of cardiovascular risk [27]. In addition, the ingestion of food with a high sodium content is a risk factor for hypertension, and urbanization usually leads to the consumption of salty foods. One example is in the preparation of soup; the traditional melon seeds are being replaced by commercially available seasonings high in salt [28].

It is unknown if a sex difference exists in Africa in the prevalence of hypertension [27]. However, detection, treatment, and control of hypertension are better in women than men [25•]. In one study, 71% of women but only 44% of men knew they were hypertensive; further, compliance with treatment regimens was 20% higher in women than in men [26]. It is postulated that greater detection of hypertension in women is a result of the health care that women receive both prenatally and postpartum [27]. Further, women may be more compliant than men with treatment because they may accept their diagnosis more readily, knowing they must stay healthy to support their families [25•].

Unfortunately, in all regions of Africa, detection of hypertension often occurs only after the onset of irreversible complications. Africans regularly present for medical care with severe headaches, blurred vision, chest pains, and strokes [29,30]. The reasons are multifactorial, but it is clear that only a fraction of Africans receive adequate antihypertensive treatment. To describe this situation in Africa, the term “rule of halves” has been coined [31]. The rule means that half of hypertensives go undetected; half of those diagnosed with hypertension go untreated; and only half of those treated achieve adequate control.

Western Africa

Over several decades, hypertension in Western African has progressively spread from urban to rural areas. For example, the prevalence of hypertension in urban Ghana was 11% in the 1970s [29]. In data collected contemporaneously, Pobee et al. [32] reported in 1977 that less than 5% of the rural population of Ghana had high blood pressure, and they recommended that hypertension control programs be limited to urban areas. Twenty-five years later, the prevalence of hypertension in both rural and urban populations of Ghana was reported to be between 20% and 35% [27,29]. The rate and pattern of hypertension in Nigeria and Benin appear to be similar to the Ghanaian experience [14,23,28].

Eastern Africa

As in Western Africa, the prevalence of hypertension is rising throughout Eastern Africa. This was particularly well illustrated in a landmark investigation in Tanzania by Njelekela et al. [33]. In 1987 and 1998, using the same assessment techniques, the authors recorded blood pressure in rural and urban Tanzanians 47 to 57 years old. Over 11 years, the prevalence of hypertension doubled—from 14% to 27% in rural men and from 13% to 30% in rural women. The results were similar in urban inhabitants. In 1987, 33% of urban Tanzanian men and 48% of urban women had hypertension. Just one decade later, the rates had increased to a staggering 63% and 62%, respectively. The reasons given for the remarkable rise in hypertension were physical inactivity, the consumption of food with a high sodium content, and obesity. This study appears to be emblematic of the problem of hypertension not just in Eastern Africa but throughout the African continent.

Southern Africa

Historically, the prevalence of hypertension has been higher in Southern Africa than Western Africa, but the approach to the hypertension in the two regions has been remarkably similar. For example, Seedat et al. [34] reported in 1982 that the prevalence of hypertension in rural South Africa was only 10% and therefore recommended that hypertension programs should be concentrated in urban areas. Twenty-five years later, hypertension affected 20% to 25% of South African men and women, respectively, from both rural and urban areas [24,35]. Hypertension clearly has become a health issue in rural and urban areas.

Fasting Hyperglycemia

Fasting hyperglycemia, a feature of MetSyn, is a risk factor for T2DM, which is a devastating disease with a myriad of consequences, including atherosclerosis, renal failure, autonomic dysfunction, and the need for lower extremity amputations. The reason for the rising prevalence of T2DM in Africa is due, at least in part, to earlier and better diagnosis. In decades past, T2DM was diagnosed by measuring glucose concentration in urine. However, if T2DM is diagnosed by glucosuria, the disease is likely to have been present for years. More recently, fasting glucose has been used, which has made earlier detection possible. The IDF and the American Diabetes Association define fasting glucose ≥ 100 mg/dL as pre-T2DM and fasting glucose ≥ 126 mg/dL as T2DM. Performing oral glucose tolerance tests would further improve the detection of diabetics in Africa [36]. However, the cost of the oral tests is prohibitive and widespread usage is unlikely.

To appreciate the impact of T2DM in Africa, it is necessary to examine the association between T2DM and obesity as well as the effect of urban and rural environments. Further, the rates of T2DM in men and women must be examined. Obesity, a risk factor for T2DM, may be the most important reason for the rising prevalence of T2DM in Africa. Even though obesity is more common in women than men, surprisingly in Africa there appears to be no sex difference in the prevalence of T2DM. Some studies even report a higher prevalence in men than women [37]. One explanation offered is that men have better access to health care than women [38]. Yet for hypertension we presented the opposite idea that access to care was better in women than men. This apparent contradiction may occur because the diagnosis of hypertension is inexpensive. To monitor blood pressure, neither sophisticated equipment nor advanced training is required. In contrast, blood glucose monitoring requires laboratory equipment and trained personnel. It is likely that men have better access to expensive care. Further, the onset of T2DM may occur after the childbearing years, and at that time women may have less contact with health care systems.

Another surprising characteristic of T2DM in Africa is the occasional absence of a difference in prevalence between urban and rural areas [37]. The higher than expected rate

of T2DM in rural areas may occur because symptomatic individuals attend the study sites hoping for treatment, leading to a recruitment bias. It is also possible that data were collected in rural regions that were actually within an urban realm of influence (ie, semi-urban villages could have been misclassified as rural).

Western Africa

In 1958, T2DM was reported in less than 2% of the urban population in Ghana [39]. In 2002, Amoah et al. [37] reported that in 3400 Ghanaians from rural and urban areas, the prevalence of T2DM was 8% in men and 6% in women. The rates of T2DM in Nigeria are remarkably similar to those reported in Ghana. In 1989, T2DM was reported in less than 2% of men and women in a study that enrolled 2800 Nigerians from urban and rural regions [40]. By 2003, in a sample size of more than 500 urban Nigerians the prevalence of T2DM had increased to 8% in men and 6% in women [41]. In urban Benin, despite a high rate of obesity there is a very low prevalence of T2DM [14]. In 200 men and women from Benin, the prevalence of T2DM was reported to be only 1% in men and 0% in women [14]. This low rate of T2DM in Benin needs confirmation.

Eastern Africa

In 1984, a study of a Tanzanian population of 3000 subjects reported that T2DM affected less than 2% of the population in rural and urban areas [42]. These observations were confirmed by similar results in a study of 6300 Tanzanians [36]. However, over time the prevalence of T2DM in urban areas has increased. A report from 2000 revealed that the prevalence rate of T2DM in urban Tanzania had increased to 6% [18]. This study also found that compared with women, men experienced a higher rate of T2DM at a lower body mass index.

Southern Africa

The prevalence of T2DM is higher in South Africa than in Western and Eastern Africa. In 1972, the prevalence of T2DM among 900 black South Africans was 4%, which was two times higher than contemporaneous rates of T2DM in other regions of Africa [40,42,43]. By 1999, a study of more than 970 blacks living in a peri-urban community showed that the prevalence of T2DM had almost tripled to 11%, which is generally higher than rates reported elsewhere in Africa [44].

Dyslipidemia

The dyslipidemia of MetSyn has two components: low HDL and hypertriglyceridemia. Research on dyslipidemia in Africa is less extensive than for obesity, hypertension, or T2DM. Social, financial, and technological barriers contribute to the lack of studies. Due to the HIV/AIDS epidemic, participation in studies that involve a blood draw is often met with suspicion [27]. Furthermore, lipid assays are expensive. At a minimum, trained personnel, sterile supplies, and access to refrigeration are required. Therefore, studies of HDL and TG are more likely to be performed in urban than rural areas.

Nonetheless, evidence suggests that there has been a downward trend in HDL levels in Africans in recent decades. In the 1970s, mean HDL levels in Africans were reported to be between 60 and 70 mg/dL [45]. In the next two decades, levels were between 40 and 60 mg/dL [46,47]. In 2006, mean HDL levels even in apparently healthy Nigerians were 35 mg/dL [48]. Changes in Africa that promote this decline in HDL levels include obesity, T2DM, physical inactivity, and the high-fat, low-fiber urban diet. If HDL levels are indeed declining in Africa, an increase in cardiovascular deaths may start to occur in the coming decades. This is because HDL is cardioprotective and high levels are beneficial. HDL participates in

reverse cholesterol transport and has antithrombotic, anti-inflammatory, and antioxidant actions. Therefore, low HDL levels may represent a loss of this protection.

Hypertriglyceridemia is the other component of the dyslipidemia of MetSyn. In African Americans, TG levels are often normal even in the presence of low HDL levels, obesity, and insulin resistance [49]. It is unknown whether the same is true for Africans. For several reasons, studies of TG in Africans are difficult to evaluate (ie, they were performed in different populations, did not use the same methods, or were not done when participants were fasting). In addition, compared with other MetSyn variables, TG levels may be even more sensitive to geographic variation. For example, a Tanzanian study showed that one population with a high intake of fish due to proximity to a lake had lower TG levels than a nearby vegetarian population [50].

Our review of the literature has led us to believe that in recent decades, even though HDL is declining, TG levels do not appear to be increasing. Mean TG levels in Africans are generally reported well below the MetSyn threshold set for hypertriglyceridemia (≥ 150 mg/dL). This is surprising because the factors that cause HDL to fall, such as obesity and physical inactivity, are also risk factors for hypertriglyceridemia. Therefore, we postulate that TG levels in Africans may not be a good marker for vascular disease risk. If evidence becomes available to support this impression, MetSyn may not be an effective tool in Africans to predict atherosclerosis and T2DM. Alternatively, it is possible that the TG threshold set for hypertriglyceridemia (≥ 150 mg/dL) is not appropriate for Africans and a lower level would be more appropriate.

Conclusions

The dramatic increase in obesity, hypertension, atherosclerosis, and T2DM in sub-Saharan Africa requires an effective response. In Europe and North America, MetSyn has proven useful in predicting increased risk of atherosclerosis and T2DM. However, the value of MetSyn in Africa is unknown. Until the prevalence of MetSyn in African countries is known, it cannot be determined if the presence of MetSyn will forecast diseases. Prospective studies in Africa should be designed to collect data on MetSyn. However, these studies should not deflect attention from the immediate need to treat hypertension, atherosclerosis, and T2DM. As data are collected, attention needs to be paid to urban, semi-urban, and rural communities; differences between men and women; and the impact of local culture on recruitment and ascertainment bias. With these data, it should be possible to determine if the focus in Africa should be on MetSyn as a whole or obesity, hypertension, atherosclerosis, and T2DM as individual conditions.

Acknowledgments

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Table 1

Sub-Saharan African countries listed by geographic region

Western	Eastern	Middle	Southern
Benin	Burundi	Angola	Botswana
Burkina Faso	Comoros	Cameroon	Lesotho
Cape Verde	Djibouti	Central African Republic	Namibia
Cote d'Ivoire	Eritrea	Chad	South Africa
Gambia	Ethiopia	Democratic Republic of the Congo	Swaziland
Ghana	Kenya	Equatorial Guinea	
Guinea	Madagascar	Gabon	
Guinea-Bissau	Malawi	Republic of the Congo	
Liberia	Mauritius	Sao Tome and Principe	
Mali	Mozambique		
Mauritania	Rwanda		
Niger	Seychelles		
Nigeria	Somalia		
Senegal	Uganda		
Sierra Leone	Tanzania		
Togo	Zambia		
	Zimbabwe		