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Risk Factors for Cardiovascular Disease and Diet of Urban and Rural Dwellers in Northern Nigeria

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ABSTRACT

Over the last 30 years, cardiovascular diseases (CVDs), including stroke and myocardial infarction, have increased in developing countries. Serum lipids and diet of the Fulani, a rural Nigerian population, were previously studied. Despite their consumption of a diet rich in saturated fat, the overall blood lipid profiles of Fulani men and women are generally favourable. However, Fulani males in the same study had mean serum levels of homocysteine, an emerging risk factor for CVD, that exceeded the upper limit of the homocysteine reference range. The authors were interested in knowing if these findings in the Fulani nomads were representative of the biochemical parameters of CVD risk in other ethnic groups in the same region of Nigeria. To address this question, the nutrient content of diets of 55 men, aged 20-75 years, and 77 women, aged 20-70 years, who were inhabitants of a large urban centre in northern Nigeria, was assessed, and their serum levels of total cholesterol, LDL-cholesterol, HDL-cholesterol, triglycerides, and homocysteine were determined. These data were compared with those of the same rural Fulani population studied previously. Urban subjects consumed more calories than rural subjects (men: 2,061 vs 1,691 kcal; women: 1,833 vs 1,505 kcal) and had a significantly higher mean body mass index (BMI) and percentage of body fat than rural subjects. Both urban males and females had carbohydrate intakes that were greater than those of Fulani pastoralists (men: 56% vs 33% total calories; women: 51% vs 38% total calories), but had a significantly lower dietary intake of total fat and saturated fat (men: 36% vs 51% of total calories; women: 40% vs 51% of total calories). With the exception of HDL-cholesterol levels, which were significantly lower in the rural population, the blood lipid profiles of rural subjects were more favourable compared to those of urban subjects. Both urban and rural males had homocysteine levels above the upper limit of the reference range for healthy adults (urban males–12.7µmol/L; rural males–15.2 µmol/L). The dietary intakes of folate and vitamin B12 were lower for rural Fulani subjects, and this was reflected in their significantly lower serum concentrations of these two vitamins. Results of this study suggest that, although the lipid profiles of urban and rural men and women in northern Nigeria indicate a relatively low risk for CVD, their elevated serum homocysteine levels are a cause for concern. The high homocysteine levels among rural men and women could be explained in part at least by their marginal status with respect to folate and vitamin B12.

***Key words*:** Cardiovascular diseases; Risk factors; Serum lipids; Diet; Cholesterol; Homocysteine; Nigeria

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INTRODUCTION

It is widely acknowledged that blacks globally have one of the highest rates of cardiovascular disease (CVD) (1). In Africa, urban dwellers have a higher incidence of hypertension, an important CVD risk factor, compared to their rural neighbours (2-6). In our recent study conducted to investigate the lipid profiles of adult males in northern Nigeria (7), we found that the mean systolic blood pressure of urban males in Abuja (the federal capital) and Jos was significantly higher than that of semi-nomadic Fulani rural males living about 40 km away from Jos. However, when the lipid profiles of the urban and rural populations in and around Jos were compared, a mixed picture emerged: while the total cholesterol and LDL-cholesterol levels of rural men were lower than those of urban men, among the semi-nomadic Fulani the mean serum triglyceride concentration was higher and the HDL-cholesterol level was lower compared to males who lived in Jos (7).

In addition to physical activity, diet plays a major role in determining one's risk factors for CVD. For example, the consumption of a diet high in saturated fat, palmitic acid in particular, tends to raise total cholesterol and LDL-cholesterol levels (8,9). Diets containing mono-unsaturated fatty acid, oleic acid, are associated with a more favourable serum lipid profile from the standpoint of CVD risk. Trans fatty acids that are present in relatively large amounts in processed hydrogenated oils and in dairy products increase CVD risk by raising the LDL-cholesterol level and depressing that of HDL-cholesterol (10). Since folate, vitamin B12, and vitamin B6 are required for metabolic assimilation of homocysteine, which is another risk factor for CVD (11-13), the quantities of these water-soluble vitamins in the diet can influence one's risk of stroke or myocardial infarction.

We had reported previously on diets of rural Fulani cattle herders in Nigeria (14), but we lacked quantitative and comprehensive information on diets of urban dwellers in Jos, which prevented us from relating the lipid profiles of urban subjects to their dietary habits. To fill that gap in our knowledge, we revisited the question of CVD risk factors among adults in metropolitan Jos and expanded the study to include both men and women and a dietary survey in our study design. Our panel of serum biochemical analyses included serum lipids, homocysteine, folate, and vitamin B12, which enabled us to investigate the possible relationships between the dietary intakes of folate and vitamin B12 and the high levels of homocysteine we previously documented in the adult population of Jos (7). The main aims of this study were to compare the anthropometric and biochemical CVD risk factors of two populations in Nigeria—one rural and one urban—and to examine the effect that diet contributes to these risk factors.

MATERIALS AND METHODS

Study population

The urban subjects were recruited in the city of Jos, which is situated in the centre of the 2,200-metre high plateau of north-central Nigeria. They were volunteers from the staff and constituency of the Jos University Teaching Hospital, were in apparent good health, and comprised 43 different ethnic groups. The five major ethnic groups were Fulani, Hausa, Igbo, Yoruba, and Berom, with 12-19 representatives from each group participating in the study. The other 74 participants reported ethnicity in 38 additional groups.

The rural subjects were of the Fulani ethnic group and were recruited from four hamlets located approximately 40 km east of Jos. The Fulani are semi-nomadic pastoralists whose main occupation is cattle-rearing. Their diet is high in fat (50% of total calories) with approximately half the fat being saturated fat (14). None were taking medications for malaria or other infectious diseases.

Informed consent was obtained from each subject after the requirements for participation in the study were explained. A physician, fluent in Hausa or Fulfulde, obtained consent from Fulani subjects. The Human Research Review Committee of the University of New Mexico School of Medicine, Albuquerque, NM and the Ethics Review Committee of the Jos University Teaching Hospital, Jos, Nigeria, approved the study.

Anthropometric measurements

A portable stadiometer (accurate to within 0.25 cm) and a battery-operated scale (accurate to 0.5 kg) were used for determining, respectively, height and weight of each subject. Blood pressure was determined using a nylon cuff and latex inflation system (Prestige Medical, Inc., Northridge, CA, USA). The mid-upper-arm circumference was determined using a tape measure (Creative Health Products, Plymouth, MI, USA), and the triceps skinfold thickness was determined using a Body Caliper (The Caliper Company, Inc., Carson City, NV, USA). Fat-free mass (FFM) and body fat were estimated by bioelectrical impedance analysis conducted using a portable bioelectrical impedance analyzer (Quantum, RJL Systems, Clinton Township, MI, USA) as described elsewhere (15). Reactance and resistance values, together with age, height, weight, and gender information, were used for calculating FFM and body fat using software provided by the manufacturer.

Biochemical analyses

Blood samples, obtained by venipuncture, were allowed to clot at room temperature for 45 minutes before centrifugation to separate the serum. The samples were then aliquoted into cryovials and stored at -40 ^{o}C until they were transported in a frozen state to Albuquerque, NM, USA, for analysis. Total cholesterol was determined by the end-point colorimetry method of Allain *et al.* (16) using a Vitros 950 analyzer. HDL-cholesterol was determined using Kodak Vitros cholesterol slides and a Vitros 250 analyzer (17). Triglycerides were determined by the method of Spayd *et al*. (18) using a Vitros Analyzer Clinical Chemistry Slide (TRIG) and a Vitros 950 analyzer. LDL-cholesterol was calculated using the following equation: LDL-cholesterol=total cholesterol-(HDL-cholesterol+triglycerides/5). Serum folate and vitamin B12 were determined immunologically by competitive magnetic separation assays using kits purchased from Technicon. Homocysteine was determined using the Imx homocysteine assay kit (Abbott Diagnostics Division, Abbott Laboratories, Columbus, OH, USA).

Dietary analysis

Two interviewers collected data with the assistance of interpreters fluent in the appropriate language of subjects being interviewed (English, Hausa, or Fulfulde). The two interviewers who worked closely used the same questions to probe for completeness of dietary information. Both the interviewers used the same food models for assisting the subjects in estimating the quantities of food eaten. They made every effort to obtain complete and comparable records.

For urban subjects, the assessment was based on four-day dietary recall using food models and containers for estimating the quantity of each item consumed. Dietary data were analyzed using the FOOD PROCESSOR nutrient analysis software (Version 7.81, ESHA Research, Inc., Salem, OR, USA). Composition of nutrients was determined from foods already reported in the FOOD PROCESSOR database and from other foods we added to this database using information contained in the U.S. Department of Agriculture nutrient database for standard reference (19) and a food-composition table for use in Africa (20). The FOOD PROCESSOR program has been validated by comparing the database with chemical analysis of food and found to have acceptable accuracy (21,22).

Recipes for mixed foods were recorded during interviews from information provided by those who had prepared the food. Representative recipes were entered into the FOOD PROCESSOR program for analysis of food composition. Overall nutrient analysis of an individual's diet included all those macronutrients and selected micronutrients that are pertinent to cardiovascular disease.

After completing dietary analysis of each subject's actual intake of various macro- and micronutrients, these values were compared with recommendations compiled for developing countries by the Food and Agriculture Organization (FAO) (23). The mean intakes of various nutrients for men and women were then determined separately.

For rural subjects, dietary assessment included a seven-day dietary recall and a food-frequency questionnaire (FFQ). Data were analyzed using the FOOD PROCESSOR software (Version 7.2, ESHA Research, Inc., Salem, OR, USA). Although a seven-day recall may be inaccurate when diets are highly variable, the Fulani diet is consistent throughout the year and among individuals because of their reliance on a limited number of locally-available food items. Because neither FFQ nor seven-day recall included exact serving portions, a standard portion for each food was established by a dietitian based on her direct observation of meals consumed by rural subjects. Dietary analyses were based on these portions.

Statistical analyses

Descriptive statistics, group comparisons, and correlations were performed using the Number Cruncher Statistical Software (Version 2001, NCSS, Kaysville, UT, USA). Since the body composition parameters (i.e. body fat, FFM) and serum lipid concentrations are known to be gender-dependent, data on the male and female subjects were analyzed separately. For those variables that were age-dependent, age-adjusted means were used for comparing urban and rural subjects using analysis of covariance. To test for the effect of diet on serum and body composition risk factors, regression analysis was used with serum lipid and body composition parameters as the dependent variables and dietary intake of specific nutrients as the independent variables. A p value of 0.05 was considered significant.

RESULTS

Comments on study population

The urban subjects, consisted of 55 men aged 20-75 (mean 41.2) years and 77 women aged 20-70 (mean 39.8) years (Table 1), represented almost entirely ethnic groups whose primary language was Hausa; however, 43 different tribal identifications were reported by the subjects. Although men were, on average, slightly taller than women (1.70 vs 1.69 m), age-adjusted weight and BMI of women exceeded that of men. The blood pressure of men was 128/83 mmHg and that of women was 132/84 mmHg (Table 1).

The rural (Fulani) subjects consisted of 42 men and 79 women. Although the Fulani women were shorter and weighed less than the Fulani men, their BMI values were comparable (Table 1). The systolic and diastolic blood pressures of Fulani men and women were also similar.

Anthropometric and body composition characteristics of urban and rural men are compared in Tables 1 and 2. Because the Fulani men were significantly younger than urban men, it was necessary to calculate the age-adjusted means of these parameters. Although there was no significant difference in height between the two male groups, the rural Fulani men weighed, on average, 7.7 kg less ($p<0.001$) and had a mean BMI value that was 2.5 kg/m^2 lower than that of their urban counterparts. In terms of body composition, the Fulani males had a lower FFM and body fat compared to urban males in Jos. However, because both FFM and body fat were proportionally lower among Fulani men compared to urban men, there was no difference in the percentage of body fat or FFM between the two male groups.

Greater differences in anthropometric parameters between urban and rural subjects were observed for female subjects (Tables 1 and 2). Age-adjusted means for weight, height, and BMI were all significantly lower for rural Fulani women compared to urban females. As was observed for male subjects, the Fulani women had significantly lower FFM and body fat than urban females. Body fat of urban women was twice that of Fulani women (29.4 vs 14.8 kg respectively), resulting in a significantly higher percentage of body fat for urban women. Although the Fulani women had a lower mean FFM, because of their lower body fat content, they had a significantly greater percentage of FFM than urban women. The rural females had significantly lower systolic and diastolic blood pressures than urban females; how-

Table 1. Anthropometric characteristics of urban and rural Nigerian subjects

Parameter	Male			Female		
	Jos (n=55)	Fulani (n=42)	p value	Jos (n=77)	Fulani (n=79)	p value
	Age-adjusted means (standard error)					
Age (years)	41.2±12.5*	33.8±12.5	0.004	39.8±13.3	31.9±13.0	<0.001
Height (cm)	170 (0.39)	169 (1.02)	NS	162 (0.75)	158 (0.74)	0.003
Weight (kg)	65.5 (1.21)	57.8 (1.38)	<0.001	72.2 (1.39)	50.5 (1.37)	<0.001
BMI (kg/m^2)	22.6 (0.36)	20.1 (0.42)	<0.001	27.6 (0.51)	20.2 (0.50)	<0.001
Blood pressure (mmHg)						
Systolic	128 (2.44)	122 (2.8)	NS	132 (2.1)	121 (2.1)	<0.001
Diastolic	83 (1.4)	75 (1.6)	0.001	84 (1.4)	78 (1.4)	0.003

*Mean±standard deviation; BMI=Body mass index; NS=Not significant

Table 2. Body composition parameters of the urban and rural Nigerian subjects

Parameter	Male			Female		
	Jos (n=55)	Fulani (n=42)	p value	Jos (n=77)	Fulani (n=79)	p value
	Age-adjusted means (standard error)					
Fat-free mass (kg)	56.1 (0.76)	50.2 (0.87)	<0.001	42.7 (0.47)	35.6 (0.46)	<0.001
% fat-free mass	86.1 (0.63)	86.9 (0.72)	NS	60.8 (0.95)	71.6 (0.94)	<0.001
Body fat (kg)	9.43 (0.54)	7.65 (0.61)	0.04	29.4 (1.08)	14.8 (1.07)	<0.001
% body fat	13.8 (0.63)	13.0 (0.73)	NS	39.2 (0.95)	28.4 (0.94)	<0.001

ever, there was a significant difference only in the mean diastolic blood pressure between urban and rural men.

Concentrations of biochemical parameters in serum

The mean serum total cholesterol concentrations of both urban and rural men and women were well below 200 mg/dL (Table 3), a value considered desirable by the National Cholesterol Education Program (NCEP) Expert Panel (24); however, the mean total cholesterol levels of urban men and women were significantly higher than those of rural subjects.

The mean LDL-cholesterol and triglyceride levels of all four groups fell in the optimal range of the NCEP guidelines and did not differ between urban and rural male subjects. The Fulani females had a mean serum triglyceride level that was significantly lower than that of urban females (108 mg/dL vs 135 mg/dL respectively). The mean HDL-cholesterol concentration of Fulani males was the lowest of all of the four study groups and significantly lower than that of urban males (45 vs 37 mg/dL, p<0.001). As was the case for male subjects, the mean HDL-cholesterol level of Fulani women was significantly lower than that of urban females (41 vs 50 mg/dL, p<0.001).

The mean serum homocysteine concentration for both the groups was much higher among men than among women (Table 3). Furthermore, the mean serum homocysteine concentration of both urban and rural men exceeded the upper limit of the reference range for Caucasians (11.4 µM) (25). Both urban and rural females had serum homocysteine concentrations below the upper cut-off of 11.4 µM. For all four groups, the mean serum folate and vitamin B12 levels were well within their respective reference ranges for healthy adults (26). However, both male and female rural subjects had the mean serum folate and vitamin B12 concentrations that were significantly below the corresponding means of their urban counterparts (Table 3).

Table 3. Biochemical parameters of the urban and rural Nigerian subjects

Parameter	Male			Female		
	Urban (n=55)	Rural (n=42)	p value	Urban (n=77)	Rural (n=79)	p value
	Age-adjusted means (standard error)					
Total cholesterol (mg/dL)	158 (3.9)	140 (4.6)	0.005	170 (3.4)	140 (3.5)	<0.001
HDL-cholesterol (mg/dL)	45 (1.4)	37 (2)	<0.001	50 (1.3)	41 (1.3)	<0.001
LDL-cholesterol (mg/dL)	84 (3.4)	74 (3.9)	NS	93 (3.1)	75 (3.1)	<0.001
Triglycerides (mg/dL)	148 (12)	146 (14)	NS	135 (7.5)	108 (7.4)	0.02
Serum folate (ng/mL)	6.9 (0.3)	3.9 (0.4)	<0.001	8.3 (0.4)	4.1 (0.4)	<0.001
Vitamin B12 (pg/mL)	526 (33)	360 (38)	0.002	572 (24)	251 (24)	<0.001
Homocysteine (µmol/L	12.7 (0.64)	15.2 (0.74)	0.015	9.3 (0.4)	11.1 (0.4)	0.002

Serum folate reference range: 3-20 ng/mL (7-45 nmol/L); Serum vitamin B12 reference range: 200-835 pg/mL (148-616 pmol/L) (25); NS=Not significant

Dietary analysis

Food records were obtained for 55 men and 77 women residing in the city of Jos and from 22 men and 73 females residing in the rural Fulani hamlets. As shown in Table 4, the estimated mean daily energy intake for urban males was 8,508 kJ (2,061 kcal), a value which corresponds to 71% of energy intake of 11,950 kJ predicted to maintain energy balance in men of similar size based on standards developed for developing countries (23). The estimated caloric intake of urban women was 7,566 kJ (1,833 kcal), which is 83% of the recommended energy intake of 9,123 kJ for women.

The energy intake for rural males was significantly lower compared to urban males (6,980 kJ vs 8,508 kJ or 11,691 kcal vs 2,061 kcal respectively, p<0.001) and provided 58% of the recommended energy intake (23). The rural women also had a significantly lower caloric intake than their urban counterparts (6,212 kJ vs 7,566 kJ, or 1,505 kcal vs 1,833 kcal respectively, p<0.001). Diet of rural women provided 68% of the recommended energy intake compared to 83% for urban women. Carbohydrates were the main energy source for both male and female urban subjects (50% or more of total energy). This is in contrast to both rural men and women for whom carbohydrates supplied only 33-38% of their total energy.

Protein accounted for only 14% of energy intake for urban men and women. Grains (e.g. maize, rice, millet) provided 28-29% of protein consumed by urban adults, followed closely by meat as a protein source (25% of total protein for males and 23% for females). Legumes, mainly beans and groundnuts, provided 19% and 15% of dietary protein of males and females respectively. Fish, relatively costly in northern Nigeria, accounted for 17% of protein intake in women but only 13% of protein intake of men. Ten percent of dietary protein of men and women came from eggs and milk. Vegetable protein accounted for the rest of protein intake, amounting to less than 10% in more than 86% of women and 89% of men. It accounted for greater than 10% of total protein for only 11% of males and 14% of females. Thus, for most participants in the present study, protein was obtained from various foods. All the study participants reported consuming grain, 92% reported eating meat, 87% consumed small amounts of milk and eggs, 86% consumed fish (mainly small amounts of smoked fish as flavouring), and 77% reported eating legumes during the recording period.

Both Fulani men and women derived a greater percentage of their calories from protein compared to urban subjects: 20% of calories of Fulani men and 17% of calories of Fulani women were from protein. As reported previously (14), the major sources of protein in diet of rural subjects were meat and milk, which together provided 82% of total protein for men and 74% for women. The Fulani subjects consumed meat several times a week and all but one of women reported drinking milk daily. The rural subjects consumed fish less frequently: less than once per week by 53% of men and 60% of women.

Fat accounted for about one-third of the daily energy requirement of urban adults, but only 15-16% of fat calories were derived from saturated fatty acids. Most fat in diets of urban men and women was provided by vegetable oils: groundnut oil and palm oil were the major oils consumed. The amount of cholesterol urban men and women consumed was slightly more than half of the upper limit for cholesterol intake (300 mg/day) recommended by FAO (23). In contrast, the rural men and women received 51% of their calories from fat with half of that being provided by saturated fats. The main sources of saturated fatty acids for Fulani subjects were dairy products and red palm oil. The cholesterol intake of rural men and women were 232 mg/day and 147 mg/day respectively, both of which are below the FAO recommendations of less than 300 mg per day (Table 4).

Table 4. Summary of selected nutrients in diets of urban and rural Nigerian men and women*

Nutrient	Male			Female		
	Jos (n=55)	Fulani (n=42)	p value	Jos (n=77)	Fulani (n=73)	p value
Energy						
Calories	2,061±735	1,691±267	0.02	1,833±614	1,505±215	<0.001
Kjoules	8,508±3,034	6,980±1,102		7,566±2,534	6,212±887	
Protein (g)	75±35	85±19	NS	63±24	62±14	NS
% of total energy	14.9	20.6		14.1	16.8	
Carbohydrate (g)	279±105	136±21	<0.001	226±79	138±22	<0.001
% of total energy	56	33		51	38	
Fat (g)	79±30	93±27	0.011	78±36	81±18	
% of total energy	35.6	51.0		39.5	50.5	
Saturated fat (g)	12±8	47±15	<0.001	12±7	40±10	<0.001
% of total energy	5.4	26		5.9	25	
% of total fat	15	51		15	50	
Cholesterol (mg)	166±131	232±84	<0.001	169±136	147±45	NS
Vitamin B6 (mg)	1.7±0.9	1.2±0.3	<0.001	1.4±0.6	0.85±0.2	<0.001
Vitamin B12 (µg)	3.4±2.5	6.9±2.5	<0.001	2.9±1.7	4.7±1.3	<0.001
Folate (µg)	501±360	134±21	<0.001	366±211	125±15	<0.001
Vitamin C (mg)	84±68	52±6.8	NS	82±57	46±6	<0.001
Vitamin A (RE)	1,203±1,341	788±156	NS	970±739	721±189	NS
Vitamin E (TE)	6.0±3.7	10.9±3.4	<0.001	6.3±3.9	12±3	<0.001
Selenium (µg)	74±35	57±13	0.027	62±25	41±9	<0.001
Iron (mg)	15±8	15±6	NS	13±6	12±5	NS
Calcium (mg)	550±346	935±293	<0.001	446±246	870±315	<0.001

*Mean±standard deviation; NS=Not significant; RE=Retinol equivalents; TE=Tocopherol equivalents

The urban population consumed 92-142% of the recommended intakes for vitamin B12, folate, and vitamin B6, the three vitamins involved in homocysteine metabolism (Table 4). Although diets of rural males and females provided adequate amounts of vitamin B12, the amount of folic acid contained in diets provided only 30% of the recommended intake for folate (400 µg/day). Although the vitamin B12 intake by urban men and women was lower than the intake of rural subjects, the intake of folic acid by urban male and female subjects exceeded that of Fulani men and women living in rural areas (Table 4).

The quantities of fat-soluble antioxidant vitamin A and water-soluble antioxidant vitamin C by urban subjects were adequate for both genders based on the FAO standards of 300 µg retinol equivalents for vitamin A and 45 mg/day for vitamin C (23). There are currently no guidelines for the intake of vitamin E based on international standards. However, the intake of vitamin E by urban male and female subjects was less than half that of the U.S.-recommended dietary allowances (27). This finding was unexpected, given the fact that men and women consumed relatively large quantities of vegetable oils, which are excellent sources of vitamin E. However, since some foods in the database have not been analyzed for all micronutrients, including vitamin E, the results we report for vitamin E should be regarded as minimum values.

With regard to critical trace minerals, the intake of selenium by urban adults in Jos appears to be adequate. However, this conclusion should be regarded as provisional since the selenium content of a particular plant food depends greatly on the selenium content of the soil in which the plant is grown. The intake of iron by males met the guidelines of FAO (13.7 mg/day, assuming an average bioavailability of 10%); however, the amount of iron in diets of urban and rural women was only 45% and 41% of the recommended nutrient intake (23). Although the intake of calcium by urban males and females was only about half that recommended for men and women (1,000 mg/day), the amount of calcium their diets provided was considerably greater than that which we have observed in northern Nigerian children (28) and that has been reported for West African women (29). The average intake of calcium by rural males and females was much higher than that of their urban counterparts. As a general observation, large coefficients of variation in micronutrient intakes suggest that some individuals may be consuming inadequate quantities of these nutrients.

Correlations among dietary, anthropometric and serum biochemical parameters

The correlation coefficients for relationship between age, anthropometric and dietary variables with blood pressure and serum lipid risk factors are shown in Tables 5 and 6. Both systolic and diastolic blood pressures increased significantly with age for urban and rural male subjects (Table 5). In regard to the serum lipid risk factors, there were significant increases in serum total cholesterol and LDL-cholesterol with age for both urban and rural male subjects; however, no relationship between age and HDL-cholesterol was observed for either male group. Only the urban males exhibited a significant increase in triglycerides with age.

Regression analysis gave no significant correlation among weight, BMI, body fat, or percentage of body fat with either systolic or diastolic blood pressure for urban or rural male subjects. The urban males had a significant positive association between weight, body fat, and percentage of body fat and total cholesterol, LDL-cholesterol and triglycerides. No relationship between HDL-cholesterol and any anthropometric variable was observed for urban males. In contrast, the rural males had no significant correlations between any anthropometric variable and serum lipid parameters.

Analysis of the dietary risk factors for urban males revealed significant correlations only between intake of total fat and saturated fat with serum triglyceride concentrations (Table 5). For rural males, dietary cholesterol and intake of total fat was associated with an increase in diastolic blood pressure, whereas the intake of carbohydrate had a negative association with diastolic blood pressure. Unexplained negative correlations were observed between dietary cholesterol, total fat, and saturated fat and total cholesterol concentrations for rural males (Table 5).

The urban females had significant correlations between both systolic and diastolic blood pressures and age (Table 6). The rural females had a significant correlation only between age and systolic blood pressure (Table 6). Both urban and rural females had significant increases with age for serum total cholesterol, LDL-cholesterol, and triglycerides. HDL-cholesterol was not related to age in either urban or rural female subjects.

Of the anthropometric parameters, weight of rural female subjects was associated with a significant increase

Table 5. Pearson correlation coefficients (r) for relationship between anthropometric characteristics and serum lipids and blood pressure for rural and urban Nigerian males

Physicochemical characteristics	Blood pressure: Systolic	Blood pressure: Diastolic	Total cholesterol	HDL-cholesterol	LDL-cholesterol	Trigly-cerides
Age						
Urban	0.46*	0.42*	0.45*	NS	0.28***	0.31***
Rural	0.35	0.35***	0.39***	NS	0.46**	NS
Weight						
Urban	NS	NS	0.46*	NS	0.30***	0.40**
Rural	NS	NS	NS	NS	NS	NS
BMI						
Urban	NS	NS	0.39**	NS	NS	0.46**
Rural	NS	NS	NS	NS	NS	NS
Body fat						
Urban	NS	NS	0.49*	NS	0.32***	0.44*
Rural	NS	NS	NS	NS	NS	NS
% body fat						
Urban	NS	NS	0.48*	NS	0.31***	0.40**
Rural	NS	NS	NS	NS	NS	NS
Dietary cholesterol						
Urban	NS	NS	NS	NS	NS	NS
Rural	NS	0.50***	-0.46***	NS	NS	NS
Total dietary fat						
Urban	NS	NS	NS	NS	NS	0.32***
Rural	NS	0.49	-0.52***	NS	NS	NS
Dietary saturated fat						
Urban	NS	NS	NS	NS	NS	0.32***
Rural	NS	NS	-0.48***	NS	NS	NS
Dietary carbohydrate						
Urban	NS	NS	NS	NS	NS	NS
Rural	NS	-0.48***	NS	NS	NS	NS

*p<0.001; **p=0.001-0.01; ***p>0.01-0.05; NS: p>0.05; BMI=Body mass index; NS=Not significant

in total cholesterol, whereas weight, BMI, body fat, and percentage of body fat were associated with significant increases in serum triglycerides. Unlike urban female subjects, the anthropometric parameters of rural females showed no significant relationship with any of their serum lipid concentrations.

Among dietary risk factors, the intake of carbohydrate by urban females was associated with a significant increase in serum HDL-cholesterol (Table 6). The intake of total dietary fat by urban females was also associated positively with HDL-cholesterol. The rural females had a significant negative association between HDL-cholesterol and intake of both dietary cholesterol and saturated fat.

The urban and rural females and rural males exhibited a significant increase in serum homocysteine concentrations with age (Table 7). No increase in serum homocysteine with age, dietary intake of folate or vitamin B12 was obtained for urban males. Besides age, serum homocysteine was associated with an increase in both systolic and diastolic blood pressures for rural males and negatively correlated with the intake of dietary folate. The intake of dietary folate was negatively associated with the serum homocysteine levels for both urban and rural females. Increased serum homocysteine concentrations were also correlated with increased systolic and diastolic blood pressures for urban females, but only with diastolic blood pressure for rural females.

DISCUSSION

Growing awareness of the fact that the half-century decreasing trend in communicable diseases in under-developed nations has been offset by a proportional increase in non-communicable diseases, particularly cardiovascular disease (30,31), has stimulated us and many others to investigate the levels of various risk factors for cardiovascular disease among indigenous populations who inhabit sub-Saharan Africa, and to

Table 6. Pearson correlation coefficients (r) for relationship between anthropometric characteristics and serum lipids and blood pressure for rural and urban Nigerian females

Physicochemical characteristics	Blood pressure Systolic	Blood pressure Diastolic	Total cholesterol	HDL-cholesterol	LDL-cholesterol	Trigly-cerides
Age						
Urban	0.41*	0.27*	0.41*	NS	0.32**	0.25***
Rural	0.22***	NS	0.30**	NS	0.28***	0.33**
Weight						
Urban	NS	NS	0.23***	NS	NS	0.24***
Rural	NS	NS	NS	NS	NS	NS
BMI						
Urban	NS	NS	NS	NS	NS	0.30**
Rural	NS	NS	NS	NS	NS	NS
Body fat						
Urban	NS	NS	NS	NS	NS	0.27***
Rural	NS	NS	NS	NS	NS	NS
% body fat						
Urban	NS	NS	NS	NS	NS	0.33**
Rural	NS	NS	NS	NS	NS	NS
Dietary cholesterol						
Urban	NS	NS	NS	NS	NS	NS
Rural	NS	0.35**	NS	-0.27***	NS	NS
Total dietary fat						
Urban	NS	NS	NS	0.26***	NS	NS
Rural	NS	NS	NS	NS	NS	NS
Dietary saturated fat						
Urban	NS	NS	NS	NS	NS	NS
Rural	NS	NS	NS	-0.22***	NS	NS
Dietary carbohydrate						
Urban	NS	NS	NS	0.25***	NS	NS
Rural	NS	NS	NS	NS	NS	NS

*p<0.001; **p=0.001-0.01; ***p>0.01-0.05; NS: p>0.05; BMI=Body mass index; NS=Not significant

relate those findings to diets they consume. We recently reported on the lipid profiles and homocysteine levels in sera of semi-nomadic Fulani men and women living in rural areas of northern Nigeria and whose culture and economy are centred on cattle and dairy products (14). Having found that: (a) the caloric intakes of Fulani men and women were remarkably low (6,212 kJ and 6,980 kJ/day, 1,500-1,700 kcal/day) compared to their active lifestyles, (b) the blood lipid profiles of the Fulani were generally favourable, and (c) their serum homocysteine concentration was at a level that was sufficiently high to raise concerns about the concentration of this sulphur amino acid with regard to the risk of these men and women for CVD, we wanted to know if these findings applied only to the Fulani or if they might be representative of other populations in northern Nigeria as well.

The results of the present study showed that, in general, the urban men and women in Jos had a higher BMI and greater percentage of body fat than their respective gender counterparts among the semi-nomadic Fulani who live in

Table 7. Pearson correlation coefficients (r) for relationship between serum homocysteine and dietary and serum biochemical parameters

Physicochemical characteristics	Homocysteine Male Urban	Homocysteine Male Rural	Homocysteine Female Urban	Homocysteine Female Rural
Age (years)	NS	0.49*	0.41*	0.24***
Dietary folate	NS	NS	NS	NS
Dietary vitamin B12	NS	NS	NS	NS
Serum folate	NS	-0.56**	-0.30**	-0.33**
Serum vitamin B12	NS	NS	NS	NS
Systolic blood pressure	NS	0.54*	0.45*	NS
Diastolic blood pressure	NS	0.47**	0.44*	0.13**

*p<0.001; **p=0.001-0.01; ***p>0.01-0.05; NS: p>0.05; NS=Not significant the savannah 40 km outside of Jos and whose diet, body composition, and blood chemistries we reported recently (14). In addition, the adults who were residing in Jos had systolic and diastolic blood pressures that were generally higher than those of the rural Fulanis. With the exception of HDL-cholesterol, the blood lipid profiles of Fulani men and women were generally more favourable compared to the lipid profiles of urban adults in Jos. The adult Fulani males had lower total cholesterol and LDL-cholesterol and triglyceride levels compared to men in Jos. The Fulani women had lower mean total cholesterol, LDL-cholesterol and triglyceride levels than their urban counterparts (Table 3). The mean HDL-cholesterol levels we found for urban men and women in this study were 45 and 50 mg/dL respectively, whereas the HDL-cholesterol levels of rural men and women were 37 and 41 mg/dL respectively. Thus, with regard to body composition, blood pressure and blood lipid levels (except for HDL-cholesterol), it appeared that the overall CVD risk was higher for urban adults in Jos than it was for the Fulani whose livelihood is tied intimately to animal husbandry. However, both the populations exhibit lower CVD risk than adults in the USA (16).

Our regression analysis of dietary, body composition, and serum lipid levels allowed us to draw some general conclusions regarding particular factors that seemed to explain the differences in risk factors of CVD between the more sedentary urban adults and the more physically-active Fulani pastoralists. First, for all subjects, be they male or female, rural or urban dwellers, the major determinant of the lipid profile was age. Second, the higher levels of total cholesterol, LDL-cholesterol, and HDL-cholesterol among adult subjects in Jos were attributable to their place of habitation (i.e. urban). With regard to body fat, which is a widely-recognized risk factor for CVD, particularly for females in our study, a high percentage of body fat was associated with an increased age, urban residence, high total caloric intake, and high intake of carbohydrate. Interestingly, the low HDL-cholesterol levels of Fulani (rural) men and women were best explained by their place of residence, but not their intake of large amounts of saturated fat.

The lower LDL-cholesterol levels observed in African adults in this study and our previous studies (7,14), and observations by others (30,31), indicate that additional dietary investigations of our study populations would be worthwhile. A common food eaten in this area of Nigeria consists of a stiff porridge of boiled grain (e.g. rice, maize, or acha) dipped into a savory soup that has a gelatinous consistency from the inclusion of okra or several different types of leaves or seeds. The soup is said to 'draw' and it is this gelatinous consistency that is desired. It is likely that these soups contain considerable amounts of viscous fibre but, to our knowledge, no studies have been made regarding the fibre content of foods of this region. Most participants in the present study reported consuming these soups daily, and many reported eating soup two or three times daily, particularly if supper leftovers were eaten at the following breakfast. Because of their frequent use, these soups may serve the same function as oat bran or psyllium in American diet in helping to maintain low serum LDL-cholesterol (32).

It is noteworthy that the serum homocysteine levels of men and women residing in the Jos city were nearly identical to the values we reported previously for Fulani men and women (8). While the relatively high homocysteine levels of urban and rural males in this study seem to be explicable, in part at least, on the basis of their folate and B12 status, they could also be due to other nutritional considerations or genetic factors. Although a high intake of methionine, the precursor to homocysteine, could conceivably account for these high homocysteine levels, this is unlikely since the greatest source of protein in these diets was grains, which contain limited amounts of methionine and cysteine. This leaves us to consider genetic factors. Levels of the enzyme 5,10-methylenetetrahydrofolate reductase (MTHFR) are known to vary between different ethnic groups (33). It is possible that the populations of northern Nigeria express relatively low levels of MTHFR. Analysis of the levels of MTHFR activity and the messenger RNA, which encodes this enzyme in tissues of the various ethnic groups inhabiting the different regions of Nigeria, might shed light on this possibility. Although serum levels of vitamin B6 were not determined, we can conclude from our dietary analysis (Table 4) that the intakes of this third vitamin involved in homocysteine metabolism were in excess of 100% of the recommended vitamin B6 intake.

The different CVD risk profiles of urban dwellers in Jos and their semi-nomadic Fulani neighbours can be explained in several ways. First, the Fulani consume approximately 400 fewer calories on average each day than men and women in Jos. Second, the lower caloric intake of Fulani adults is accompanied by a lower body weight with BMI averaging 20 kg/m^2, the lower level of the desirable range (20-24 kg/m^2), while BMI of urban adults was 22.7 kg/m^2 for men and 27.6 kg/m^2 for women. It is widely accepted that physical activity and low body weight are associated with favourable lipid profiles and reduced CVD risk (34,35). The lower BMI of the Fulani may reflect their lower caloric intake, but may also reflect their higher level of physical activity, which has yet to be measured. The lifestyle of the Fulani requires considerably greater physical activity compared to urban adults: in contrast to men and women in the city of Jos who lead relatively sedentary lives, Fulani men spend most of their days trekking long distances in search of water and pasture for their animals, while women walk several miles each day to obtain water and firewood.

In conclusion, the present study has shown that the overall risk of CVD among urban dwellers of northern Nigeria is greater than it is for the semi-nomadic Fulani who have less body fat and lower BMI, are more physically active, and consume fewer calories than their urban counterparts. However, the overall CVD risk of the urban population of Jos is more favourable than that of adults in the USA (36). Future studies should be aimed at measuring directly the activity levels of urban and rural populations like the Fulani and their consumption of viscous dietary fibre and the levels of expression of enzymes involved in the assimilation of homocysteine.

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