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Cardiovascular risk factors in a Melanesian population apparently free from stroke and ischaemic heart disease: the Kitava study

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Abstract. Lindeberg S, Nilsson-Ehle P, Terént A, Vessby B, Scherstén B (Department of Community Health Sciences, Lund University, Department of Clinical Chemistry, Lund University Hospital, Department of Internal Medicine, Södderhamn Hospital, Department of Geriatrics, Uppsala University, Sweden). Cardiovascular risk factors in a Melanesian population apparently free from stroke and ischaemic heart disease: the Kitava study. *J Intern Med* 1994; **236**: 331–340.

Objectives. To compare cardiovascular risk factor levels between non-westernized Melanesians, apparently free from stroke and ischaemic heart disease [1], and healthy Swedish populations, and to analyse, among adult Melanesians, relations with age, sex and smoking status.

Design. Cross-sectional survey.

Subjects. (i) Traditional horticulturalists in Kitava, Trobriand Islands, Papua New Guinea, uninfluenced by western diet. This study tested 151 males and 69 females aged 14–87 years with 76% and 80% smokers over 20 years. (ii) Healthy Swedish reference populations.

Main outcome measures. Sitting systolic and diastolic blood pressure, weight, height, body mass index, circumferences of waist, pelvis and mid upper arm, triceps skinfold thickness, fasting serum total cholesterol, triglycerides, high-density lipoprotein cholesterol, estimated low-density lipoprotein cholesterol, apolipoprotein B, apolipoprotein A1 and apolipoprotein (a).

Results. Compared to Sweden, diastolic blood pressure, body mass index and triceps skinfold thickness were substantially lower in Kitava, where all subjects $\geqslant 40$ years were below Swedish medians. Among males $\geqslant 20$ and females $\geqslant 60$ years systolic blood pressure was lower in Kitavans. Fasting serum total cholesterol, low-density lipoprotein cholesterol and apolipoprotein B were 10–30% lower in Kitavan males $\geqslant 40$ and females $\geqslant 60$ years. Triglycerides were higher in Kitavans aged 20–39. High-density lipoprotein cholesterol did not differ while apolipoprotein A1 was lower in Kitavans. Apolipoprotein (a) tended to be lower in Kitavans, but the differences were small.

Conclusions. Of the analysed variables, leanness and low diastolic blood pressure seem to offer the best explanations for the apparent absence of stroke and ischaemic heart disease in Kitava. The lower serum cholesterol may provide some additional benefit. Differences in dietary habits may explain the findings.

Keywords: cardiovascular risk factors, epidemiology, Melanesia, nutrition, population.

Introduction

One of the very last well nourished traditional populations, uninfluenced by western dietary habits, is found on the island of Kitava, Trobriand Islands, Papua New Guinea. Stroke and ischaemic heart disease (IHD) appear to be absent as assessed by semistructured interviews, resting electrocardiography and clinical experience [1].

Here we present means and distributions of blood pressure, anthropometry and serum variables, which are related to cardiovascular disease in western populations, as well as their associations with age,

sex and smoking status within the Kitavan population.

Populations and methods

Populations

A description of the population of Kitava and its habitat, methods of age estimation, sampling procedures of study participants, and examinations of non-attendants, has previously been given [1].

Tubers, fruit, fish and coconut are dietary staples. Oil, cereals and refined sugar contribute by a median of 0.03% of the energy intake (90th percentile 0.8), and margarine, dairy products and alcohol are absent. In comparison, these items altogether provide more than 70% of the calories in the Swedish diet [2]. Estimated sodium intake is 40–50 mmol (2.3–3.0 g) per 24 h, compared to 100–250 in the west and 1–30 in most traditional populations. Coffee and tea intake is insignificant. Malnutrition appears to be absent. Seventy-five per cent of men and 80% of women are daily smokers, mainly of imported black or home-grown tobacco. One hundred per cent of adults are betel chewers. The average level of physical activity is high, although not exceedingly high. The western lifestyle has mainly influenced customs, clothing and smoking, and the use of modern tools and kerosene lamps is widespread. Approximate mean age at menarche is 12–13 years and 45 at menopause [H. Jüptner, personal communication].

Among 286 randomly selected Kitavan subjects aged 4–96, the attendance rate for blood pressure measurement was 59% in those older than 50 years (121/206) and 40% in younger subjects (32/80). The low attendance rates made necessary the inclusion of self-selected subjects in the age group 4–49. We thus recruited 190 males and 83 females aged 4–86 years for blood pressure measurement and anthropometry. For blood sampling attendance rates were 10% lower, yielding 129 males and 51 females aged 13–86, of which 33% were non-randomized subjects. Seventy-six per cent of men and 80% of women were daily smokers. All samples in Kitava were collected in November and December 1990.

Four Swedish reference populations were chosen for comparison. Blood pressure, weight and height were measured in 401 healthy men and women aged 15–84 from the city of Söderhamn, randomly selected from official population registers. Serum lipoproteins were analysed in 175 fasted men and women aged 20–80 from the city of Kristianstad, randomly selected from population registers [3]. The prevalence of smokers in this population was 23% in men and 27% in women. Serum apolipoproteins, waist circumference and height were measured in 787 healthy men and women aged 20–66 from Uppsala, employees of a telephone company. Among these, 21% of the men and 35% of the women were smokers. Arm anthropometry was studied in 1593 male and female volunteers aged 20–80 from Linköping [4].

Methods of measurement

Venous blood was collected in Kitavan subjects between 05.00 and 08.00 hours, after 9–15 h of abstaining from eating, smoking and betel chewing. With subjects sitting, blood was drawn from the antecubital vein and centrifuged for 10 min after standing for 1–3 h. Electricity was provided by a petrol powered generating set. Sera were transported at −130°C in a liquid nitrogen vessel (L'Air Liquide GT35) until storage at −70°C in Sweden. Serum analyses were performed in one series within 14 months after sampling.

Serum total cholesterol (TC), high-density lipoprotein cholesterol (HDL) and triglycerides (TG) were determined as described in [4]. Serum total cholesterol was measured using a cholesterol-esterase/cholesterol-oxidase method with Seronorm Batch no. 50 (Nyegaard, Oslo, Norway) as a calibrator. High-density lipoprotein cholesterol was determined after precipitation of very-low-density lipoprotein cholesterol and low density lipoprotein cholesterol (LDL) with dextran sulphate and magnesium chloride. The TG was analysed using an enzymatic-colorimetric method. Low density lipoprotein cholesterol (LDL) was estimated according to Friedewald [4a].

The concentrations of apolipoprotein B100 (apoB) and apolipoprotein A1 (apoA1) were determined by immunoturbidimetry in the Multistat III F/LS apparatus using monospecific polyclonal antibodies against apoB and A1. Before assay the serum samples were preincubated with triglyceride lipase [5]. Apolipoprotein(a) [apo(a)] was measured by the Pharmacia Apo(a) RIA method. This is based on the direct sandwich technique in which two monoclonal antibodies are directed against separate antigenic determinants on the apo(a) in the sample. The con-

Table 1 Means (standard deviatios) of blood pressure and anthropometric variables in males and females from Kitava and Sweden

	20–39		40–59		60–86	
Age (years)	Kitava	Sweden	Kitava	Sweden	Kitava	Sweden
Males	(n = 50)	(n = 52)	(n = 46)	(n = 69)	(n = 46)	(n = 50)
Systolic BP	115 (10)	129 (10)***	113 (13)	134 (15)***	121 (19)	144 (18)***
Diastolic BP	70 (6)	86 (10)***	71 (7)	92 ((10)***	70 (6)	91 (10)***
Weight	57 (6)	79 (11)***	51 (6)	81 (10)***	49 (6)	77 (9)***
Height	162 (6)	180 (6)***	161 (5)	178 (6)***	161 (5)	175 (6)***
BMI	22 (2)	25 (3)***	20 (2)	26 (3)***	19 (2)	25 (3)***
	(n = 48)	(n = 48)	(n = 44)	(n = 44)	(n = 46)	(n = 13)
Waist	76 (4)	83 (6)***	74 (4)	91 (8)***	74 (4)	93 (7)***
Waist/height	47 (24)	46 (38)	46 (24)	51 (41)***	46 (29)	54 (42)***
	(n = 49)	(n = 316)	(n = 45)	(n = 236)	(n = 46)	(n = 212)
Triceps skinfold	7 (2)	11 (5)***	7 (2)	12 (5)***	7 (2)	11 (4)**
AMC	25 (2)	26 (2)***	23 (2)	26 (2)***	22 (2)	25 (2)***
Females	(n = 15)	(n = 49)	(n = 26)	(n = 84)	(n = 20)	(n = 56)
Systolic BP	115 (10)	118 (11)	121 (16)c	126 (16)	129 (18)	146 (20)**
Diastolic BP	73 (6)	80 (10)**	71 (8)	86 (11)***	70 (7)	90 (11)***
Weight	46 (5)a	66 (13)***	40 (6)a	69 (13)***	38 (5)a	68 (12)***
Height	150 (5)a	168 (6)***	150 (5)a	163 (6)***	150 (4)a	163 (6)***
BMI	20 (2)a	24 (5)**	18 (2)a	26 (4)***	17 (2)a	26 (4)***
	(n = 15)	(n = 15)	(n = 31)	(n = 31)	(n = 20)	(n = 15)
Waist	73 (5)¢	71 (6)	69 (6)a	82 (10)***	68 (5)a	84 (11)***
Waist/height	49 (4)b	43 (4)***	46 (4)	50 (5)***	45 (3)	52 (7)***
	(n = 15)	(n = 411)	(n = 26)	(n = 452)	(n = 20)	(n = 202)
Triceps skinfold	12 (3)a	19 (6)***	10 (4)a	22 (6)***	9 (3)b	23 (7)***
AMC	20 (1)a	21 (2)***	19 (2)a	22 (2)***	18 (2)a	22 (2)***

BP, blood pressure; BMI, body mass index; AMC, arm muscle circumference.
Blood pressure is expressed in mm Hg, weight in kg, height, waist and AMC in cm, BMI in kg m^{-2} and triceps skinfold in mm.
Differences compared to Kitava: *** = $P < 0.001$; ** = $P < 0.01$. Differences compared to males (only tested in Kitavans):
a = $P < 0.001$; b = $P < 0.01$; c = $P < 0.05$; ¢ = $0.05 < P < 0.01$.

centration is expressed in units/L (U L^{-1}). One U of apo(a) is approximately equal to 0.7 mg of lipoprotein(a) (Lp(a)) according to the manufacturer.

Measurements of systolic (SBP) and diastolic blood pressure (DBP) and anthropometry were made by one observer in Kitava. Fifteen minutes to 3 h after breakfast, after minimal physical activity, without restrictions about betal chewing or smoking, blood pressure was measured using a mercury sphygmomanometer and three standard cuff sizes. Each subject was seated with the upper arm parallel to the sternum and the hand supported by the thigh. Three readings (diastolic phase V) were rounded to the nearest 2 mm, and the mean of the last two was recorded.

Measurements were made of weight (Seca 713 single beam balance scale), height and circumferences of waist and pelvis. Pelvis circumference was measured 2 cm below the superior anterior iliac spine. In Swedish subjects aged 20–59 with body mass index (BMI) < 25, hip circumference is larger by a mean (standard deviation) of 6(3)% in men and 4(14%) in women [S. Lindeberg, unpublished observations; $P < 0.0001$; $n = 110$]. Therefore, the waist/height ratio was used when comparing Kitava with Sweden. The waist/pelvis ratio was analysed within the Kitavan samples.

At each relaxed arm, midway between acromion and olecranon, measurements were made of the mid upper arm circumference (MAC) and triceps skinfold thickness (TSF) using a Harpenden caliper: a mean of three readings was taken. Arm muscle circumference (AMC) was derived using the equation AMC = MAC − 0.1 (vxTSF).

The Swedish and Kitavan populations were studied using identical methods and the same laboratory for each serum analysis in order to minimize analytic bias and to avoid differences due to variations between the Swedish populations.

Statistics

The Statview statistical package for the Macintosh was used, supplemented with a file for normal

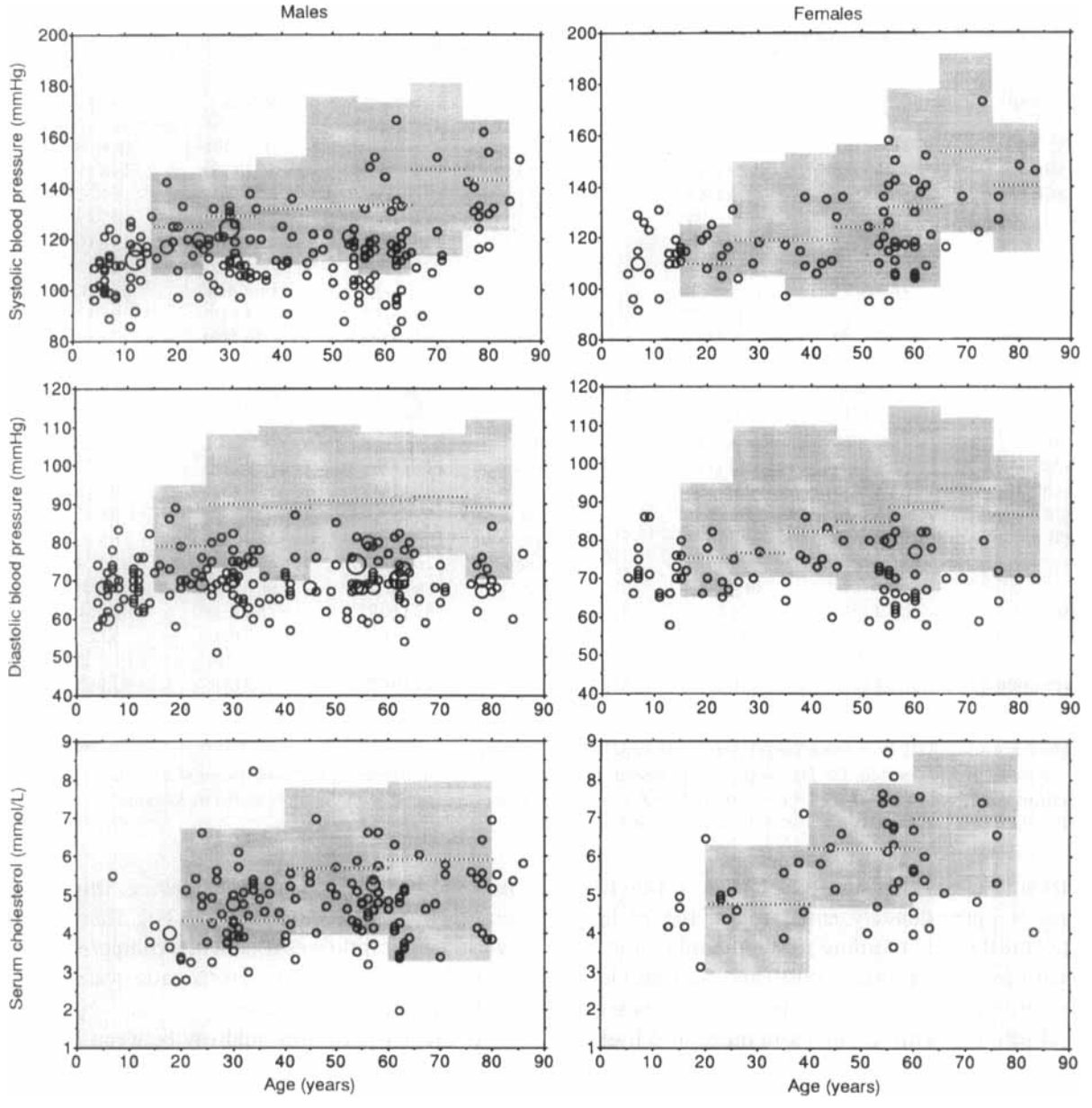

Fig. 1 Blood pressure and serum cholesterol in males (left) and females (right) from the Kitava study population. Reference intervals from healthy Swedish populations are given by the background boxes, whose lower and upper limits represent the 2.5th and 97.5th percentiles, respectively. The dashed lines show the Swedish medians. Large circles represent two or more Kitavan subjects.

plotting. Each variable was checked for or transformed into apparent normality by repeated use of normal probability plots. Five outliers which were thereafter at 3–5 standard deviations (SD) above or below the respective means were excluded from analysis, namely: a Kitavan male aged 34 with apoB 2.08 g L^{-1}, a Kitavan male aged 62 with TC 2.0 mmol L^{-1}, a Kitavan female aged 56 with HDL 0.58 mmol L^{-1}, a Kristianstad male aged 53 with TC 12.0 mmol L^{-1} and an Uppsala female with apoA1 2.00 g L^{-1}. The necessary transformations to achieve normality differed notably between Kitavan and Swedish subjects only for blood pressure, weight and BMI. Statistical analyses were only performed on transformed variables or normally distributed untransformed variables. Variances were not different according to the variance ratio test or by normal plotting of residuals.

Group comparisons were made between Kitavans and Swedes and, within the Kitavan samples, between males and females, smokers and non-smokers and between randomized and self-selected subjects.

Table 2 Means (standard deviations) of serum lipoproteins (mmol L^{-1}) in three age groups of males and females from Kitava and Sweden

	20–39		40–59		60–86	
Age (years)	Kitava	Sweden	Kitava	Sweden	Kitava	Sweden
Males	($n = 43$)	($n = 17$)	($n = 41$)	($n = 41$)	($n = 37$)	($n = 37$)
Serum cholesterol	4.5 (0.9)	4.7 (0.8)***	4.8 (0.9)	5.8 (1.0)***	4.7 (1.0)	6.0 (1.1)***
Triglycerides	1.0 (0.3)	0.8 (0.3)**	1.2 (0.5)	1.2 (0.6)	1.1 (0.4)	1.1 (0.4)
LDL	2.9 (0.8)	3.2 (0.8)	3.3 (0.8)	4.3 (0.9)***	3.1 (0.9)	4.4 (1.0)***
HDL	1.2 (0.2)	1.1 (0.2)	1.0 (0.2)	1.1 (0.3)°	1.0 (0.2)	1.1 (0.3)
LDL/HDL	2.6 (0.9)	3.0 (0.9)	3.5 (1.3)	4.2 (1.5)°	3.1 (1.2)	4.4 (1.6)***
Females	($n = 11$)	($n = 20$)	($n = 18$)	($n = 40$)	($n = 16$)	($n = 33$)
Serum cholesterol	5.1 (1.0)c	4.8 (0.9)	6.4 (1.2)a	6.3 (1.0)	5.5 (1.1)c	6.7 (1.1)**
Triglycerides	1.2 (0.9)	0.7 (0.2)**	1.3 (0.5)	1.1 (0.4)*	1.3 (0.6)	1.2 (0.4)
LDL	3.2 (0.9)	3.3 (0.7)	4.6 (1.2)a	4.6 (0.9)	3.8 (1.0)	5.0 (1.0)***
HDL	1.4 (0.4)b	1.2 (0.3)	1.2 (0.3)b	1.2 (0.3)	1.2 (0.2)c	1.2 (0.3)
LDL/HDL	2.3 (0.7)	2.9 (1.0)°	3.9 (1.2)	4.1 (1.4)	3.2 (1.1)	4.4 (1.5)**

LDL, low density lipoprotein cholesterol; HDL, high density lipoprotein cholesterol.
Differences compared to Kitava: *** = $P < 0.001$; ** = $P < 0.01$; * = $P < 0.05$; ° = $0.05 < P < 0.10$. Differences compared to males (only tested in Kitavans): a = $P < 0.001$; b = $P < 0.01$; c = $P < 0.05$.

Comparisons between populations and sexes were made for each of the age groups 20–39, 40–59 and $\geqslant 60$. Furthermore, blood pressure was compared for the age group 14–19.

With one exception, the two-sample *t*-test was used to compare groups. The exception was the comparison, in the age groups 20–39 and 40–59, of differences in apolipoproteins, waist and waist/height ratio between Kitava and Uppsala. Due to different age distributions between these two populations, and to the fact that the mentioned variables were age related, comparisons were made using the paired *t*-test for age-matched pairs. One male and two females from Uppsala were thus randomly selected for each Kitavan male and female, respectively. Within pairs, subjects differed in age by less than two years. Age distributions of Kitavans did not differ compared with the other Swedish populations. Comparisons between Kitavans and Swedes of blood pressure, weight, height and lipoproteins using the Wilcoxon two-sample test and comparisons of apolipoproteins, waist and waist/height using the Wilcoxon signed rank test did not essentially change the *P*-values in question.

Results

Kitava versus Sweden

Readings of SBP, DBP, BMI and TSF among male adults were substantially lower in Kitava than in Sweden, as were DBP, BMI and TSF among the females (Table 1, Fig. 1) Among females SBP differed only after 60 years, when it was lower in Kitavans. In the age group 14–19, there was no significant difference between the two populations in SBP ($P = 0.86$ in males and 0.087 in females) or DBP ($P = 0.23$ and 0.14, respectively), as seen in Figs 1–4. Only four Kitavans had a BMI above 25 (range 25.1–26.4). Arm muscle circumference was marginally lower in young Kitavans and the difference increased with age. In the age group 20–39 the waist/height ratio did not differ among males while among females it was higher in Kitavans. In the older age groups waist/height was much lower in Kitavans.

Kitavan males above 40 and females above 60 years had clearly lower TC and LDL, compared to Sweden, but in the other age groups there were no significant differences ($P = 0.26$–0.76) (Table 2), and overlapping was considerable as is evident from Fig. 1. High-density lipoproteins did not differ between the two populations. Triglycerides were higher in Kitavan males and females aged 20–39, but in the other age groups there was no difference.

Differences in apoB between the two populations were similar to differences in LDL. Apolipoprotein A1 was lower in Kitavans, except among females above 60 years, where it was higher. The ratio of apoB to apoA1 tended to be higher in Kitavans. Apolipoprotein (a) was slightly lower in Kitavan males and females aged 40–59.

Table 3 Means (standard deviations) of serum apolipoproteins B and A1 (g L^{-1}) and apolipoprotein(a) (U L^{-1}) in three age groups of males and females from Kitava and Sweden

	20–39		40–59		60–86	
Age (years)	Kitava	Sweden	Kitava	Sweden	Kitava	Sweden
Males	(n = 39)	(n = 39)	(n = 41)	(n = 41)	(n = 36)	(n = 13)
Apo B	0.91 (0.16)	0.92 (0.15)	1.03 (0.17)	1.14 (0.25)*	1.01 (0.19)	1.22 (0.29)**
Apo A1	1.04 (0.14)	1.14 (0.19)*	0.96 (0.18)	1.23 (0.15)***	0.96 (0.16)	1.26 (0.25)***
Apo B/A1	0.90 (0.20)	0.83 (0.20)	1.11 (0.30)	0.93 (0.21)**	1.08 (0.29)	1.00 (0.29)
Apo(a)	172 (211)	252 (302)	193 (262)	345 (379)*	361 (535)	231 (360)
Females	(n = 10)	(n = 10)	(n = 18)	(n = 18)	(n = 14)	(n = 15)
Apo B	1.01 (0.12)¢	0.95 (0.13)	1.25 (0.22)a	1.16 (0.16)	1.11 (0.19)¢	1.30 (0.25)*
Apo A1	1.23 (0.23)b	1.28 (0.12)	1.12 (0.13)b	1.32 (0.09)***	1.12 (0.21)b	1.28 (0.15)*
Apo B/A1	0.85 (0.20)	0.75 (0.15)	1.12 (0.21)	0.88 (0.14)***	1.02 (0.22)	1.04 (0.26)
Apo(a)	178 (168)	199 (177)	280 (369)	401 (278)°	305 (364)	409 (335)

Differences compared to Kitava: *** = $P < 0.001$; ** = $P < 0.01$; * = $P < 0.05$; ° = $0.05 < P < 0.10$. Differences compared to males (only tested in Kitavans): a = $P < 0.001$; b = $P < 0.01$; c = $P < 0.05$; ¢ = $0.05 < P < 0.10$.

Table 4 Means (standard deviations) of age, blood pressure, anthropometry and serum lipoproteins in smokers and non-smokers aged 20–86 among the Kitava study population

	Males			Females		
	Smokers	Non-smokers	P	Smokers	Non-smokers	P
	(n = 93)	(n = 31)		(n = 43)	(n = 10)	
Age (years)	49.1 (17.0)	53.0 (18.9)	0.28	56.1 (11.6)	42.1 (19.9)	0.012
SBP (mmHg)	115.7 (14.4)	117.0 (17.4)	0.85	123.9 (17.5)	118.2 (15.0)	0.28
DBP (mmHg)	69.5 (6.1)	71.5 (7.0)	0.16	71.0 (7.8)	69.2 (6.7)	0.41
Weight (kg)	52.5 (6.4)	52.1 (7.4)	0.78	40.0 (5.2)	40.1 (6.5)	0.90
Height (cm)	161.5 (5.6)	161.2 (5.6)	0.79	150.0 (4.7)	150.0 (5.0)	0.97
BMI (kg m^{-2})	20.1 (2.1)	20.1 (2.3)	0.87	17.8 (2.0)	17.8 (2.8)	0.72
TSF (cm)	6.7 (1.5)	7.3 (1.7)	0.058	10.0 (3.6)	10.3 (4.3)	0.95
AMC (cm)	23.5 (2.1)	23.3 (2.4)	0.80	18.7 (1.4)	18.6 (2.2)	0.78
WPR	0.94 (0.03)	0.94 (0.03)	0.28	0.89 (0.04)	0.88 (0.04)	0.91
	(n = 87)	(n = 27)		(n = 36)	(n = 9)	
TC (mmol L^{-1})	4.80 (0.9)	4.48 (0.9)	0.084	5.80 (1.2)	5.69 (1.5)	0.75
TG (mmol L^{-1})	1.14 (0.4)	1.02 (0.3)	0.15	1.29 (0.5)	1.23 (1.0)	0.30
LDL (mmol L^{-1})	3.23 (0.8)	2.87 (0.9)	0.039	4.00 (1.1)	3.62 (1.4)	0.27
HDL (mmol L^{-1})	1.05 (0.2)	1.16 (0.2)	0.028	1.21 (0.2)	1.52 (0.4)	0.022
LDL/HDL	3.2 (1.1)	2.6 (1.1)	0.0049	3.4 (1.2)	2.4 (0.7)	0.010
ApoB (g L^{-1})	1.00 (0.17)	0.93 (0.20)	0.067	1.17 (0.20)	1.06 (0.22)	0.16
ApoA1 (g L^{-1})	0.97 (0.16)	1.05 (0.14)	0.026	1.10 (0.15)	1.32 (0.22)	0.0017
ApoB/apoA1	1.06 (0.26)	0.90 (0.27)	0.0038	1.07 (0.22)	0.82 (0.18)	0.0011
Apo(a) (U L^{-1})	248 (354)	227 (435)	0.68	292 (357)	162 (157)	0.53

SBP, systolic blood pressure; DBP, diastolic blood pressure; BMI, body mass index; TSF, triceps skinfold thickness; AMC, arm muscle circumference; WPR, waist/pelvis ratio; TC, total cholesterol; TG, triglycerides; LDL, law density lipoprotein; HDL, high density lipoprotein; Apo, apolipoproteins.

Comparisons by age, sex and smoking status within the Kitavan population

Among Kitavans aged 40–59, SBP was higher in females than in males (Table 1). Diastolic blood pressure did not differ between the sexes. Females of at least one age group had higher TC, LDL, HDL, apoB, apoA1, TSF and waist/height, while BMI and AMC were lower (Tables 1–3). Triglycerides did not differ significantly.

As seen in Fig. 1, SBP increased with age after 40 years in males and females. In males TC, TG, LDL and apoB increased up to about 50 years, while HDL and apoA1 decreased. Among females, no significant

relation was found between age and serum lipoproteins or apolipoproteins. Apolipoprotein (a) showed a slight tendency to rise with age among males (Spearman's rho = 0.18; $P = 0.056$). In males BMI decreased with age above 30 years and in females above 20 years. Diastolic blood pressure and height were not age related in either sex.

Male smokers had lower HDL, apoA1 and TSF, while LDL and apoB tended to be higher than in non-smokers (Table 4). Female smokers had lower HDL and apoA1 and were older than non-smokers.

Discussion

The Kitava study population is a random sample mixed with a substantial number of self-selected subjects. Nevertheless it appears largely representative of the Kitava islanders. In the age group older than 80 years, non-attending subjects were slightly more often disabled and were older than participants. Randomized, self-selected and non-attending subjects in the other age groups did not differ grossly in body composition, agility or level of physical activity. Any differences in the intake of western food items would seem unimportant, due to their insignificant contribution to energy and nutrient intake. Risk factor levels did not differ between randomized and self-selected subjects. Different selection criteria of the four Swedish populations preclude any strict comparisons, but with respect to qualitative differences between Kitava and Sweden we believe our results are valid. Due to the lack of international reference standards for HDL and apoliproteins the analysis of each variable was made at the same laboratory within a reasonably short time, which minimizes methodological bias.

Kitava versus Sweden

The most striking findings are the low DBP, BMI and TSF in Kitava, where all subjects above 40 years were below Swedish medians, with the exception of one female having a DBP of 86 mmHg. If, at the age of 50, Swedish males and females had the BMI of Kitavans, they would, respectively, weigh 19 and 22 kg less than they do. In a large number of traditional populations, blood pressure, BMI and TSF have been lower than in western populations [6–8].

Several nutritional factors may account for the differences in blood pressure and body composition. The available food items contain large amounts of soluble fibre, vitamins and minerals except sodium and chloride. Carbohydrate intake is high while total fat intake is low. Glycaemic index of the most important vegetables, yam, sweet potato, taro and fruit, is low [9]. The intake of phytate is very low, due to the near absence of cereals, and this is known to increase absorption of iron, calcium, zinc and magnesium [10].

Total cholesterol levels in males above 40 years are lower than in western countries and similar to the levels of contemporary Japanese [11], but considerably higher than the 3.0–3.5 mmol L^{-1} of hunter-gatherers or tribal horticulturalists living offshore [12–16]. Females younger than 60 years have similar levels to those in Sweden. Levels of LDL and apoB correspond to TC levels. In the age group 35–64, 38% of men and 67% of women have a higher than 'desirable' LDL, according to US guidelines [17].

Habitual saturated fat intake appears to be the most important environmental determinant of TC, LDL and apoB. The almost exclusive sources of saturated fat in Kitava are coconut and fish. Fish is eaten 2–4 times a week (roughly 100–300 g at each occasion), and the expected influence on serum lipoproteins would be a decrease in TG, a marginal increase in LDL, apoB and HDL and no net effect on TC [18]. The roughly estimated median daily intake of saturated fat is 40 g from coconut and 1 g from fish. In case of a daily energy intake of 10 MJ, saturated fat would provide 17% of the energy. In search of causes of the partly unfavourable serum lipoprotein levels, our suspicions therefore fall heavily on the coconut.

The roughly estimated 25–135 mg of dietary cholesterol per day (Swedish mean is 300 mg), almost exclusively from fish, as well as the higher intake of soluble fibre, is expected to result in slightly lower levels of TC, LDL and apoB than in Sweden.

Levels of TG, HDL and apoA1 are not 'beneficial' compared to westerners, and similar levels have been found in observational studies among non-western populations and in dietary intervention trials with low-fat diets [12, 19–22]. Habitual diets which are high in carbohydrates and low in total fat, but where saturated fat dominates, result in low HDL and high TG levels [19]. In males LDL/HDL and apoB/A1 are no different compared to Sweden, and in females of all ages they are higher in Kitavans.

The complete absence of alcohol, which accounts for 1–3% of the energy intake in Sweden, may

slightly contribute to the low population means of BMI, SBP, DBP and apoA1 [23].

Levels of apo(a) which is a worldwide risk factor for atherosclerosis, IHD, stroke and peripheral vascular disease [24], do not differ much from Swedish levels. The small differences that do tend to exist may be genetically determined or due to the negligible intake of trans-fatty acids in Kitava [25].

Individual levels of physical activity were not measured. After 7 weeks of observation it was evident that, although the average level of physical activity undoubtedly is higher than in western populations of the 1990s, many westerners are more active at work and during leisure time.

Sex differences

The higher BMI among Kitavan males is consistent with findings in other traditional populations, as well as in European populations with low mean BMI [26]. The higher SBP in females aged 40–59 and the absent difference in other age groups, as well as the similar DBP across all ages, are unexpected from western studies. In traditional populations, sex patterns have been inconsistent.

The higher levels of TC, LDL, HDL, apoB and apoA1 in females than in males in Kitava are not entirely expected. In populations with moderate or high IHD incidence rates essentially the same differences have been noted, and in addition TG levels have been lower in females. On the other hand, sex differences of lipoproteins appear to have been minimal in societies with little or no IHD [27]. However, in most of these populations lipoprotein levels appear to have been more beneficial than in Kitavans.

Age relations

Apart from a higher intake of fruit at young ages, a slightly higher fish intake among boys than girls, the universal habits of smoking tobacco and chewing betel from about age 15 and a slightly lower level of physical activity from about age 60, the Kitavan lifestyle appears rather similar across all ages in both males and females. The intake of western food is equally negligible (and equally popular) at all ages. Furthermore, secular trends in nutrition, smoking habits, betel chewing and physical activity seem to have been very small for the last four generations or more. Therefore, the noted age relations of blood pressure, anthropometry and serum lipoproteins and apolipoproteins do not appear mainly environmentally induced.

Diastolic blood pressure does not vary with age among Kitavans, which is expected from earlier studies on non-westernized populations. The age increase of SBP above 40 years is unexpected, in light of the absent age increase in most traditional populations. Among traditional Yi farmers in China, SBP shows a similar age relation in the males, but not in the females [28].

Contrary to western populations, weight, BMI, waist, AMC, and, in females, TSF, decrease steadily with age from 20 years and onwards. These negative age relations have, with the exception of waist circumference for which limited data is available, consistently been present in non-westernized populations [29, 30]. The absent age decrease in height, which has also been noted among traditional populations, is probably to a large extent caused by an absent popular trend, due to an apparent nutritional stability for several generations. Nevertheless, protective factors against disc degeneration and osteoporosis in the Kitivan lifestyle cannot be excluded.

The typical western age related increase of TC, TG, LDL and apoB up to about 50 years in males, and even further in females, is present in Kitavan males though much less marked, while in the females no age trend is seen. High-density lipoprotein, which shows little variation with age in the west, decreases between 20 and 50 years in Kitavan males, but is not age related in females. Apolipoprotein A1 decreases from 20 years in Kitavan males, while it increases in the Swedish males. In females, no age relation of apoA1 was seen in either population. The commonly found increase in apo(a) after menopause in western populations [31] was not apparent in the few Kitavan females. However, apo(a) showed a successive slight tendency to rise with age in males, which is unexpected.

Impact of smoking

In Kitava, the impact of western dietary habits appears to be negligible. Physical activity does not seem to be related to smoking, and alcohol is not available. Therefore, the lower HDL, apoA1 and TSF in the smokers, as well as the higher LDL, apoB, LDL/HDL and apoB/A1, are likely to be true effects of tobacco. The differences in TC (not significant), LDL, HDL and apoA1 between smokers and non-smokers

in this study were about twice as great as the pooled differences from 54 observational studies on westerners, while TG (not significant) differed by the same magnitude [32].

Conclusion

Among the analysed variables, blood pressure and body composition may have a high explanatory value for the apparent absence of stroke and ischaemic heart disease in Kitava. Although serum cholesterol levels in males above 40 and in females above 60 years are lower than in Sweden, serum lipoproteins and apolipoproteins appear to be less important risk factors in this population. Highly beneficial lipoprotein levels may not be a prerequisite for very low incidence rates of ischaemic heart disease in human populations, a notion which finds support in observational studies among Polynesian horticulturalists [33, 34], East African nomads [35], Eskimos [36] and Cretans [37]. In Kitava this would be most evident in the females.

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