Metabolic Syndrome in a Rural Nigerian Community: Is Central Obesity always the key Determinant?

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ABSTRACT

Background

Metabolic syndrome (MS) is primarily the consequence of excess central adiposity but can also result from low grade systemic inflammation inducing insulin resistance. There is a global increase in the prevalence of MS; it is on this background that evaluation of the prevalence of MS in a poor rural farming community with a low expected low prevalence of obesity is relevant. The objective of this study was to determine the prevalence of metabolic syndrome using the National Cholesterol Education Project: Adult Treatment Panel III definition (MS-ATP) in a rural Nigerian community.

Methods

300 adult consenting participants were bled after an overnight fast, and venous blood obtained for lipid studies and fasting blood glucose estimation. Measurements were made to determine height, weight, waist circumference and blood pressure. The prevalence of each diagnostic component was determined and the relative risk (RR) of each component for MS-ATP was calculated.

Results

The prevalence of MS-ATP was 6.30%, central obesity 5.33% (RR=3.3[95% CI:1.08-10.26]), and hypertriglyceridaemia 11.33% (RR=21.91[95% CI:8.42-57.32]). The prevalence of low HDL-cholesterol was highest (85.67%) but the RR was not calculable.

Conclusion

Unlike previous reports the prevalence of central obesity was very low in this study and contributed little to the development of MS-ATP. Hypertriglyceridaemia appears to be associated with the greatest risk of developing metabolic syndrome in this community while Low HDL-cholesterol although most prevalent is a poor diagnostic requirement for metabolic syndrome.

Key Words: Metabolic syndrome; rural community; Nigeria

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INTRODUCTION

The metabolic syndrome is a cluster of cardiovascular disease risk factors that are metabolic in origin and include atherogenic dyslipidaemia, hypertension and hyperglycaemia. Its aetiogenesis is thought to be related to excess adiposity-mediated insulin resistance. Mediators of this adiposity-mediated insulin resistance include physical inactivity, genetic factors, advancing age, endocrine dysfunction and drugs [1-3].

Abdominal (central) obesity is characterized by enlarged fat cells as well as increased numbers of monocyte-derived macrophages within adipose tissue. These enlarged adipocytes release an excess of free fatty acid that impairs the actions of insulin in muscle and liver [1,4]. Enlarged fat cells and their surrounding macrophages further produce an excess of adipokines, including leptin and resistin and decreased quantities of adiponectin, together with increased amounts of the adipocytokines, tumour necrosis factor-α (TNFα) and interleukin (IL)-6, each of which, in addition to free fatty acid, contribute to impaired insulin sensitivity [1,4].

In addition to insulin resistance, low-grade systemic inflammation [5-8] has been strongly implicated in the pathophysiology of the metabolic syndrome. Inactivity is associated with insulin resistance [9-12] and elevated levels of the proinflammatory marker, high-sensitivity C-reactive protein (hs-CRP), which is associated with many other metabolic syndrome features [13]. The excessive intake of carbohydrates and saturated fats in addition to causing obesity were recently reported to directly induce several proinflammatory effects, including the increased production of reactive oxygen species, upregulation of nuclear factor ß in monocytes and polymorphonuclear cells and CRP production [14].

A recent meta-analysis of longitudinal studies revealed that the metabolic syndrome was associated with a relative risk of cardiovascular (CV) events and death of 1.54 (95% CI: 1.32-1.79) after adjustment for traditional CV risk factors [15].

Reports on community-based prevalence of MS in Nigeria and Sub-Saharan Africa are not common; previous studies have reported MS in a Sub-Saharan African setting[16], diabetics[17] and outpatients in family medicine clinics in southern Nigeria[18].

The objectives of this study therefore, are to determine the prevalence of metabolic syndrome as defined by the National Cholesterol Education Program Adult Treatment Panel III (MS-ATP) and the relative risk of the MS components in adult Nigerians living in the rural

community of Odufor Etche, Rivers State, Nigeria.

MATERIALS AND METHODS

This study was approved by the Research Ethics Committee of the College of Health Sciences, University of Port Harcourt, Rivers State, Nigeria.

Participants

This study was conducted in the village of Odufor in Etche Local Government Area of Rivers State, Nigeria. Odufor is a small, predominantly farming village with a resident adult population of about 1000.

Three hundred adults excluding pregnant women, individuals with obvious ascites and other forms of oedema, as well as non-ambulatory subjects who could not stand for weight and height measurements in spite of previous consent to participate were excluded. Participants were educated on the goals of the study and the extent of their involvement in the study. The study population consisted of 140 males and 160`females.

Data Collection

The study was conducted between 8.00am and 10 am daily, in May/June of 2008. On arrival at the study venue, each subject was allowed to rest for 15 minutes, and then a pretested questionnaire designed for the study was filled out with the help of a researcher. Personal and family medical history of obesity, hypertension, diabetes mellitus, and renal disease was also obtained. The subject's history of leisure/voluntary exercise and occupation was used to assess his/her level of physical activity.

Determination of Waist Circumference

Waist circumference of the subjects was recorded using a measuring tape. The iliac crest was first identified by palpation and then a measuring tape placed around the waist, at the level of the iliac crest in a horizontal plane, parallel to the floor. The tape was snug but did not compress the skin. Subjects were asked to inhale and then exhale. The measurement was taken at the end of a normal expiration, in centimeters[19].

Measurement of Blood Pressure

Blood pressure was measured using the auscultatory method, with the subject sitting upright in a straight-back chair. An inflatable 6 inch cuff attached to a mercury sphygmomanometer (Accoson, UK) was wrapped around the upper left arm and a stethoscope (Littman, 3M, USA) placed over the brachial artery at the elbow. The cuff pressure at which the tapping (Korotkoff) sounds were first heard was recorded as the systolic blood pressure and the point at which these Korotkoff sounds disappeared (phase 5) was taken as the diastolic pressure. Average blood pressure readings based on records on at least two occasions were computed for this study.

Serum Glucose and Lipid Estimations

Patients were asked to fast overnight prior to presentation for the study and samples were collected in the morning as they presented at the study centre set up in the village. 10 mls of blood was collected from each subject by venepuncture and then distributed into a fluoride bottle for determination of fasting plasma glucose, and a heparinized bottle for determination of Total, HDL- and LDL-cholesterol.

Fasting plasma glucose was analysed by the glucose oxidase method[20], total cholesterol by the cholesterol oxidase method[21] and triglyceride by the lipase method[22].

Statistical Analysis

The results obtained were analysed using SPSS for windows software version 14.0 and Epi info version 6.04D and are expressed as mean ± SEM, percentages and tables. P values less than 0.05 were considered significant.

RESULTS

Age and sex Distribution of Subjects

The age and sex distribution of the subjects is as shown in Table I. One hundred and forty males and 160 females participated in this study. The mean age of the participants was 40.55±0.99 years. Seventy two of the participants were farmers, 75 were students, 15 were civil servants and 38 were self employed as petty traders, tailors/seamstresses.

Prevalence of Risk Factors

Abdominal Obesity

Sixteen subjects (5.33%) had large waist circumferences or abdominal obesity as defined by ATP diagnostic criteria (Table II). Of these subjects, 12 (75.00%) were females and 4 (25.00%) were males. Only 3 (18.80%) of them had MS-ATP. The relative risk (RR) of large waist circumference for MS-ATP was 3.33 (95% CI: 1.08-10.26).

Hypertension

One hundred and one of the 300 participants (33.67%) had systolic hypertension as defined by ATP III (Table 2). Forty seven of the participants with hypertension (46.53%) were males while 54 (53.46%) were females. Fourteen (13.90%) of these participants had MS-ATP. The relative risk (RR) of high blood pressure for metabolic syndrome was 5.52 (95% CI: 2.02-20.56).

Impaired Fasting Plasma Glucose

The prevalence of impaired fasting blood glucose (IFPG) among the participants was 7.33% (22 participants); 59.09% (13 participants) of these were females while 40.91% were males (Table 2). RR = 11.37 (95% CI: 5.72-25.03).

Hypertriglyceridaemia

A total of 34 participants had serum triglyceride levels greater than or equal to 1.7 mmol/L, making the prevalence of hypertriglyceridaemia among the participants 11.33% (61.80% were females while 38.20% were males) (Table 2). Fourteen of the participants with hypertriglyceridaemia had MS-ATP. RR=21.91 (95% CI: 8.42-57.32).

Low Hdl-cholesterol

Two hundred and fifty seven of the 300 subjects that participated in this study at Odufor had low serum HDL-cholesterol, making the prevalence 85.67% (Table 2). One hundred and fifty five were females (60.30%) and 102 were males (39.70%). RR was not calculable as an expected cell had 0 value (No participant with normal HDL cholesterol had MS-ATP).

Metabolic Syndrome as Defined by ATP III (MS-ATP)

The prevalence of MS-ATP among the participants was 6.3% (Table 2). Fifty two point six three percent of those diagnosed with MS-ATP (10 participants) were females or 6.25% of the females that participated in the study. Forty seven point three seven percent of all those diagnosed with MS-ATP (9 participants) were males. This proportion represented 6.43% of the male subjects. The average age of all the participants with metabolic syndrome was 42.68±4.55 years. Thirteen (68.42%) of all those with metabolic syndrome were farmers, 4 (21.05%) were students and 2 (10.53%) were civil servants.

Table 1: Age- and Sex-distribution of Odufor Study Participants

Odufor Study Participants		
Age Group	**Frequency**	**%**
d19	20	6.67
20-29	85	28.33
30-39	46	15.33
40-49	51	17.00
50-59	45	15.00
60-69	32	10.67
70-79	11	3.67
80-89	7	2.33
90-99	2	0.66
100-109	1	0.33
TOTAL	300	100
Males	140	46.67
Females	160	53.33

Table 2: Prevalence of Risk Factors

Risk Factors	Odufor Study participants n=300		
Abdominal Obesity WCe 102cm M; e88cm F	Frequency 16	Percent 5.33	RR(95% CI) 3.33(1.08-10.26
Hypertension (SBPe130 or DBP e 85 mmHg)	101	33.67	5.52(2.02-20.56)
Impaired fasting Blood glucose (IFG) ATP III (FG e 6.1 mmol/L)	22	7.33	11.37(5.72-25.03)
Hypertriglyceridaemia Serum Trig e 1.7mmol/L	34	11.33	21.91(8.42-57.32)
Low HDL-cholesterol (HDL-Chol < 1.03 in M; < 1.29 in F)	257	85.67	Not Calculable

DISCUSSION

The main determinant of metabolic syndrome is excess adiposity that often (but not always) results in insulin resistance[1,2,23,24]. We found in this study however, that the prevalence of abdominal obesity (large waist circumference serving as proxy) was only 5.33% and that only 3 of the 16 participants with abdominal obesity had MS-ATP (ages 35, 46 and 60; 1 male and 2 females). The relative risk of abdominal obesity for MS-ATP was 3.33 (95% CI: 1.08-10.26), smaller than the relative risk of the other components calculated. This is at variance with the findings reported by Fezau et al[16] and Siminialayi *et al*[18]. Both studies found that central obesity was the most prevalent component of the metabolic syndrome in Africans.

The Fezau study[16] also reported that hypertriglyceridaemia was almost non-existent in their subjects. We however, found that the prevalence of hypertriglyceridamia was 11.33%, third, behind low HDL-cholesterol (85.67%) and hypertension (33.67%) but the relative risk of hypertriglyceridamia for MS-ATP (table 2) was highest of all the metabolic syndrome components (21.91, 95% CI: 8.42-57.32). The Low HDL-cholesterol finding is in agreement with an earlier report by Siminialayi *et al*[18]. Like that study also, which reported the RR as insignificant for one set of participants and incalculable for the other, the RR of low HDL-cholesterol in this study was incalculable.

The Odufor people eat mainly carbohydrates in the form of cassava and yam for all three meals of the day. They are however very hard working, physically exerting subsistence farmers, explaining the low prevalence of obesity in the community. It was recently reported that the excessive intake of carbohydrates and saturated fats in addition to causing obesity could directly induce several proinflammatory effects, including the increased production of reactive oxygen species, upregulation of nuclear factor ß in monocytes and polymorphonuclear cells and CRP production [14]. Also, we now know that apart from excess adiposity, low grade systemic inflammation can induce insulin resistance[5-8].

Insulin resistance is an impaired biological response to insulin actions in the insulin-responsive organ systems of skeletal muscle, the liver and fat tissues[25]. This means that muscle, fat and liver cells are less able to take up glucose from the blood and there is an increase in gluconeogenesis that can lead to increased circulating glucose concentrations and compensatory hyperinsulinaemia, enhanced free fatty acid release by fat tissue that can result in increased triglycerides and reduced HDL-cholesterol concentrations and protein catabolism[15,24]. This also means that recently identified biological actions of insulin, including anti-inflammatory effects mediated by decreasing nuclear factor ß, increasing inhibitor of ß, reducing reactive oxygen species, and circulating adhesion molecules as well as profibrinolytic action such as decreasing plasminogen activator inhibitor-1production, are inhibited[14]. Thus, insulin resistance not only accelerates atherogenesis through the development of classical metabolic risk factors but also by directly generating proinflammatory and prothrombotic states[24].

We think the prevalence of low HDL-cholesterol is only partly the consequence of insulin resistance. The low levels of

HDL-cholesterol are in keeping with the findings of the National Survey of Non-communicable diseases in Nigeria reported by the Federal Ministry of Health[26], and the reports of Isezuo[17] and Siminialayi *et al*[18]. All these reports indicate that Nigerians and other Africans have low levels of total, LDL- and HDL-cholesterol and that low-HDL cholesterol is a poor indicator of cardiovascular disease risk in Africans.

CONCLUSION

The prevalence of MS in Odufor Etche community is low, central obesity has low a prevalence rate in the community and a low relative risk for MS-ATP. Hypertriglyceridaemia appears to be associated with the greatest risk of developing metabolic syndrome in this community while Low HDL-cholesterol although most prevalent is a poor diagnostic requirement for metabolic syndrome. These findings reinforce the view already expresses that existing metabolic syndrome definitions need to be modified for Africans. In this particular community at least, central obesity is not the key determinant of metabolic syndrome. We postulate that this is perhaps related to the fact that they eat largely carbohydrate based meals and are very active subsistence farmers.

REFERENCES

1. Grundy SM. Controversy in clinical endocrinology. Metabolic syndrome: a multiplex cardiovascular risk factor. J Clin Endocrinol Metab 2007; 92(2), 399-404.
2. Eckel RH, Grundy SM, Zimmet PZ. The metabolic syndrome. Lancet 2005; 365(9468) 1415-1428.
3. Alberti KG, Zimmet P, Shaw J. The metabolic syndrome - a new worldwide definition. Lancet 2005; 366(9491), 1059-1062.
4. Gonzalez-Gay MA, Gonzalez-Juanatey C, Martin J. Rheumatoid arthritis: a disease associated with accelerated atherogenesis. Semin Arthritis Rheum 2005; 35(1), 8-17.
5. Hotamisligil GS, Shargill NS, Spiegelman BM. Adipose expression of tumor necrosis factor-a: direct role in obesity-linked insulin resistance. Science 1993; 259(5091), 87-91.
6. Hotamisligil GS, Peraldi P, Budavari A, Ellis R, White MF, Spiegelman BM. IRS-1 mediated inhibition of insulin receptor tyrosine kinase activity in TNF-a- and obesity-induced insulin resistance. Science 1996; 271(5249), 665-668.
7. Rui L, Yuan M, Frantz D, Shoelson S, White MF. SOCS-1 and SOCS-3 block insulin signaling by ubiquitin-mediated degradation of IRS1 and IRS2. J Biol Chem 2002; 277(44), 42394-42398.
8. Ridker PM, Wilson PW, Grundy SM. Should C-reactive protein be added to metabolic syndrome and to assessment of global cardiovascular risk? Circulation 2004; 109(23), 2818-2825.
9. Gabriel SE, Crowson CS, O'Fallen WM: Comorbidity in arthritis. J Rheumatol 1994; 26(11), 2475-2479.
10. Del Rincon ID, Williams K, Stern MP, Freeman GL, Escalante A. High incidence of cardiovascular events in a rheumatoid arthritis cohort not explained by traditional cardiac risk factors. Arthritis Rheum 2001; 44(12), 2737-2745.
11. Solomon DH, Karlson EW, Rimm EB et al. Cardiovascular morbidity and mortality in women diagnosed with rheumatoid arthritis. Circulation 2003;107(9), 1030-1307.
12. Wolfe F, Freundlich B, Straus WL. Increase in cardiovascular and cerebrovascular disease prevalence in rheumatoid arthritis. J Rheumatol 2003; 30(1), 36-40.
13. Festa A, D'Agostino R Jr, Howard G, Mykkanen L, Tracy RP, Haffner SM. Chronic subclinical inflammation as part of the insulin resistance syndrome: the Insulin Resistance Atherosclerosis Study (IRAS). Circulation 2000; 102(1), 42-47.
14. Dandona P, Aljada A, Chaudhuri A, Mohanty P, Garg R. Metabolic syndrome. A comprehensive perspective based on interactions between obesity, diabetes, and inflammation. Circulation 2005; 111(11), 1448-1454.
15. Gami AS, Witt BJ, Howard DE et al. Metabolic syndrome and risk of incident cardiovascular events and death: a systematic review and meta-analysis of longitudinal studies. J Am Coll Cardiol 2007; 49(4), 403-414.
16. Fezau L, Balkau B, Kegne A-P, Sobngwa E, Mbonya J-C. Metabolic syndrome in a sub-Saharan African setting: central obesity may be the key determinant. Atherosclerosis 2007; 193(1): 70-76.
17. Isezuo SA. Is high density lipoprotein cholesterol useful in diagnosis of metabolic syndrome in native Africans with type 2 diabetes? *Ethn Dis* 2005; 15: 6-10.
18. Siminialayi IM, Emem-Chioma PC, Odia OJ. Relative risk of metabolic syndrome components in Nigerians: the adult treatment III definition. PMJ 2009; 3: 302-311.
19. Grundy SM, Cleeman JI, Daniels SR, Donato KA, Eckel RH, Franklin BA, Gordon DJ, et al. Diagnosis and management of metabolic syndrome. *Circulation* 2005; 112: 2735-2752.
20. World Health Organization (WHO). Blood safety and clinical technology: guidelines on standard operating procedures for clinical chemistry. Available at: http://www.searo.who.int/EN/Section10/Section17/Section53/Section481_1753.htm Accessed March 17, 2007.
21. Emeis JJ, van Gent CM, van Sabben CM. An enzymatic method for the histochemical localization of free esterified cholesterol separately. *The Histochem J* 1977; 9: 197-204.
22. Gibbons VB, Ballantyne FC. Triglyceride estimation in high density lipoproteins. *Med Lab Sci* 1981; 38: 277-279.
23. Dessein PH, Gonzalez-Gay MA, Woodwiss AJ, Joffe BI, Norton GR, Solomon A. The impact of metabolic syndrome on cardiovascular risk factors and disease in rheumatoid arthritis. Future Rheumatol 2008; 3(4):335-349.
24. Grundy SM. Does a diagnosis of metabolic syndrome have value in clinical practice? Am J Clin Nutr 2006; 83(6), 1248-1251.
25. Reaven GM. Role of insulin resistance in human disease. Diabetes 37(12), 1595-1607 (1988).
26. Akinkugbe OO, ed. Non-communicable diseases in Nigeria: final report of a national survey. Federal Ministry of Health (Nigeria) 1997; 4: 5-118.

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