Cardiovascular Topics

Waist circumference predicts clustering of cardiovascular risk factors in older South Africans

KAREN E. CHARLTON, INGRID SCHLOSS, MARIANNE VISSER, ESTELLE V. LAMBERT, TRACY KOLBE, NAOMI S. LEVITT, NORMAN TEMPLE

Summary

Objective and design. A cross-sectional analytical study to determine the cardiovascular risk factor profile of older residents of fishing villages on the West Coast of South Africa, and to determine which anthropometric measures are associated with risk factors.

Subjects. A convenient community-based sample of 152 subjects of mixed ancestry aged 55 years and over was recruited door-to-door using an address list of age-eligible subjects provided by the local public health care clinics.

Methods. Cardiovascular relationships were investigated between: (*i*) number of risk factors (hypertension, hypercholesterolaemia, diabetes) and body mass index (BMI), waist-to-hip ratio (WHR), and waist circumference; and (*ii*) continuous cardiovascular risk factor variables and physical activity, smoking, dietary intake, and 24-hour urinary sodium and potassium concentrations.

Results. The prevalence of hypertension (≥ 160/95 mmHg) was 74.3% (95% CI: 67.2 - 81.4%). Neither 24-hour urinary sodium nor potassium concentrations was associated with blood pressure (BP). Past, but not present, moderate-intensity physical activity, particularly that associated with occupation, was negatively associated with systolic BP ($r = -0.24$, $P < 0.05$). The prevalence of diabetes and hypercholesterolaemia (serum cholesterol ≥ 6.5 mmol/l) was 24.6% (95% CI: 17.2 - 32%) and 40% (95% CI: 31.8 - 48.2%), respectively. The percentage of subjects with 0, 1, or 2 or more cardiovascular risk factors was 13.4%, 44.1% and 42.5%, respectively. Subjects with a waist circumference ≥ 92 cm had a significantly higher number of cardiovascular risk factors than those with a waist circumference < 92 cm ($\chi^2 = 9.29$, $P < 0.01$), and this association remained significant even after controlling for age, sex and smoking ($P < 0.05$). Neither BMI tertiles according to sex, nor a BMI cut-point ≥ 30, was significantly associated with a clustering of risk factors.

Nutrition and Dietetics Unit, Department of Medicine, University of Cape Town
KAREN E. CHARLTON, PE.Dip.Diet., M.Phil., M.Sc.
INGRID SCHLOSS, B.Sc. (Med.) Hons (Nutrition & Dietetics)
MARIANNE VISSER, B. Nutr., M.Phil.

Research Unit for Exercise Science and Sports Medicine, University of Cape Town
ESTELLE V. LAMBERT, Ph.D.*
TRACY KOLBE, B.Sc. (Biokinetics)*

Endocrinology and Diabetes Unit, Department of Medicine, University of Cape Town
NAOMI S. LEVITT, M.B. Ch.B., M.D.*

Athabasca University, Canada
NORMAN TEMPLE, Ph.D.*

*Consultant scientists in the Chronic Diseases of Lifestyle Programme, Medical Research Council, Tygerberg, W. Cape

Conclusion. **In a sample of older South Africans of mixed ancestry at high risk of cardiovascular disease, waist circumference ≥ 92 cm predicts clustering of risk factors, independently of BMI. This simple, population-specific reference value may provide a useful screening tool to identify at-risk individuals for targeted prevention for coronary heart disease and associated metabolic disorders.**

Cardiovasc J South Afr 2001; **12:** 142-150.

The adult South African mixed-ancestry population (this population is of Afro-Euro-Malay ancestry, and has historically been socio-politically and socio-economically disadvantaged as a result of apartheid legislation) has been identified as being at high risk of developing heart disease because of a relatively high prevalence of hypertension, hypercholesterolaemia and tobacco use.[1] Forty-six per cent of men and 73% of women aged 55 - 64 years have previously been found to be hypertensive (BP ≥ 160/95 mmHg).[2] A study of a representative sample of older (65+ years) mixed-ancestry residents of Cape Town[3] demonstrated that the age-specific prevalence of diabetes was among the highest reported worldwide (28.7%, 95% CI: 21.7 - 35.7%), and that 72% (95% CI: 68.5 - 74.9%) of subjects were found to be hypertensive.[3,4] In addition, clinical indicators measured in subjects who had been previously diagnosed reflected poor management of these conditions. Based on these observations, diabetes and hypertension constitute major problems in this population and effective strategies to prevent and manage these conditions are required.

The atherogenicity of a Western-style diet, which typically comprises a high proportion of energy from fat, is well established. There is also evidence that populations with a high intake of fish, specifically fish oils, are at reduced risk of cardiovascular disease.[5,6] Fish oils are rich sources of omega-3 fatty acids, notably eicosapentanoic acid (EPA) and docosahexaenoic acid (DHA), which are precursors of the 3-series of prostaglandins and 5-series of leukotrienes which have an inhibitory effect on platelet function, hence their beneficial cardiovascular effect.[7,8] However, a community of subsistence fishermen on the West Coast of South Africa, a population with an unusually high consumption of omega-3 fatty acids, has been shown to have a higher prevalence of hypertension than their counterparts in Cape Town.[9] It was hypothesised that the high prevalence of hypertension may be associated with a higher intake of sodium, related to the widespread practice of drying fish with salt.[9]

The aim of the present study was to investigate the association between anthropometric measurements, dietary and lifestyle factors and cardiovascular risk factor profiles (hypertension, hypercholesterolaemia and diabetes) in older mixed-ancestry adults living in small fishing towns on the West Coast of South Africa.

Methods

Sampling and subject characteristics

A sample was drawn from among older residents (aged over 55 years) of villages on the West Coast, about 150 km north of Cape Town. A list of names and addresses of age-eligible subjects in two small villages, St Helena Bay and Velddrif, was obtained from the local clinics, which the community sampled attend for primary health care services. Off-shore and in-shore trawling and pelagic fishing are practised in both areas, and a pilchard canning industry is based in St Helena Bay. During July/August 1997 a convenience sample of 152 subjects was drawn using the address list, and by personal referral. Written informed consent was obtained from all participants and the study was approved by the Ethics and Research Committee of the University of Cape Town and Allied Teaching Hospitals.

Blood pressure and anthropometric measurements

Blood pressure (BP) was measured according to the American Heart Association *Recommendations for Human Blood Pressure Determination*,[10] using automated Omron BP monitors endorsed by the British Hypertension Association as being reliable for use in clinical trials. A large cuff was used for subjects with a mid-arm circumference of ≥ 33 cm. After being seated for at least 5 minutes, three readings were recorded at 1-minute intervals and an average of these three readings was calculated. Hypertension was defined using the World Health Organisation (WHO) classification, i.e. either a systolic BP (SBP) ≥ 160 mmHg and/or diastolic BP (DBP) ≥ 95 mmHg, or currently taking antihypertensive medication.[11] The self-reported prevalence of hypertension and diabetes was obtained by asking the subjects whether they had ever been told by a doctor or a nurse that they had either of the conditions. Weight was determined in duplicate on a bathroom scale to the nearest 0.5 kg, with the participant barefoot and in light clothes. The scales were calibrated against a beam balance before commencement of the study. Standing height was measured in duplicate to the nearest 0.1 cm using a metal measuring tape against a wall with a flat headboard at right angles to the wall. Body mass index (BMI) was calculated as weight (kg)/height squared (m^2). Waist circumference was recorded at the level of the umbilicus and hip circumference was measured at the largest diameter below the umbilicus or maximum circumference over the buttocks. Subjects were instructed to breathe normally during the measurements. All anthropometrical measurements were taken in duplicate and an average of was calculated.

Blood glucose and cholesterol

After an overnight fast, blood was drawn for assessment of total serum cholesterol and fasting plasma glucose. A 2-hour glucose tolerance test was performed following the ingestion of a solution containing 75 g of glucose monohydrate. Plasma glucose was measured using the glucose oxidase reference method.[12] Diabetes and impaired glucose tolerance (IGT) were diagnosed according to WHO criteria[13] for epidemiological surveys (2-hour plasma glucose ≥ 11.1 mmol/l for diabetes, or ≥ 7.8 and < 11.1 mmol/l for IGT).

Diabetes prevalence was also assessed using the 1997 American Diabetes Association (ADA) reference values (fasting plasma glucose ≥ 7.0 mmol/l).[14]

24-hour urine collections — urinary sodium, potassium and nitrogen assessments

Subjects were asked to collect urine samples in 2 l plastic containers containing 3 g boric acid (Saarchem 140 52 00) as a preservative, for a 24-hour period, starting at 08h00. Subjects were asked to void the first urine collection of the day (if it was after 08h00) and to begin collecting thereafter. After measuring total volume of the sample, aliquots of 50 ml were stored at - 20°C. As a marker of completeness of collection, three tablets of non-metabolisable para-aminobenzoic acid (PABA) (Laboratories for Applied Biology, London) were given to the subjects, to be taken with meals during the collection period, providing a total dose of 240 mg, according to the methods described by Bingham and Cummings[15] and urinary concentration of PABA was measured calorimetrically. For those samples where PABA collections were incomplete (< 85%), adjustments to estimations of urinary electrolytes were made by dividing urinary nitrogen and electrolyte values by the percentage value of PABA retrieved, multiplied by 100. No differences were found between extrapolated values of subjects with complete (PABA ≥ 85%) and incomplete (PABA > 0 and < 85%) collections, therefore results were pooled, by sex, for urinary sodium and potassium estimations. Urinary sodium and potassium concentrations were determined by flame photometry. Total urinary urea was analysed using an enzymatic rate method. Daily urinary nitrogen (N) excretion was calculated as urea (g) x 0.560, and daily protein excretion as (N (g) x 6.25) + (estimated average non-urinary losses of N (i.e. 2 g) x 6.25).

Habitual dietary intake and physical activity levels

Trained interviewers administered a questionnaire on socio-demographic and lifestyle factors, and 10 postgraduate dietetics students administered a quantified food frequency questionnaire (FFQ) in the home language of the subjects. The FFQ listed 175 food and drink items, including items on the types of foods and drinks consumed during the previous 2 weeks, the frequency of consumption and the quantity consumed at a time. Standard household measuring utensils, rulers and foam food models were used to quantify food portion sizes. The reported fortnightly food intake was quantified using the National Research Institute for Nutritional Diseases' *Food Quantities Manual*,[16] and was divided by 14 to yield daily food intake in grams. Average daily nutrient intake was calculated using the Foodfinder computer package, based on the 1991 food composition database of the South African Medical Research Council.[17] Discretionary salt use, either in cooking or added at the table, was not assessed.

Habitual physical activity was assessed using an adapted version of the Yale Physical Activity Survey (YPAS) for older persons questionnaire[18] which has previously been found to provide a valid measure of physical activity in this sector of the population.[19] Historical physical activity was assessed for five age categories during the subjects' lives (14 - 24, 25 - 34, 35 - 49, 50 - 64, 65+ years), using a modified version of the questionnaire developed by Kriska *et al.*[20] During each age epoch, subjects were asked to rate participation in three activities (leisure, occupation and housework), according to either low (< 3 metabolic equivalents (kcal/kg/h) (METS)), moderate (3 - 6 METS) or high intensity (> 6 METS). Lower body muscle strength was assessed during a 'sit-to-stand' test which measures the number of times a subject can rise from a seated position, unassisted, in a 10-second period.[21]

Statistical analyses

All normally distributed continuous variables are expressed as means and standard deviations (SD); non-parametric variables are expressed as medians and interquartile ranges (IQR). In order to assess validity of the dietary assessment method, differences between reported dietary and measured urinary protein and electrolytes (sodium and potassium) were calculated. Differences between the urinary and dietary parameters were tested for significance using the paired *t*-test for parametric data and the Wilcoxon-signed rank test for skewed data, and their SDs were reported to assess measure of dispersion (or variability) in error of reporting between subjects. Ninety-five per cent confidence intervals (CIs) of the mean differences are reported.

Associations between: (*i*) anthropometric and other variables and (*ii*) BP, fasting plasma glucose and plasma cholesterol were assessed using Pearson's and Spearman's (non-parametric data) correlation coefficients. Clustering of risk factors was assessed, according to categories of waist circumference and BMI, using the chi-square (χ^2) test. Regression modelling was performed to investigate risk factors for cardiovascular risk factor clustering, controlling for age, sex and smoking. In all cases, statistical significance was assessed at the $\alpha = 0.05$ level.

Results

Sample characteristics

The mean age of the subjects was 65.4 years (SD 6.9 years). Seventy-three per cent of subjects had attended school; of these only 28% had received some secondary school education. Most of the men (64%) had previously worked in the fishing industry, either as fishermen (49%) or in a fish-processing factory (15%). Forty-two per cent of the women had worked in a fish factory, 30% had been employed as domestic workers, and 12% had worked in the service industry. Most subjects (69%) received a means-tested State old age pension (R470 per month at the time of the survey), while 14% of the subjects who did not age qualify for a pension received a government disability grant to the same value. Most subjects lived in households with an average of 4.5 persons (SD 2 persons; range 1 - 10 persons).

Cardiovascular risk profiles

A summary of the cardiovascular risk profile of the sample is shown in Table I. Fifty-seven per cent of hypertensive subjects were currently being treated for the condition; however, compliance with antihypertensive medication was not assessed. Only 11% of treated hypertensive patients had BP levels < 140/90 mmHg, 14% had levels ≥ 140/90 and ≤ 160/95 mmHg, while the remainder (75%) had levels above 160/95 mmHg. One-third of the subjects on antihypertensive medication (32.8%) had DBPs < 85 mmHg, the 'J-point' below which an increased risk of mortality has been reported.[22]

TABLE I. DESCRIPTIVE STATISTICS (MEAN (SD)) AND PREVALENCE (%) OF CARDIOVASCULAR RISK FACTORS IN THE WEST COAST MIXED-ANCESTRY POPULATION AGED 55 YEARS AND OLDER

	Men	*Women*	*Total*
Blood pressure profile			
Number of patients	46	106	152
Systolic blood pressure (mmHg)	166 (26)	164 (29)	164 (28)
Diastolic blood pressure (mmHg)	91 (14)	89 (16)	89 (15)
% Hypertension (95% CI) (≥ 160/95 mmHg and/or on treatment)	71.1 (64.3 - 74.9)	76.0 (71.6 - 80.4)	74.3 (70.6 - 78.0)
% Moderate-risk hypertension (not on treatment) (≥ 140/90 < 160/95 mmHg)	19.6	10.8	13.5
% Isolated systolic hypertension (SBP ≥ 160 mmHg, DBP < 95 mmHg)	24.4	32.0	29.7
% Total hypertensives with isolated systolic hypertension	34.4	40.5	38.9
% Diagnosed hypertensives	59	67	64.8
% Untreated hypertensives	48.5	40.5	43.0
24-h urinary electrolytes			
Number of patients	33	75	108
Sodium (mg)	3 743 (2 386)	3 911 (2 198)	3 859 (2 247)
Potassium (mg)	1 380 (1 087)$^{\dagger *}$	1 536 (1 026)$^{\dagger *}$	1 529 (998)†
Glucose			
Number of patients	42	94	136
Fasting glucose (mmol/l)	5.79 (1.67)	6.99 (3.37)§	6.62 (2.98)
Two-hour glucose (mmol/l)‡	7.21 (4.2)	9.67 (6.9)§	8.92 (6.23)
Prevalence of diabetes (95% CI)	15.8 (4.2 - 27.4)	28.9 (19.5 - 38.2)	24.6 (17.2 - 32.0)
% Diagnosed diabetics	33.3	48	45.2
Prevalence of IGT (95% CI)	13.2 (2.4 - 24.0)	10.0 (3.8 - 16.2)	11.5 (5.9 - 17.0)
Lipid profile			
Number of patients	42	94	136
Total cholesterol (TC) in mmol/l	5.4 (1.2)	6.4 (1.3)§	6.1 (1.4)
% Moderate-risk hypercholesterolaemia (TC ≥ 5.7 < 6.5 mmol/l)	12.2	22.6	19.2
% High-risk hypercholesterolaemia (TC ≥ 6.5 mmol/l)	24.4	47.3	39.7
Smoking profile			
Number of patients	47	101	148
% Current smokers (≥ 1 cigarette per day)	48.9	28.7	34.9
% Heavy smokers (≥ 10 cigarettes per day)	23.4	6.9	12.1
Anthropometric profile			
Number of patients	41	104	145
Weight (kg)	66.9 (16.7)	70.6 (17.2)	69.2 (19.8)
Height (m)	1.65 (0.06)	1.54 (0.06)§	1.57 (0.08)
Body mass index (BMI)	24.6 (5.6)	29.6 (6.7)§	28.0 (6.8)
% Underweight (BMI < 18.5)	9.8	3.9	5.5
% Desirable weight (BMI 18.5 - 24.9)	46.3	24.0	30.3
% Overweight (BMI 25 - 29.9)	29.3	26.0	26.9
% Obese (BMI ≥ 30)	14.6	46.1	37.2
Waist hip ratio	90.1 (13.6)	93.5 (13.2)	92.5 (13.4)
Waist circumference > 102 cm (men), > 88 cm (women) (%)	15.2	66.7	53.5

* $P < 0.0001$, Wilcoxon matched pairs test for differences between the sexes.
† Median (interquartile range).
‡ Sample sizes for 2-hour glucose are smaller because of incomplete blood sample collection ($N = 39$ for men and $N = 90$ for women).
§ $P < 0.05$, two-sample t-test for differences between the sexes.
IGT = improved glucose tolerance.

Urine samples were successfully collected for 103 subjects. Hypertensive subjects had significantly lower 24-hour urinary sodium excretion values than normotensive patients (3 657 (2 185) mg (159 (95) mmol) versus 4 807 (2 392) mg (209 (104) mmol), $P < 0.05$). However, analyses according to treatment status of hypertensives indicated that values differed only between treated hypertensive and normotensive patients (3 542 (1 840) mg (154 (80) mmol)/day versus 4 807 (2 392) mg (209 (104) mmol)/day, $P < 0.05$). Mean 24-hour potassium excretion was low (1 861 (1 318) mg (47.6 (33.7) mmol)/day), and did not differ between treated hypertensive, untreated hypertensive or normotensive patients. The type of medication regimen most commonly prescribed was a combination of a potassium-sparing diuretic (amiloride) and a centrally acting anti-adrenergic agent (Aldomet).

One-quarter of the subjects were classified as being diabetic (Table I) using WHO reference-derived figures.[13] However, the prevalence of diabetes calculated using ADA[14] reference values of fasting plasma glucose ≥ 7 mmol/l, was markedly lower (19.1%; 9.5% (men), 23.4% (women)).

Women had significantly higher total serum cholesterol concentrations and a higher prevalence of obesity than men (46.1% of women had a BMI ≥ 30 (Table I)). Most men fell within the desirable weight category (BMI 18.5 - 24.9 kg/m²).[23] Two-thirds of the women had waist circumferences that exceeded the sex-specific reference value of 88 cm,[24] above which health risk is significantly increased, whereas only 15% of the men had waist girths exceeding the sex-specific reference value of 102 cm.[24]

The percentage of subjects with 0, 1, or 2 or more cardiovascular risk factors (i.e. hypertension, diabetes (fasting plasma glucose ≥ 7.0 mmol/l), and/or hypercholesterolaemia (fasting plasma cholesterol ≥ 6.5 mmol/l)) was 13.4%, 44.1% and 42.5%, respectively ($N = 127$ subjects with complete data). Levitt and colleagues[25] have previously demonstrated that a waist circumference ≥ 92 cm was independently associated with non-insulin-dependent diabetes in a study of a South African mixed-ancestry population. In the present study, the number of cardiovascular risk factors was significantly higher in those with a waist circumference ≥ 92 cm (Fig. 1) ($X^2 = 9.29$, $P < 0.01$). Neither BMI tertiles according to sex, nor a BMI cut-point ≥ 30,[23] significantly categorised the number of risk factors (Fig. 2). In regression models that included age, sex and smoking, a waist circumference cut-off of ≥ 92 cm was predictive ($P < 0.05$) of the number of risk factors, where:

No. of risk factors = –0.364 + 0.302 (sex)* –0.046 (smoking) + 0.010 (age) + 0.339 (waist category)* (*$P < 0.05$).

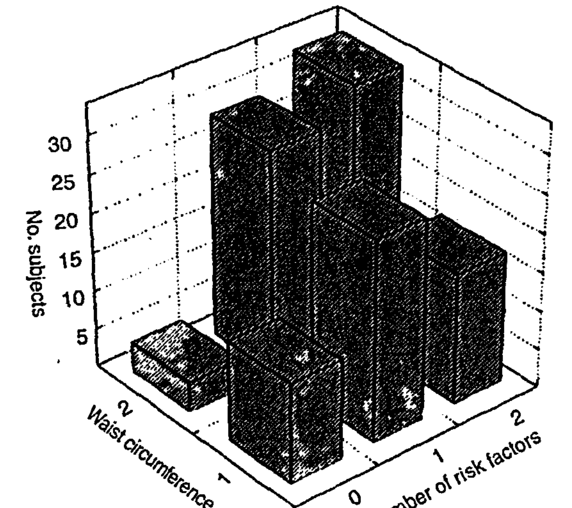

Fig. 1. Number of cardiovascular risk factors according to waist circumference (Waist circumference < 92 cm = 1: ≥ 92 cm = 2).

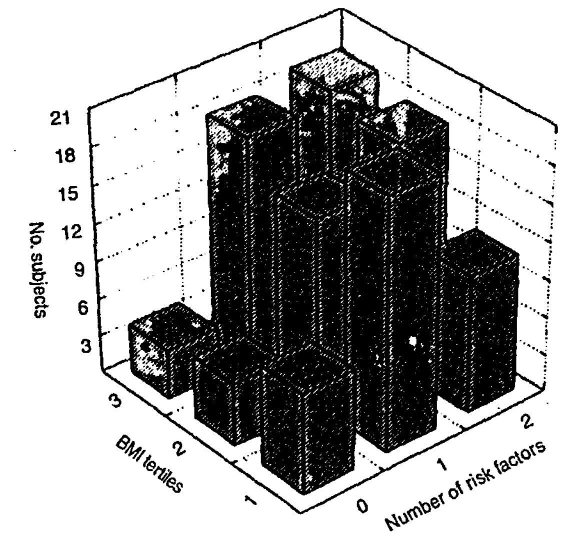

Fig. 2. Number of cardiovascular risk factors according to tertiles of BMI for men and women (BMI tertiles — men ≤ 20.6, 20.7 - 27, > 27; women: ≤ 26.5, 26.6 - 32, > 32).

Dietary intake

Mean daily intake of macronutrients and micronutrients known to affect BP is shown in Table II. Energy profiles are in line with prudent dietary guidelines, with the exception of a relatively high mean daily alcohol intake in the men (8 (SD 12.1) % energy intake). Mean alcohol intake was equivalent to about three alcoholic drinks in men and half a drink in women; however, intake was highly variable. The dietary fatty acid intake of the sample with regard to omega-3 and omega-6 fatty acid intake (median ϖ-6: ϖ-3 ratio = 16.8 (IQR = 15.2)) more closely resembles that of an elderly sample in Cape Town[26] than that found in a previous study of subsistence fishermen in Paternoster (a village about 20 km away from the present sample area),[9] which suggests that the subjects were not consuming a high intake of oily fish.

Median dietary intake of calcium was low (455 (354) mg, 84% of subjects had intakes < 67% of the daily reference intakes (DRI).[27] Intakes of magnesium (mean = 275

TABLE II. DAILY INTAKE OF SELECTED NUTRIENTS (MEAN (SD))

Nutrient	DRI[27] or RDA[28] or (men/women)	Men (N = 38)	% Subjects < 67% RDA/DRI	Women (N = 91)	% Subjects < 67% RDA/DRI	Total (N = 129)	% Subjects < 67% RDA/DRI
Energy (kJ)	9 625/7 950	9 911 (3 812)	10.5	7932 (3999)*	25.3	8 515 (3 626)	20
Protein (g)	63/50	85.2 (34.0)	10.5	66.7 (32.0)*	11.0	72.1 (33.6)	10.8
Plant protein (g)		33.3 (16.8)		25.5 (11.5)*		27.8 (13.7)	
Animal protein (g)		52.0 (29.4)		40.7 (26.8)*		44.0 (27.9)	
Fat (g)		86.4 (40.6)		70.9 (36.7)*		75.5 (38.3)	
Saturated (g)		27.3 (13.2)		23.4 (14.4)		24.6 (19.1)	
Monounsaturated (g)		31.2 (16.8)		24.9 (12.8)*		26.8 (14.3)	
Polyunsaturated (g)		20.3 (10.2)		15.5 (8.3)*		16.9 (9.1)	
Cholesterol (mg)		293 (165)		222 (159)*		243 (159)	
Carbohydrates (g)		312 (139)		248 (115)*		267 (125)	
Added sugar (g)		99.1 (70.9)		64.7 (62.4)†*		67 (71)†	
Fibre (g)		22.1 (9.6)		17.6 (9.7)		18.9 (9.8)	
Alcohol (g)							
Total		29.2 (49.2)		6.1 (40.8)		12.7 (47.1)	
Consumers only		53.6 (56.4)		40.5 (44.8)		48.4 (82.8)	
Energy profile							
%E protein		13.7 (3.5)		14.4 (3.7)		14.2 (3.7)	
%E fat		29.4 (8.1)		32.3 (6.4)*		31.5 (7.0)	
%E carbohydrate		47.3 (11.1)		49.7 (8.1)		49.0 (9.1)	
%E alcohol		8.0 (12.1)		0.98 (5.5)*		3.0 (8.6)	
Micronutrients							
Calcium (mg)	1 200	493 (384)†	84.2	455 (360)†	84.6	455 (354)†	84.5
Magnesium (mg)	420/320	306 (132)	50.0	262 (112)	40.6	275 (119)	43.4
Vitamin D (µg)	10	3.75 (3.60)†	89.5	2.09 (1.95)	95.6	2.94 (2.26)	93.8
Sodium (mg)		2 273 (1 068)		1 725 (1 391)†		2 072 (1 172)	
Potassium (mg)		2 901 (1 322)		2 096 (1 535)†*		2 574 (1 203)	

*$P < 0.05$, independent 2-sample t-test for differences between the sexes.
†Median (interquatile range).
DRI = daily reference intakes; RDA = recommened daily allowance.

(119) mg; 43.4% of subjects had intakes < 67% DRI) and vitamin D (mean = 2.9 (2.3) µg; 93.8% of subjects had intakes < 67% DRI) were also low.

Validity of dietary data

In order to assess validity of the FFQ method, differences between dietary and urinary data for 24-hour protein, sodium and potassium were investigated for subjects who had completed both urinary collections and an FFQ (N = 99). Six subjects who were clear outliers with regard to error in protein reporting were excluded from the validation analyses (as well as the dietary reporting), leaving a final sample of 93 subjects. Men systematically over-reported protein intake by an average of 34 (43) g protein per day, compared with urinary estimations of protein excretion (95% CI of difference (i.e. diet - urine) = 17 to 50.4 g/day) (Table III). The mean difference between measures was small for women (mean under-reporting by an average of 7 (42) g/day, or 3% of urinary protein); however, a large variation in error of reporting is demonstrated by the large SDs. Furthermore, the 95% CI of the mean difference (–17 to 3 g) includes zero, which suggests random rather than systematic error.

Dietary sodium intake was significantly and systematically under-reported by a mean of 1 040 (SD 1 525) mg/day for men (95% CI: 424 - 1 656 mg/day) and 1 917 (2 585) mg/day for women (95% CI: 1 280 - 2 553 mg/day) (Table III). Discretionary (added) salt intake was not assessed using the FFQ; the magnitude of under-reporting of sodium intake relates to a discretionary salt intake of about 2.3 and 4.3 g/day for men and women, respectively. Dietary potassium was significantly and systematically over-reported in both men and women by a mean of 3 113 (1 216) and 2 419 (1 192) mg/day, respectively (Table III). Reported dietary energy intake was significantly higher than estimated dietary energy requirements in men (11 875 (6 426) kJ and 8 395 (1 030) kJ, respectively, $P < 0.05$), calculated using the age- and weight-dependent prediction equations of Schofield *et al.*,[29] whereas no difference between the values was found for women (8 499 (4 179) and 8 185 (954) kJ, respectively), further suggesting over-reporting of dietary intake by men. An inverse association between BMI and error in dietary protein intake reporting was demonstrated in women ($r = -0.28$, $P < 0.05$); women with higher BMI values tended to under-report protein intake the most. In men, no association between BMI and error in dietary reporting was found.

Other lifestyle factors

Regarding other lifestyle behaviours, as indicated in Table I, 49% of men and 29% of women were smokers.

TABLE III. ASSOCIATION BETWEEN 24-HOUR URINARY AND DIETARY ELECTROLYTE AND PROTEIN EXCRETION (MEAN (SD)) IN SUBJECTS WITH BOTH URINARY AND DIETARY DATA (N = 93)

	Men (N = *28*)	*Women* (N = *65*)	*Total* (N = *93*)
Sodium			
Urinary sodium (mg/day)	3 381 (1 617)	3 993 (2 307)	3 818 (2 139)
Dietary sodium (mg/day)	1 990 (1 269)†	1 856 (1 256)†	1 932 (1 306)†
Mean difference (SD) (urinary — dietary)	1 040 (1 525)*	1 917 (2 585)*	1 669 (2 360)*
(95% CI of difference)	424 - 1 656	1 280 - 2 553	1 180 - 2 158
Correlation (r)	0.44 ‡ (P < 0.05)	0.10‡	0.16‡
Potassium			
Urinary potassium (mg/day)	1 499 (936)	1 494 (1 026)†	1 798 (1 221)
Dietary potassium (mg/day)	3 151 (1 215)	2 098 (1 535)†	2 661 (1 230)
Mean difference (SD) (urinary — dietary)	–3 113 (1 216)§	–2 419 (1 192)*	–2615 (1 233)§
(95% CI of difference)	–2 662 - –3604	–2 126 - –2 712	–2 360 - –2 870
Correlation (r)	–0.05	0.12‡	–0.08
Protein			
Urinary protein (g/day)	65.0 (20.8)	76.2 (28.1)	72.8 (26.5)
Dietary protein (g/day)	98.7 (45.5)	69.2 (34.1)	78.1 (40.0)
Mean difference (SD) (urinary — dietary)	–33.7 (43.1)§	7.0 (42.3)	–5.2 (46.3)
(95% CI of difference)	–17 - –50.4	–3.4 - 17.5	–14.8 - 4.3
Correlation (r)	0.34	0.09	0.08

* $P < 0.05$, Wilcoxon's matched pairs t-test for differences between urinary and dietary assessments.
† Median (interquartile range).
‡ $P < 0.05$, Spearman's correlation coefficients.
§ $P < 0.05$, paired t-test for difference between urinary and dietary assessments.

Reported current physical activity levels were significantly higher in women than men (3 478 (3 177) and 1 906 (2 709) kcal/week, respectively, $P < 0.05$), which was explained by a higher participation in housework by the women (3 003 (2 642) and 1 078 (2 190) kcal/week, respectively). Current activity was inversely associated with age ($r = -0.19$, $P = 0.052$). No association was found between any coronary heart disease (CHD) risk factors and reported current activity levels. 'Sit-to-stand' measure was associated with current activity ($r = 0.28$, $P < 0.005$). Regarding historical physical activity levels, a negative association was found between SBP and total moderate intensity (3 - 6 METS) activity during the age periods 14 - 24 years ($r = -0.19$, $P = 0.063$), 25 - 34 years ($r = -0.22$, $P < 0.05$) and 35 - 49 years ($r = -0.22$, $P < 0.05$). Of the three indices of composite past activity (occupation, leisure and housework) during all five age epochs, only total moderate intensity activity associated with occupation was correlated with SBP ($r = -0.24$, $P < 0.05$).

Discussion

The findings of this study have identified a population at high cardiovascular risk, with a similar profile to a slightly older sample of mixed-ancestry subjects in Cape Town.[30] In both men and women, a clustering of risk factors was seen, with 43% of subjects having either two or three of the risk factors investigated, namely diabetes, hypertension or hypercholesterolaemia. Further, a waist circumference of 92 cm or greater was associated with increased clustering of CHD risk factors. This association remained significant in regression models that included age, sex and smoking as potential confounders. Neither waist-to-hip ratio nor BMI (whether classified as a continuous variable, according to sex-specific tertiles, or using a cut-point of 30 or greater) was associated with a clustering of cardiovascular risk factors in either men or women.

The findings of this study support those from a much larger sample of the adult mixed-ancestry population in the village of Mamre, where a community-based hypertension programme has been initiated.[25] In that study, regardless of sex, a waist circumference of 92 cm or greater predicted the prevalence of type 2 diabetes, whereas BMI did not. The use of BMI across different populations to assess degree of total adiposity and associated health risks has recently been questioned because of the substantial variation in abdominal fat mass which may exist between individuals with the same BMI or total body fat mass.[31,32] Further, the interpretation of BMI is limited in the elderly because of a reduction in the proportion of lean body mass to fat mass with age that results in an empirical underestimation of fatness, as well as an age-associated reduction in height.[33]

Waist circumference is a convenient and simple measurement that is unrelated to height and therefore does not have the same inherent methodological problems as BMI. Moreover, it has been shown to be correlated with total visceral adipose tissue (VAT), measured by computed tomography.[34] In practical terms, the measurement of waist circumference alone to screen at-risk subjects for weight loss intervention, compared with a ratio calculation incorporating either waist and hip or weight and height measurements, takes less time for the clinician to perform and has a lower margin of potential observer-error. However, the importance of developing population-specific cut-points for waist circumference is demonstrated by the inability of previously published reference values from a Finnish population[24] to predict the number of cardiovascular risk factors in this study.

The alarmingly high prevalence of hypertension identified in this study, as well as in two other studies of older residents in Cape Town[3] and Paternoster,[9] suggests that the older mixed-ancestry South African population, wherever they live, is at particularly high risk of elevated BP. As well as obesity, excessive sodium chloride intake (in salt-sensitive individuals) and alcohol consumption are established causes of hypertension.[35] In the present study, 24-hour urinary sodium excretion, corrected for incompleteness of collection, corresponded with a dietary intake of about 9 g of salt per day, which exceeds the recommended value of 6 g or less per day of the US National High Blood Pressure Education Program (NHBPEP).[36] Urinary potassium concentrations were low compared with studies of untreated hypertensive patients in which mean values ranged from 52 to 71 mmol/day.[36-41] A randomised controlled trial[42] has shown that marginal deficiency of dietary potassium intake evokes salt-sensitivity in normotensive African-American men. Further studies are warranted to determine whether the high manifestation of hypertension commonly seen in the coloured population may be attributed to an increased sensitivity to salt, or whether it is a function of an inadequate dietary intake of potassium, calcium or other micronutrients.

The discrepancy between dietary and urinary estimations of sodium and potassium intakes in the present study indicates that a 14-day FFQ is unable to estimate intake of these electrolytes accurately. High intra- (45%) and inter- (45 - 56%) subject variability for reporting of non-discretionary salt sources (i.e. sodium inherent in food and salt added during food processing) has implications for the reliability of food record estimates; it has been estimated that 81 days of dietary recording would be required to estimate an individual's intake within 10% of the observed mean.[43] Correlations between urinary potassium and 16-day weighed dietary records (considered to be the gold standard of dietary assessment methods) of between 0.73[44] and 0.36[45] have been reported in studies of women aged 40 - 65 years. However, this type of dietary assessment is difficult to perform in epidemiological studies, and is not even attempted in studies of older people of low socio-economic status who are likely to have poor visual acuity, low literacy and numeracy skills and possible memory loss. Further studies that attempt to investigate associations between BP and dietary intake will need to account for these methodological difficulties in dietary assessment.

The finding that one-quarter of the women had reported energy intakes below two-thirds of the RDA, despite a high prevalence of obesity of almost 50%, further questions the validity of the 14-day food frequency method. Under-reporting of food intake by obese women has been well documented. An inverse association between BMI and error in dietary protein intake reporting was demonstrated in women in the present study; women with higher BMI values tended to under-report protein intake the most. However, reported energy intakes of women were not significantly different from estimated energy requirements, calculated using the age-adjusted prediction equation of Schofield *et al.*[29] Men, on the other hand, were found to systematically over-report both protein and energy intake. At least for protein, error in dietary reporting appears to be systematic for men (i.e. over-reporting), whereas in women the error is random, which suggests that the method may be acceptable for use in epidemiological studies for which group summary measures are used, provided that the sample size is large enough.

Regarding macronutrient intake, the energy profile of the diet closely resembles prudent dietary guidelines, at least in terms of percentage energy from fat sources (31.5% E). Surprisingly, although the subjects lived close to the sea, and had mostly been employed in the fishing industry, a high ω-6:ω-3 fatty acid intake ratio was reported, which suggests that the subjects were not consuming a high-fish diet. The high prevalence of hypercholesterolaemia, particularly in women, further supports the unfavourable reported fatty acid content of the diet.

It is noteworthy that historical, but not present, levels of physical activity were associated with lower SBP. Current physical activity energy expenditure was generally low and mean activity levels were less than half of those reported for older North Americans using the same questionnaire.[18] The higher activity levels of women compared with men may be explained by greater participation in housework, a trend also found in an urban Cape Town sample.[46] It may be assumed that the instrument used to assess present activity in this older sample had acceptable construct validity since a significant association was found between the composite index of activity and a 'sit-to-stand' measurement, which is an indicator of lower body strength and therefore physical functioning. This information highlights for the first time, among older South Africans of low socio-economic status, the importance of determining past levels of physical activity, particularly moderate-intensity activities associated with previous occupation, in studies which attempt to determine physiological and metabolic risk or benefit associated with different lifestyles.

Conclusions

A high prevalence of cardiovascular risk factors was found, and clustering of more than one risk factor was common in a sample of older subjects of low socio-economic status, living in villages on the West Coast of South Africa. Neither BMI nor waist-to-hip ratios were useful measures of cardiovascular risk factor clustering in this population. It is suggested that a waist circumference reference value of 92 cm or greater be used to identify individuals in greatest need of lifestyle modification advice. The challenge remains to develop effective, accessible, culturally-appropriate models for the prevention and management of central obesity in South African communities that are already advanced in the epidemiological transition.

This study was supported by a research grant from the Medical Research Council, Tygerberg, South Africa.

Dr Derrick Veldman, Department of Chemical Pathology, Technikon of the Free State, South Africa, is thanked for performing the urinary analyses. This work was carried out, in part, while K. E. Charlton was a Researcher at the HSRC/UCT Centre for Gerontology, University of Cape Town.

References

1. Steyn K, Jooste PL, Langenhoven ML, *et al.* Coronary risk factors in the coloured population of the Cape Peninsula. *S Afr Med J* 1985; **67:** 619-625.
2. Steyn K, Jooste PL, Fourie JM, Parry CDH, Rossouw JE. Hypertension in the coloured population of the Cape Peninsula. *S Afr Med J* 1986; **69:** 165-169.
3. Charlton KE, Fourie JM, Steyn K, Lombard CJ. Prevalence of hypertension among the elderly coloured population of the Cape Peninsula. *S Afr Med J* 1997; **87:** C75-C80.
4. Charlton KE, Levitt NS, Lombard CJ. Prevalence of NIDDM and associated risk factors in elderly coloured South Africans. *S Afr Med J* 1997; **87:** 364-367.
5. Bang HO, Dyerberg J, Nielsen AB. Plasma lipid and lipoprotein pattern in Greelandic West coast Eskimoes. *Lancet* 1971; **i:** 1143-1146.
6. Kagawa Y, Nishizawa M, Suzuki M, *et al.* Eicosapentanoeic acids of serum lipids of Japanese Islanders with low incidence of cardiovascular diseases. *J Nutr Sci Vitaminol* 1982; **28:** 441-453.
7. Simopolous AP. Omega-3 fatty acids in health and disease and in growth and development. *Am J Clin Nutr* 1991; **54:** 438-463.
8. Simopolous AP. Summary of the NATO advanced research workshop on dietary ω-3 and ω-6 fatty acids: biological effects and nutritional essentiality. *J Nutr* 1989; **119:** 521-528.
9. Schloss I, Kidd MSG, Tichelaar HY, Young GO, O'Keefe SJD. Dietary factors associated with a low risk of colon cancer in coloured West Coast fishermen. *S Afr Med J* 1997; **87:** 152-158.
10. American Heart Association. *Recommendation for Human Blood Pressure Determination by Sphygmomanometers.* Dallas: AHA, 1967.
11. World Health Organisation Expert Committee. Arterial hypertension. *World Health Organ Tech Rep Ser* 1978; No. 628.
12. Trinder P. Determination of blood glucose using 4-amino phenasone as oxygen acceptor. *J Clin Pathol* 1969; **22:** 246.
13. World Health Organisation Study Group on Diabetes Mellitus. Diabetes mellitus: Report of a WHO Study Group. *World Health Organ Tech Rep Ser* 1985; No. 727.
14. American Diabetes Association. Clinical Practice Recommendations. Report of the Expert Committee on Diagnosis and Classification of Diabetes Mellitus. *Diabetes Care* 1999; **22:** Suppl 1, S1-S114.
15. Bingham SA, Cummings JH. The use of 4-amino benzoic acid as a marker to validate the completeness of 24 h urine collections in man. *Clin Sci* 1983; **64:** 629-635.
16. Langenhoven MJ, Conradie PJ, Wolmarans P, Faber M. *MRC Food Quantities Manual.* 2nd ed. Tygerberg: Medical Research Council, 1991.
17. Langenhoven ML, Kruger M, Gouws E, Faber M. *Food Composition Tables.* 3rd ed. Parow: Medical Research Council, 1991.
18. Dipietro L, Casprese CJ, Ostfeld AM, Nadel ER. A survey for assessing physical activity among older adults. *Med Sci Sports Exerc* 1993; **25:** 628-642.
19. Lambert EV, Charlton KE. Energy expenditure and habitual physical activity levels. In: Charlton KE, Wolmarans P, eds. *Food Habits, Dietary Intake and Health of Older South Africans.* Cape Town: HSRC/UCT Centre for Gerontology, 1995: 148-159.
20. Kriska AA, Sandler RB, Couley JA, LaPorte RG, Hom DL, Pambianco G. The assessment of historical physical activity and its relation to adult bone parameters. *Am J Epidemiol* 1998; **127:** 1053-1063.
21. Brown M, Sinacove DR, Host HH. The relationship of strength to function in the older adult. *J Gerontol A Biol Sci Med Sci* 1995; **50A:** 55-59.
22. Cruickshank JM. Coronary flow reserve and the J curve relation between diastolic blood pressure and myocardial infarction. *BMJ* 1988; **297:** 1227-1230.
23. World Health Organisation. *Obesity: Preventing and Managing the Global Epidemic. Report On a Consultative Meeting.* Geneva: WHO, 1997.
24. Han TS, Van Leer EM, Seidell JC, Lean ME. Waist circumference action levels in the identification of cardiovascular risk factors: prevalence study in a random sample. *BMJ* 1995; **311:** 1401-1405.
25. Levitt NS, Steyn K, Lambert EV, *et al.* Modifiable risk factors for type 2 diabetes in a peri-urban community in South Africa. *Diabet Med* 1999; **16:** 946-950.
26. Charlton KE, Wolmarans P, eds. *Food Habits, Dietary Intake and Health of Older Coloured South Africans.* Cape Town: HSRC/UCT Centre for Gerontology, 1995.
27. Institute of Medicine: Food and Nutrition Board. *Dietary Reference Intakes for Calcium, Phosphorus, Magnesium and Vitamin D and Fluoride.* Washington, DC: National Academy Press, 1997.
28. Subcommittee on the Tenth Edition of the RDAs. *Recommended Dietary Allowances.* 10th Food and Nutrition Board, Commission on Life Sciences, National Research Council. Washington, DC: National Academy Press, 1989: 1-285.
29. Schofield WN, Schofiled C, James WPT. Basal metabolic rate prediction. *J Hum Nutr Clin Nutr* 1985; **39C:** suppl 1, 1-96.
30. Charlton KE, Wolmarans P, Marais AD, Lombard CJ. Nutritional status of older coloured South Africans: Macronutrient intake, food habits and cardiovascular risk profiles. *East Afr Med J* 1997; **74:** 478-486.
31. Lovejoy JC, de la Bretonne JA, Klemperer M, Tulley R. Abdominal fat distribution and metabolic risk factors: effects of race. *Metabolism* 1996; **45:** 1119-1124.
32. Swinburn BA, Craig PL, Daniel R, Dent DP, Strauss BJ. Body composition differences between Polynesian and Caucasians assessed by bioelectrical impedance. *Int J Obes Relat Metab Disord* 1996; **20:** 889-894.
33. Enzi G, Gasparo M, Biondetti PR, Fiore D, Semisa M, Zurlo F. Subcutaneous and visceral fat distribution according to sex, age and overweight, evaluated by computed tomography. *Am J Clin Nutr* 1987; **45:** 7-13.
34. Whelton PK, Kumanyika SK, Cook NR, *et al.* Efficacy of nonpharmacological interventions in adults with high-normal blood pressure: results from phase 1 of the Trials of Hypertension Prevention. *Am J Clin Nutr* 1997; **65:** suppl, 625S-660S.
35. National High Blood Pressure Education Program. Sixth report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. *Arch Intern Med* 1997; **157:** 2413-2446.
36. Smith SR, Klotman PE, Svetkey LP. Potassium chloride lowers blood pressure and causes natriuresis in elderly hypertensive patients. *J Am Soc Nephrol* 1992; **2:** 1302-1309.
37. Fotherby MD, Potter JF. Potassium chloride lowers clinical and ambulatory blood pressure in elderly hypertensive patients. *J Hypertens* 1992; **10:** 1403-1408.
38. Cushman WC, Langford HG. Randomized control trial of potassium chloride versus placebo in mildly hypertensive blacks and whites (Abstract). *Circulation* 1988; **78:** II-370.
39. Valdes G, Vio CP, Montero J, Avendano R. Potassium supplementation lowers blood pressure and increases urinary kallikrein in essential hypertension. *J Hum Hypertens* 1991; **5:** 91-96.
40. Patki PS, Singh J, Gokhale SV, Bulakh PM, Shrotri DS, Patwardham B. Efficacy of potassium and magnesium in essential hypertension: a double-blind, placebo-controlled, crossover study. *BMJ* 1990; **301:** 521-523.
41. Chalmers J, Morgan T, Doyle A, *et al.* Australian National Health and Medical Research Council Dietary Salt Study in Mild Hypertension. *J Hypertens* 1986; **4:** suppl 6, S629-S637.
42. Morris RC, Sebastian A, Forman A, Tanaka M, Schmidlin O. Normotensive salt sensitivity. Effects of race and dietary potassium. *Hypertension* 1998; **33:** 18-23.
43. Mattes RD, Donnelly D. Relative contributions of dietary sodium sources. *J Am Coll Nutr* 1991; **10:** 383-393.
44. Bingham SA, Cassidy A, Cole TJ, *et al.* Validation of weighed records and other markers of dietary assessment using the 24 h urine nitrogen technique and other biological markers. *Br J Nutr* 1995; **73:** 531-550.
45. Gregory J, Foster K, Tyler H, Wiseman M. *The Dietary and Nutritional Survey of British Adults.* London: HMSO, 1990.
46. Charlton KE, Lambert EV, Kreft J. Physical activity, change in blood pressure and predictors of mortality in older South Africans — a 2-year follow-up study. *S Afr Med J* 1997; **87:** 1124-1130.