

Coronary heart disease risk factors in sub-Saharan Africa: studies in Tanzanian adolescents

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Abstract

Study Objective—To assess the level of cardiovascular risk factors in young people in sub-Saharan Africa living in rural and urban settings.

Design—Cross sectional survey of the population aged 15 to 19 years.

Setting—Eight rural Tanzanian villages in three regions, and two districts in Dar es Salaam.

Participants—664 males and 803 females in rural villages and 85 males and 121 females in the city. Response rates for total population were 74% to 94% in the rural areas and 60% in the city.

Measurements and results—Measurements included blood pressure, body mass index, serum lipids, and blood glucose concentrations (fasting and two hours after 75 g glucose). Blood pressure was slightly but significantly higher in young women than in young men (115/67 mmHg versus 113/65 mmHg) and increased significantly with age. Only 0.4% subjects had blood pressure greater than 140 and/or 90 mmHg. There were no urban-rural differences.

Body mass index was higher in females (mean (SD) 20.3 (2.8) kg/m²) than males (18.5 (2.1)). Overweight was found in only 0.6% at age 15 years but 5.4% at age 19 years. Serum cholesterol concentrations were low at 3.5 mmol/l in males and 3.7 mmol/l in females. Only 7% had values above 5.2 mmol/l. The highest concentrations were found in the city and in Kilimanjaro, the most prosperous rural region. Serum triglycerides were 1.0 (0.5) mmol/l in males and 1.1 (0.5) mmol/l in females, and were highest in the city dwellers. Diabetes was rare (0.28% males, 0.12% females) but impaired glucose tolerance was present in 4.7% and 4.1% respectively. Drinking alcohol was equally prevalent in males and females, reaching 30% at age 19 years. Only 0.4% of females smoked compared with 7.3% of males. Smoking was commoner in rural areas than in the city.

Conclusions—Several risk factors for cardiovascular disease were found in Tanzanian adolescents, but levels were much lower than in studies reported from developed nations. The challenge is to maintain these low levels as the population becomes more urbanised and more affluent.

Although coronary heart disease occurs mainly in middle age or later, the underlying atherosclerotic process may start early in life. In low incidence populations, the onset of atherosclerosis may possibly take place in adolescence or young adulthood.^{1 2} The major coronary heart disease risk factors and the behavioural patterns conducive to them also develop in youth. Moreover, it is well known that a 'tracking' effect exists, whereby risk factor levels of a child, unless controlled, tend to impose a higher risk in adulthood.³ Thus, there is some evidence, for example, that blood pressure in childhood is related to cardiovascular mortality in adulthood.⁴

Studies of cardiovascular disease risk factors in children and young people are necessary, as it is only when potential risk factors and health related behaviour are measured and analysed that specific intervention programmes may be designed, targets set, and outcomes evaluated. While many previous studies have assessed the prevalence of specific risk factors in selected populations, this is the first in which the prevalence of several major risk factors for cardiovascular disease has been assessed in young people in sub-Saharan African communities. Little information is available on the prevalence of coronary heart disease in rural sub-Saharan Africa, although anecdotally it is rare. We have recently reported that 10.5% of men and 21.1% of women in Tanzania over the age of 40 years showed possible or probable ischaemia on ECGs although none were symptomatic.

In the present study values of risk factors established as predictive of the development of coronary heart disease in adults have been used to compare the magnitude of these disorders in 15-19 year old teenagers in eight rural villages in three regions of Tanzania and in urban Dar es Salaam. This forms part of a larger study of risk factors across the total adult age range.⁵

Subjects and methods

BACKGROUND

Tanzania is a participating country in the World Health Organisation (WHO) Interhealth programme.^{6 7} Two districts, Morogoro rural district and Hai district in Morogoro and Kilimanjaro regions were selected as pilot districts. Six villages were selected at random in the two regions for baseline studies to determine the prevalence rates of hypertension, diabetes, and other cardiovascular disease risk factors before the establishment of community based health care for subjects with chronic non-communicable diseases. A further village in Mara region was studied to investigate the relationship between diabetes

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and cyanide toxicity from the consumption of inadequately processed cassava. As a control, an eighth village in Kilimanjaro region where cassava is rarely eaten was also studied. To investigate differences between rural and urban populations, a community was studied in the Manzese area of Dar es Salaam city.

In four of the eight villages the total population aged 15 years and over numbered around 1000. The entire adult population was therefore invited to participate. In the other four villages and in Manzese, Dar es Salaam random selection of 10 cell units was made to yield approximately 1000 subjects in each village. The response rate varied from 60 to 94%. Of the total subjects 1669 were aged 15 to 19 years and are the subjects of this report. Some characteristics of the four regions and study population are shown in table I.

METHODS

Blood tests

Subjects were requested to report to the village school or dispensary after an overnight fast. Venous blood samples were obtained for measurement of serum total cholesterol and triglycerides, blood glucose, and haemoglobin. Serum was separated on site. It was stored at -20°C and later shipped by air to the University of Newcastle upon Tyne, UK for analysis. Serum cholesterol and triglycerides were measured by standard enzymatic methods using a Cobas Bio centrifugal analyser. The interassay coefficients of variation were 2.2% for cholesterol and 3.2% for triglycerides.

After the fasting venous sample had been taken each subject was given 75 g glucose monohydrate in 300 ml water. Venous blood was again drawn two hours later and placed in a fluoride oxalate tube. Blood glucose was analysed immediately at the survey site using a Yellow Springs Instruments glucose analyser (Yellow Springs Instruments, Ohio, USA) powered by a Honda EM 650 generator. An aliquot of every 5th sample was kept frozen at -20°C and later analysed by a hexokinase fluorometric method using a Cobas Bio Centrifugal analyser (Roche products Ltd, Welwyn Garden City, UK) at the University of Newcastle upon Tyne. The linear correlation coefficient between the survey site and the Newcastle upon Tyne laboratory was 0.98 and the

slope did not differ significantly from 1 with an intercept at less than 0.1 mmol/l. The coefficient of variation for measurements on site was 1.8%. Haemoglobin was measured using a Cyanox digital haemoglobinometer (Buffalo Medical Specialties, Buffalo, USA).

Blood pressure

Blood pressure (phase 1 and V) was measured twice with a mercury sphygmomanometer, using the right arm and with the subject seated. The mean of the two readings was used.

Cigarette smoking

Subjects were asked if they smoked, at the time of the survey or in the past. If they were current or past smokers, the number of cigarettes smoked per day and duration of smoking was recorded.

Body mass index

Weight and height were measured, without shoes or coats, using a beam balance stadiometer, and body mass index (BMI) calculated from weight (kg) over height² (m²),

History

Questionnaires were completed for all subjects on which were recorded the patients age, sex, alcohol intake, chest pain, and past history of cardiac or cerebrovascular disease, and a number of other symptoms and signs.

DEFINITIONS AND DATA ANALYSIS

Serum total cholesterol

Concentrations were divided into two groups: high ≥ 5.2 and normal < 5.2 mmol/l.

Serum triglyceride

Concentrations were divided into two groups: high, ≥ 1.7 mmol/l and normal, < 1.7 mmol/l.

Blood pressure

Values were divided into three groups: normal blood pressure $< 140/90$ mmHg, intermediate blood pressure (borderline hypertension) ≥ 140 and/or $\geq 90 < 160/95$, and high blood pressure (hypertension) ≥ 160 and/or ≥ 95 mmHg.

Smoking

Subjects were grouped into two—those who were current smokers and those who had never smoked or had not smoked for the previous six months.

Glucose tolerance

This was classified according to the 1985 WHO criteria for epidemiological studies—that is two hour venous whole blood glucose concentrations ≥ 10 mmol/l for diabetics, ≥ 6.7 mmol/l < 10 mmol/l for impaired glucose tolerance (IGT), and normal, < 6.7 mmol/l.

Table I Characteristics of the study population

	Urban	Rural		
	Dar es Salaam	Kilimanjaro	Morogoro	Mara
No surveyed (% total)*				
Male	85 (13.5)	266 (15.5)	246 (17.0)	152 (31.4)
Female	121 (14.6)	429 (15.6)	255 (15.6)	119 (19.9)
Response rate for whole area (%)	60	94	84	74
Major tribal group	Mixed	Chagga	Luguru	Jaluo
Major staple diet	Rice and maize	Bananas	Maize, rice, and millet	Millet, cassava

*Total=total number of subjects (all ages) surveyed in the particular area

Table II Mean values (SD) of cardiovascular risk factors of the adolescent population by gender

Variable	Male			Female			p
	No	Mean	(SD)	No	Mean	(SD)	
Systolic blood pressure (mmHg)	747	113	(12.7)	923	115	(12.1)	0.001
Diastolic blood pressure (mmHg)	747	65	(9.7)	923	67	(9.3)	0.001
Serum cholesterol (mmol/l)	617	3.5	(1.0)	792	3.7	(1.1)	0.001
Serum triglycerides (mmol/l)	621	0.99	(0.5)	792	1.06	(0.5)	0.063
Body mass index (kg/m ²)	748	18.6	(2.3)	922	20.2	(2.7)	0.001
Fasting blood glucose	740	4.2	(0.7)	916	4.2	(0.6)	NS
2-hour blood glucose (mmol/l)	725	4.6	(1.1)	915	4.7	(1.1)	0.074
Age (y)	749	16.7	(1.4)	924	16.8	(1.5)	-

Body mass index (BMI)

The BMI was defined as weight (kg) divided by the square of height (m²). Patients with BMI below 20 were regarded as being underweight, those with BMI values of 20–25 as normal weight, and those with BMI values over 25 as overweight.

Statistics

Data were analysed using the *Statistical Package for the Social Sciences (SPSS/PC+)* for the IBM/AT microcomputer. Proportions were compared by the standard test for differences between two proportions. Results are presented as mean (SD) unless otherwise stated. Analysis of variance was used to compare group means.

Results

Table II shows mean values of measured risk factors by gender, table III percentile distributions, and table IV the values by area studied.

Overall, females had slightly but significantly higher mean (SD) systolic and diastolic blood pressures of 115 (12)/67 (9) mmHg compared with 113 (13)/65 (10) mmHg for males ($p < 0.001$) (Table II). Only six (0.4%) subjects (four females and two males) had both diastolic

and systolic blood pressures above 140 and 90 mmHg respectively. The mean systolic blood pressure in males increased from 107 (12) mmHg at age 15 years to 119 (11) mmHg at age 19 ($p = 0.07$ for trend). Females showed no significant difference in systolic blood pressure with values of 112 (13) mmHg at age 15 years and 116 (12) at age 19 years. Mean diastolic blood pressure increased from 62 (10) mmHg at age 15 years in males to 69 (8) mmHg at age 19 ($p = 0.009$) and from 66 (10) mmHg at age 15 years to 68 mmHg at age 19 years ($p = 0.05$) in females.

The mean total serum cholesterol concentration was 3.5 (1.0) mmol/l for males and 3.7 (1.1) mmol/l for females ($p < 0.001$). The mean total serum cholesterol did not change with age. About 7% of the subjects had a mean total serum cholesterol of ≥ 5.2 mmol/l; males 5.5% and females 8.0% ($p = 0.070$). Dar es Salaam (urban) and Kilimanjaro (relatively more prosperous) regions had the highest prevalence (9.5% and 9.4% respectively) of raised total serum cholesterol (≥ 5.2 mmol/l) compared to Mara (4.2%) and Morogoro (3.9%).

Mean serum triglycerides for males were 1.0 (0.5) mmol/l compared with 1.1 (0.5) for females ($p = 0.006$). High serum triglycerides (> 1.7 mmol/l) were detected in 6.3% of the males and 7.2% in females (NS). The prevalence of raised serum triglyceride values was greatest in Dar es Salaam (9.4%) followed by Mara (7.8%), Morogoro (6.8%), and Kilimanjaro (5.6%) (Table IV). No age trend was noticed in the mean serum triglycerides.

Mean blood glucose values did not differ significantly between males and females and there was no trend with age. Mara region adolescents had the highest mean fasting blood glucose (4.6 (0.7) mmol/l) and Kilimanjaro and Morogoro the lowest (4.1 mmol/l), whereas Dar es Salaam had a mean of 4.4 mmol/l.

Subjects from Kilimanjaro region tended to show the lowest mean two hour blood glucose concentration 4.5 (1.06) mmol/l, compared with Dar es Salaam 5.0 (1.04) mmol/l, Mara 5.0 (0.85) mmol/l, and Morogoro 4.7 (1.18) mmol/l ($p = 0.0001$). The prevalence of diabetes mellitus was 0.28% and impaired glucose tolerance was present in 4.7% males compared with values of 0.12% and 4.1% respectively for females (NS). Dar es Salaam adolescents had the highest IGT prevalence rate (6.5%) compared with Morogoro (5.2%), Mara (4.1%), and Kilimanjaro (2.7%). The IGT rate increased from 2.4% at age 15 years to 6.2% at the age of 19 years ($p = 0.001$).

The mean (SD) body mass index (BMI) was higher for females (20.3 (2.8)) than males (18.5 (2.1)) ($p = 0.001$). The body mass index increased with age from 18.2 at age 15 to 21.1 at age 19 ($p < 0.001$). Only 0.4% of the males were overweight compared with 4.6% of the females.

There was no significant difference between the prevalence of drinking alcohol among males and females (25.4% for males and 21.9% for females). Drinking increased with age, however, from 18.7% at 15 years to 30.2% at age 19 years ($p = 0.008$). Kilimanjaro region had the highest prevalence of drinkers (45.8%) compared with Dar es Salaam (13.0%), Morogoro (9.4%), and Mara (0.4%) ($p = 0.0001$).

Table III Centile distribution of cardiovascular risk factors in adolescents by gender

	Centiles					
	10	20	50	80	90	95
Males:						
Systolic blood pressure (mmHg)	99	104	114	124	130	135
Diastolic blood pressure (mmHg)	54	59	66	74	79	81
Serum cholesterol (mmol/l)	2.4	2.8	3.5	4.3	4.9	5.5
Serum triglycerides (mmol/l)	0.6	0.7	0.9	1.3	1.6	1.9
Fasting blood glucose (mmol/l)	3.4	3.7	4.2	4.7	5.0	5.3
Two hour blood glucose (mmol/l)	3.4	3.8	4.6	5.5	6.0	6.6
Body mass index (kg/m ²)	16.2	17.2	19.4	21.5	22.8	23.9
Females:						
Systolic blood pressure (mmHg)	100	105	115	126	130	135
Diastolic blood pressure (mmHg)	56	60	68	75	80	82
Serum cholesterol (mmol/l)	2.6	3.0	3.6	4.5	5.1	5.7
Serum triglycerides (mmol/l)	0.6	0.7	1.0	1.4	1.6	1.9
Fasting blood glucose (mmol/l)	3.4	3.7	4.2	4.7	4.9	5.2
Two hour blood glucose (mmol/l)	3.4	3.9	4.7	5.5	6.0	6.5
Body mass index (kg/m ²)	16.7	17.9	20.3	22.4	23.6	24.9

Table IV Mean and prevalences of cardiovascular risk factors in adolescent population by region

	Dar es Salaam	Kilimanjaro	Mara	Morogoro	p
Blood pressure (mmHg):					
Systolic	113 (11.6)	114 (12.8)	116 (12.9)	114 (11.7)	0.0085
Diastolic	67 (8.1)	66 (9.9)	62 (9.7)	69 (8.8)	0.0001
No	206	694	268	501	
Borderline hypertension (%)	2.0	3.3	4.5	2.6	NS
Hypertension (%)	0	0.1	0.4	0.2	0.3120
Serum cholesterol (mmol/l):					
No	3.8 (1.1)	3.8 (1.0)	3.7 (0.9)	3.3 (1.0)	0.0001
≥ 5.2 mmol/l (%)	179	576	239	414	0.001
Serum triglyceride (mmol/l):					
No	1.12 (0.65)	0.98 (0.42)	1.02 (0.47)	1.70 (0.43)	0.0006
≥ 1.7 mmol/l (%)	179	577	243	413	0.2741
Blood glucose (mmol/l):					
Fasting	4.4 (0.6)	4.1 (0.6)	4.6 (0.7)	4.1 (0.6)	0.0001
2 hour	5.0 (1.0)	4.5 (1.1)	5.0 (0.8)	4.7 (1.2)	0.0001
No	205	687	265	498	
Impaired glucose tolerance (%)					
Diabetes (%)	6.5	2.7	4.1	5.2	0.0890
No	0	0.3	0	0.2	0.0001
Body mass index (kg/m²):					
No	20.8 (2.9)	19.3 (2.6)	19.5 (2.8)	19.2 (2.4)	0.0001
Underweight (%)	206	692	271	501	
Overweight (%)	41.5	60.5	58.3	62.5	0.001
No	6.8	2.0	3.0	2.0	0.0018
Smoking (%):	1.9	5.6	0	4.4	0.0027
No	211	693	271	500	
Alcohol (%):					
No	13.1	45.8	0.4	9.4	0.0001
No	207	695	271	500	

p, significance of difference between groups. Results are mean (SD) or %.

Among males, 8.3% were smokers compared with 0.4% of the females. The prevalence of smoking increased from 1.1% at age 15 years to 7.3% at the age of 19 years ($p=0.0016$). None of those from Mara region smoked, whereas 1.9% of those in Dar es Salaam, 4.4% in Morogoro, and 5.6% in Kilimanjaro region were smokers ($p=0.0024$).

Discussion

The striking finding in this study was the number of adolescents who already seemed to be at risk for the development of coronary heart disease. This conclusion was based on criteria which have been established for adults from data gathered from prospective studies. In adults there is a direct relationship of risk of coronary heart disease to the level of serum cholesterol, blood pressure, and cigarette smoking.⁸ In the course of individual development from childhood through youth to adulthood, serum cholesterol and systolic blood pressure tend to remain at similar levels relative to those of other members of the same population.⁹ Thus, it would seem appropriate to identify and consider at risk those children whose serum cholesterol concentration and blood pressure are at levels established in adults as predictive of the development of early occlusive atheromatous disease.

The serum cholesterol concentration that constitutes a risk factor for coronary heart disease in adults has long been debatable. The Framingham study indicated a continuous increase of risk for coronary heart disease with serum cholesterol values above 4.65 mmol/l (180 mg/dl).¹⁰ In countries in which the incidence of coronary heart disease is very low, the mean serum cholesterol values of adults are in the 3.62 to 4.14 mmol/l (140–160 mg/dl) range^{11 12} but there is still a continuum of risk.¹² Furthermore, in experimental animals atherosclerosis does not develop when serum cholesterol are below 4.65 mmol/l (180 mg/dl).¹⁰ In young people (ages 5–18 years) the ideal mean is stated to be 2.85 mmol/l (110 mg/dl) and the feasible mean 3.62 mmol/l (140 mg/dl).⁸ Our study showed the mean serum total cholesterol to be 3.46 mmol/l (134 mg/dl) in young men and 3.74 mmol/l (144 mg/dl) in young women. There is need for health promotion to keep the population cholesterol values at such acceptable rates in Tanzania.

Kannel and Dawber¹³ have suggested an upper limit for normal blood pressure of 140/90 mmHg which seems very high for adolescents.¹⁴ Only six (0.4%) of our subjects had both systolic and diastolic blood pressure above 140 and 90 mmHg. In longitudinal studies it has been shown that adolescents with a high blood pressure maintain the high pressure later in life.^{15 16} Therefore it may be of importance to follow these persons who may eventually need treatment. In general, however, blood pressure was at safe levels in most adolescents. Levels were slightly higher than in Zambian 16 year olds.¹⁷ As here they found a modest increase in females compared with males. Values were, however, lower than in Nigeria.¹⁸

The prevalence of regular cigarette smoking varies considerably among children and young

people by age, gender, and country.³ The prevalence of smoking among adolescents in our study is lower than in any other country in a WHO report in which India had the lowest prevalence of 1.0% in males age 15–20 years and 4% in females.³ Figures were 40% or more in most European countries. In our study the prevalence of smoking increased from 1.1% at age of 15 years to 7.3% at age 19, hence the need for intensified education and primary prevention before the age of 15 years.

In adults, alcohol consumption has been shown to influence blood pressure levels. The prevalence of alcohol drinking in our study increased from 18.7% at age 15 to 30.2% at the age of 19. Kilimanjaro region which is relatively more prosperous, had the highest prevalence of alcohol drinkers (45.8%). Mara region whose main religious groups are the Seventh Day Adventists had the lowest prevalence of drinkers (and smokers) indicating importance of religious beliefs in prevention of certain risk factors of cardiovascular disease.

It is well recognised that diabetes mellitus is associated with an increased risk of coronary heart disease. Females with diabetes experience coronary heart disease at higher rates than non-diabetic females. Men with diabetes experience coronary heart disease at twice the rate of men without diabetes.¹⁹ It is not known whether blood glucose or diabetes is a risk factor for coronary heart disease in blacks, although the frequency of coronary heart disease as a contributing cause of death suggests that it is.²⁰ A study of 198 diabetic African patients in Nairobi, Kenya showed that 30 had anginal pain, and 24 of these had ECG abnormalities consistent with coronary heart disease (ST depression or T inversion or both).²¹ The prevalence of diabetes and impaired glucose tolerance was low in our study, as would be expected in a country where type 1 diabetes is infrequent²² and type 2 diabetes is also uncommon.²³ On the other hand, there was already a significant prevalence of IGT. Some of this may have been transient due to alarm at venepuncture,²⁴ but nonetheless these IGT rates at this young age indicate a potential for later diabetes if the lifestyle becomes more westernised.

It is pertinent to compare risk factor levels with those from westernised societies. An equivalent study from Denmark was published recently based on a relatively small number (293) of 16–19 year olds.¹⁴ Mean values for blood pressure were markedly higher in Danish boys (125/73 mmHg *v* 113/65) but were more similar in girls. Not surprisingly, cholesterol values were also higher in the Danes (4.1 mmol/l in males, 4.5 mmol/l in females) although triglycerides were lower in Denmark. Presumably this reflects a response to the very high carbohydrate diet in Tanzania. Smoking was also more prevalent in Denmark at 25 to 30%, although less than in the 1970s. Blood glucose values were not reported in the Danish study. The body mass index calculated from the Danish data was also higher than in Tanzania. Similar differences were found with American children in the Muscatine study.⁹ In both Denmark and the USA many more values were in the abnormal range than in Tanzania.

Thus, the overall prevalence of the major cardiovascular disease risk factors (raised blood

pressure, dyslipidaemia, abnormal glucose tolerance, and overweight) was gratifyingly low. Among the reasons for this are undoubtedly high levels of exercise, high unrefined carbohydrate diets, lack of high fat/high sugar food, and lack of excess food and cigarettes. Despite this alcohol consumption was high in Kilimanjaro.

Data available indicate that, within populations the serum cholesterol and blood pressure levels of individual children and young people are significantly related to the dietary patterns.³ Most of the risk factors in our study are established before the age of 15 years. Hence there is need for health promotion on the avoidance of the risk factors of cardiovascular disease not only to parents but to school age children before age 15 once greater affluence and/or availability develop.

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