Prevalence of ischaemic ECG abnormalities according to the diabetes status in the population of Fiji and their associations with other risk factors

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Summary

The prevalence of ECG abnormalities indicating the presence of coronary heart disease was examined in the Melanesian (444 men and 457 women) and Asian Indian (408 men and 435 women) population living in Fiji. The aim of the present analysis was to determine the levels of coronary risk factors in people with diabetes, impaired glucose tolerance (IGT) or normal glucose tolerance. The prevalence of ECG abnormalities suggesting coronary heart disease (Q-waves, ST-depression or T-wave changes) was higher among women than men and among Asian Indians than Melanesians. The prevalence of ECG abnormalities was highest in diabetic subjects, intermediate in people with IGT and lowest in people who had normal glucose tolerance. People with IGT were more likely than others to have high risk factor levels. In people with IGT the increased levels of other coronary risk factors might explain a great deal of the increased prevalence of the ECG abnormalities as compared with the prevalence in those with normal glucose tolerance. Also in diabetic subjects, the levels of other coronary risk factors were increased in those who had ECG abnormalities, but not more than was the case with IGT, so that diabetes itself seemed to remain as the major identified risk factor for ECG abnormalities. The prevalence of diabetes in our study populations, especially in Asian Indians, was very high. This suggests that diabetes is the major risk factor for coronary heart disease in such populations.

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Introduction

Diabetes mellitus, which affects about 2% of the world's population, is associated with a significantly increased morbidity and mortality [1,2]. Despite the efforts to prevent this disease, its prevalence appears to be on the increase, in the industrialised as well as in the developing countries [3] and especially in the Pacific Islands [4–7].

The relationship between coronary heart disease (CHD) and diabetes mellitus has attracted attention for many years. A positive association has been reported in several studies [1,2,8–12]. Although some investigators have suggested that asymptomatic hyperglycaemia or impaired glucose tolerance (IGT) may increase the risk of CHD [13–18], debate exists as to whether there is a true causal association. Main reasons why this issue is still controversial are that many earlier studies have not been based on representative population samples, that the criteria for IGT have not been appropriate and that the impact of other risk factors for CHD has not been adequately taken into account.

In the present report we examined the prevalence of ischaemic ECG changes in subjects with diabetes mellitus, IGT and normal glucose tolerance in the biracial population of Fiji based on survey data from the population. In particular, we attempted to explore the question whether other coronary risk factors were associated with the ischaemic ECG changes in the same way in all three categories of glucose tolerance.

Materials and methods

Background information
Fiji is a group of islands located in the South-West Pacific with a population of about 600 000. About 43% are indigenous Melanesians (of Mongoloid origin) and 52% Hindi-speaking Asian Indian (Caucasoids) whose ancestors migrated to Fiji at the end of the 19th century. The prevalence of diabetes is significantly higher among Asian Indians than Melanesians in Fiji and the statistics on mortality and hospital admissions in Fiji suggest that the occurrence of CHD is also higher in Asian Indians [8,11].

Survey
In a survey carried out in 1980, 1340 Melanesians and 1298 Asian Indians were selected both from Suva, the capital of Fiji, where the population is nearly completely urbanised, and from the Sigatoka Valley, a relatively isolated rural area, where the Melanesians live as subsistence farmers and the Indians are involved in subsistence and cash-crop agriculture. Sampling methods, response rates and survey procedures are described in more detail elsewhere [19]. The participation rates varied from 83.2% to 89.6% in the urban and rural samples of each ethnic group.

Methods

Impaired glucose tolerance (IGT) was defined according to the current WHO (1985) criteria [20] in people who were not known to be diabetic and who had 2-h post-75-g glucose load plasma glucose levels between 7.8 and 11.0 mmol/l.

Diabetes mellitus was also defined according to WHO (1985) criteria. People whose 2-h plasma glucose levels after a 75-g glucose load were 11.1 mmol/l (200 mg/dl) or greater were considered to have diabetes, or known diabetes.

Body mass index (BMI) was used as a measure of obesity and calculated as follows:

$$BMI = \frac{\text{weight (kg)}}{[\text{height (m)}]^2}$$

Obesity was defined as a BMI of 29.0 or more. The groups with a BMI of less than 29.0 contained people who may have had overweight but not more than 10–15%.

Blood pressure was recorded using a Hawksley random zero mercury sphygmomanometer with the subject seated for at least 10 min. Usually a 14-cm-wide and 22-cm-long cuff was used, but larger cuffs were selected for obese people. Blood pressure was recorded to the closest 2 mm Hg and diastolic blood pressure was defined as the fifth phase of Korotkoff sounds. Two recordings were taken and the mean of the two readings was used as the individual's pressure in the present analysis.

Serum cholesterol. Serum cholesterol and triglyceride levels were determined from frozen sera, using a SMAC 20 (Technicon Instrument Corporation).

Serum uric acid concentrations were determined by a colorimetric method also using a SMAC 20.

Cardiac auscultation and a resting 12-lead electrocardiogram (ECG) were performed on people aged 30 years or over. ECGs were coded in Melbourne according to the Minnesota code [21] by two independent observers. If they did not agree, a third person's assessment was used for the final judgement. ECG abnormalities were further allocated to the following categories suggesting the presence of CHD: (a) Q/QS-wave changes (codes 1.1.–1.3.), (b) ST-depressions (codes 4.1.–4.4.) or T-wave inversion or flattening (codes 5.1.–5.3.). and (c) left bundle-branch block (code 7.1.). The presence of any of these abnormalities was regarded as indicative of CHD. All other ECGs were classified as normal. This ECG classification has been used in several other studies including the Whitehall study [18] and the WHO Multinational Study on Macrovascular Complications of Diabetes Mellitus [22]. It is known that Q-waves are specific for CHD or for previous myocardial infarction but the sensitivity is low. The sensitivity of ST-T wave changes is somewhat greater but they are not so specific for CHD as Q-waves are.

In the data analysis, people with diagnosed congenital or rheumatic heart disease were excluded. As smoking did not contribute to the ECG abnormalities in univariate analyses of our cross-sectional data it was not included in final analyses.

Data were collected on standardised forms and were stored in the computer centre in Melbourne and from there the data were transferred to the University of Kuopio in Finland where they were analysed. In the data analysis, a Digital Vax-780 computer with an SPSS software package was used.

The statistical significance of the variance levels of known coronary risk factors between the categories of ECG changes (0 = no ECG abnormalities; 1 = ECG abnormalities detected) and the significance between pairs of categories of diabetes mellitus (0 = normal glucose tolerance, 1 = IGT, 2 = diabetes mellitus) were tested by analysis of covariance (ANCOVA). In the test, covariance correction for age was made. All mean values shown in Tables 2–8 are corrected for age. Statistical inferences were based on the *F*-ratio statistics from the ANCOVA models [23], where *F*-ratio = between-groups mean square/within-groups mean square. The observed significance level is the probability of obtaining an *F* statistic at least as large as one calculated when all population means are equal. If this probability is small enough, the hypothesis that all means are equal is rejected. A significant *F* statistic indicates only that the population means are probably unequal. It does not show where the differences are, but such inferences from data can be often done simply by visual inspection of actual mean values. If the interaction between two variables, ECG abnormalities and diabetes status, is significant in the ANCOVA model, it means that these two variables jointly effect the dependent variable. If there is no significant interaction, statistical testing will be based on both variables individually.

Results

Table 1 gives the number of people in the study by Q-wave or ST-segment changes in ECG, their glucose tolerance status, ethnic origin and gender. Generally, Q-wave or ST-segment changes were more frequent in Asian Indians than the Melanesian study population. Women had a higher prevalence of ECG changes than men in nearly all groups, the only exception being diabetic Asian Indians. There was a tendency that persons who had overt diabetes mellitus had the highest prevalence of ischaemic ECG changes, varying from 22.7% to 36.0%.

People with IGT had a slightly lower prevalence of ECG abnormalities than those with diabetes, but compared with those who had normal glucose tol-

TABLE I

NUMBER OF PEOPLE AND AGE-ADJUSTED[a] PERCENTAGE OF Q-WAVE OR ST-SEGMENT CHANGES, DIABETES STATUS, ETHNIC ORIGIN AND SEX

Diabetes status		Men						Women					
		Melanesian			Indian			Melanesian			Indian		
		Q-wave or ST-segment changes			Q-wave or ST-segment changes			Q-wave or ST-segment changes			Q-wave or ST-segment changes		
		No	Yes	Total	No	Yes	Total	No	Yes	Total	No	Yes	Total
Normal	*n*	344	31	375	250	25	275	282	59	341	227	53	280
	%	91.5	8.5	100.0	89.7	10.3	100.0	82.3	17.7	100.0	80.7	19.3	100.0
IGT[b]	*n*	29	6	35	34	11	45	56	16	72	37	25	62
	%	83.8	16.2	100.0	73.2	26.8	100.0	79.0	21.0	100.0	62.3	37.7	100.0
Diabetes	*n*	17	5	22	48	27	75	27	11	38	53	23	76
	%	70.2	29.8	100.0	69.4	30.6	100.0	74.5	25.5	100.0	79.9	21.0	100.0
Total	*n*	390	42	432	332	63	395	365	86	451	317	101	418
	%	90.5	9.5	100.0	84.0	16.0	100.0	80.7	19.3	100.0	75.7	24.3	100.0

[a] To the total Melanesian and Indian population at the 1976 census (age > 30 years) by the direct method.
[b] IGT = Impaired glucose tolerance.

erance, the prevalence in people with IGT was 2–3 times higher. The higher overall prevalence of ECG abnormalities in Asian Indians was due to the difference between the two ethnic groups in people with IGT and diabetes, whereas the ECG abnormalities in people with normal glucose tolerance were equally common in the two ethnic groups, about 10% in men and slightly less than 20% in women.

The analysis of the association between Q-wave changes only in ECG and various cardiovascular risk factors showed that after adjusting for age, the only significant differences were found in plasma cholesterol and uric acid levels and only in Melanesian men. None of the other variables (blood pressure, plasma triglycerides and body mass index) correlated significantly with Q-wave changes. In women, the number of cases with Q-wave changes was too small to allow any useful analyses.

In Table 2 the mean values of plasma cholesterol and serum uric acid by Q-wave changes are shown in men by glucose tolerance status and ethnic origin. In Melanesian men, plasma cholesterol was significantly higher ($P = 0.009$) in persons having Q-wave changes (5.3 mmol/l) than in those without such changes (4.4 mmol/l). Also IGT seemed to be associated with an elevated plasma cholesterol. In Indian men, the plasma cholesterol level was significantly higher in people with diabetes or IGT than in those with normal glucose tolerance. Q-wave abnormalities were associated with plasma cholesterol only in Indians with normal glucose tolerance (interaction: Q wave changes – diabetes status $P = 0.058$).

In Melanesian men the plasma uric acid level was significantly higher in those with ischaemic Q-wave changes (0.46 mmol/l) than in men without (0.38 mmol/l), regardless of glucose tolerance status (Table 2). In Indian men such a difference was not found.

The mean values of risk factors shown in Tables 3–7 are adjusted for age so that the effect of age is eliminated.

In every ethnic and sex group diabetes status had

TABLE 2

MEAN VALUES OF PLASMA CHOLESTEROL (mmol/l) AND PLASMA URIC ACID (mmol/l) ADJUSTED FOR AGE BY Q-WAVE CHANGES, DIABETES STATUS AND ETHNIC ORIGIN IN MEN (NUMBERS IN PARENTHESES)

Diabetes status	Cholesterol						Uric acid					
	Melanesian			Indian			Melanesian			Indian		
	Q-wave changes			Q-wave changes			Q-wave changes			Q-waves changes		
	No	Yes	Total	No	Yes	Total	No	Yes	Total	No	Yes	Total
Normal	4.4	4.9	4.4	4.6	5.5	4.6	0.38	0.48	0.38	0.36	0.34	0.36
	(354)	(5)	(359)	(258)	(5)	(263)	(352)	(5)	(357)	(261)	(5)	(266)
IGT	5.0	6.4	5.0	5.1	3.7	5.0	0.39	0.42	0.39	0.38	0.25	0.37
	(30)	(3)	(33)	(33)	(2)	(35)	(30)	(3)	(33)	(34)	(2)	(36)
Diabetes	4.3	5.3	4.3	5.4	5.2	5.4	0.38	0.48	0.38	0.31	0.28	0.31
	(16)	(2)	(18)	(48)	(14)	(62)	(17)	(1)	(18)	(49)	(7)	(56)
Total	4.4	5.3	4.5	4.8	4.8	4.8	0.38	0.46	0.38	0.35	0.31	0.35
	(400)	(10)	(410)	(339)	(21)	(360)	(399)	(9)	(408)	(344)	(14)	(358)

ANCOVA:	Cholesterol Melanesian	Cholesterol Indian	Uric acid Melanesian	Uric acid Indian
Main effects:				
Diabetes status	$P = 0.002$	$P < 0.001$	N.S.	$P < 0.001$
Q-waves	$P = 0.009$	N.S.	$P < 0.001$	N.S.
Interaction:	N.S.	$P = 0.058$	N.S.	N.S.
Covariate: Age	$P = 0.005$	N.S.	N.S.	$P = 0.013$

a statistically significant association with systolic blood pressure. Also in every group except in diabetic Indian women people with ECG abnormalities had significantly higher mean systolic blood pressure levels than people with normal ECG after adjusting for age and glucose tolerance status (Table 3). The lowest mean values of systolic blood pressure adjusted for age were found in people who had no Q-wave or ST-segment changes and who also had normal glucose tolerance in both sexes (Table 3). In every subgroup the mean systolic blood pressure level was higher in those who had Q-wave or ST-segment abnormalities than in those who did not, with the exception of diabetic Indian women. Of the three categories of diabetes status the highest systolic blood pressure values were usually seen in those with IGT, but in Melanesian men who had no ECG abnormalities the highest value of systolic blood pressure was in diabetic men.

In Melanesian women, the mean value of systolic blood pressure was highest in those with IGT, second highest in diabetics and lowest in those with normal glucose tolerance. In Indian women, the highest mean value was found in those with diabetes and the lowest in those with normal glucose tolerance.

The mean diastolic blood pressure values adjusted for age were also significantly and independently associated with Q-wave or ST-segment changes in each ethnic and sex group (Table 4). The highest mean diastolic blood pressure levels were found in Melanesians with IGT and in Indians with diabetes.

Overall, the lowest diastolic blood pressure mean values were found in people with a normal glucose tolerance and a normal ECG in all ethnic and sex groups. Among diabetic patients with ECG abnormalities the diastolic blood pressure level was higher than in those with a normal ECG. The interac-

TABLE 3

MEAN VALUES OF SYSTOLIC BLOOD PRESSURE (mm Hg) ADJUSTED FOR AGE BY Q-WAVE OR ST-SEGMENT CHANGES, DIABETES STATUS, ETHNIC ORIGIN AND SEX

Diabetes status	Men				Women			
	Melanesian		Indian		Melanesian		Indian	
	Q-wave or ST-segment changes		Q-wave or ST-segment changes		Q-wave or ST-segment changes		Q-wave or ST-segment changes	
	No	Yes	No	Yes	No	Yes	No	Yes
Normal	124	132	122	141	127	137	119	127
IGT	133	149	129	148	138	149	126	131
Diabetes	136	139	129	144	136	138	136	135
Total	125	134	124	142	129	139	123	128
ANCOVA:								
Main effects:								
Diabetes status	$P = 0.001$		$P < 0.016$		$P < 0.001$		$P < 0.001$	
Q-wave or ST-segment changes	$P = 0.005$		$P < 0.001$		$P < 0.001$		$P = 0.04$	
Interaction:	N.S.		N.S.		N.S.		N.S.	
Covariate: Age	$P = 0.001$		$P < 0.001$		$P < 0.001$		$P = 0.001$	

TABLE 4

MEAN VALUES OF DIASTOLIC BLOOD PRESSURE (mm Hg) ADJUSTED FOR AGE BY Q-WAVE OR ST-SEGMENT CHANGES, DIABETES STATUS, ETHNIC ORIGIN AND SEX

Diabetes status	Men				Women			
	Melanesian		Indian		Melanesian		Indian	
	Q-wave or ST-segment changes		Q-wave or ST-segment changes		Q-wave or ST-segment changes		Q-wave or ST-segment changes	
	No	Yes	No	Yes	No	Yes	No	Yes
Normal	74	81	74	85	76	83	71	76
IGT	82	89	79	84	82	86	72	78
Diabetes	78	74	79	87	80	78	79	79
Total	75	81	76	82	77	83	73	77
ANCOVA:								
Main effects:								
Diabetes status	$P = 0.005$		$P < 0.046$		$P < 0.02$		$P < 0.003$	
Q-wave or ST-segment changes	$P = 0.006$		$P < 0.001$		$P < 0.001$		$P = 0.008$	
Interaction:	N.S.		N.S.		N.S.		N.S.	
Covariate: Age	$P = 0.027$		$P < 0.009$		$P < 0.001$		$P = 0.001$	

TABLE 5

MEAN VALUES OF PLASMA URIC ACID (mmol/l) ADJUSTED FOR AGE BY Q-WAVE OR ST-SEGMENT CHANGES, DIABETES STATUS, ETHNIC ORIGIN AND SEX

Diabetes status	Men				Women			
	Melanesian		Indian		Melanesian		Indian	
	Q-wave or ST-segment changes		Q-wave or ST-segment changes		Q-wave or ST-segment changes		Q-wave or ST-segment changes	
	No	Yes	No	Yes	No	Yes	No	Yes
Normal	0.37	0.43	0.35	0.36	0.32	0.34	0.26	0.32
IGT	0.39	0.43	0.37	0.36	0.35	0.39	0.30	0.33
Diabetes	0.37	0.38	0.31	0.34	0.33	0.35	0.28	0.28
Total	0.38	0.42	0.35	0.36	0.33	0.35	0.27	0.31
ANCOVA:								
Main effects:								
Diabetes status	N.S.		$P < 0.002$		$P < 0.002$		N.S.	
Q-wave or ST-segment changes	$P = 0.001$		N.S.		$P < 0.002$		$P = 0.015$	
Interaction:	N.S.		N.S.		N.S.		N.S.	
Covariate: Age	$P = 0.093$		$P = 0.012$		$P = 0.002$		$P = 0.085$	

TABLE 6

MEAN VALUES OF PLASMA CHOLESTEROL (mmol/l) ADJUSTED FOR AGE BY Q-WAVE OR ST-SEGMENT CHANGES, DIABETES STATUS, ETHNIC ORIGIN AND SEX

Diabetes status	Men				Women			
	Melanesian		Indian		Melanesian		Indian	
	Q-wave or ST-segment changes		Q-wave or ST-segment changes		Q-wave or ST-segment changes		Q-wave or ST-segment changes	
	No	Yes	No	Yes	No	Yes	No	Yes
Normal	4.4	4.6	4.6	4.9	4.5	4.6	4.3	4.2
IGT	5.0	5.7	5.1	4.9	4.7	4.3	4.6	4.6
Diabetes	4.3	5.0	5.4	4.8	4.8	4.7	4.8	4.5
Total	4.5	4.8	4.8	4.6	4.6	4.5	4.4	4.3
ANCOVA:								
Main effects:								
Diabetes status	$P = 0.001$		$P < 0.001$		N.S.		$P = 0.003$	
Q-wave or ST-segment changes	$P = 0.052$		N.S.		N.S.		N.S.	
Interaction:	N.S.		$P = 0.05$		N.S.		N.S.	
Covariate: Age	$P = 0.015$		N.S.		$P = 0.001$		$P = 0.001$	

tion between diabetes status and the ECG abnormalities with regard to diastolic pressure was, however, statistically not significant.

The mean values of plasma uric acid level are shown in Table 5. In all study groups, higher serum uric acid levels were found in those having Q-wave or ST-T-segment changes compared with those with a normal ECG. In both ethnic groups and in both genders, people with IGT had the highest plasma uric acid levels, but statistical significance between the three categories of diabetes status was reached only in Indian men and Melanesian women.

In people with normal glucose tolerance the uric acid levels tended to be higher if ECG abnormalities were present. In diabetic patients such a difference was smaller. The interaction between diabetes status and ECG abnormalities did, however, not exceed random variation.

Plasma cholesterol associated significantly with diabetes status in every ethnic and sex group except in Melanesian women, but with ECG abnormalities only in Melanesian men. The age-adjusted mean values of plasma cholesterol were highest in diabetic patients in all ethnic and gender groups except in Melanesian men in whom the highest mean value was found in those with IGT (Table 6). The lowest cholesterol level was found in people with normal glucose tolerance. Only in Melanesian men was the association between plasma cholesterol and Q-wave or ST-T-segment changes statistically significant ($P = 0.052$).

The age-adjusted mean values of plasma triglycerides in people with diabetes and those with IGT were higher than in people with normal glucose tolerance ($P < 0.001$ in Indian men; $P = 0.001$ in Indian women and in Melanesian men and women; Table 7). However, in Indian men with Q-wave or ST-T changes the plasma triglyceride level was highest in those with normal glucose tolerance ($P = 0.011$). The association between plasma triglyceride level and the ECG abnormalities was statistically significant only in Melanesian men ($P = 0.052$).

TABLE 7

MEAN VALUES OF SERUM TRIGLYCERIDE (mmol/l) ADJUSTED FOR AGE BY Q-WAVES OR ST-SEGMENT CHANGES, DIABETES STATUS, ETHNIC ORIGIN AND SEX

Diabetes status	Men				Women			
	Melanesian		Indian		Melanesian		Indian	
	Q-wave or ST-segment changes		Q-wave or ST-segment changes		Q-wave or ST-segment changes		Q-wave or ST-segment changes	
	No	Yes	No	Yes	No	Yes	No	Yes
Normal	1.1	1.4	1.4	1.8	1.1	1.2	1.1	1.1
IGT	1.6	1.8	2.0	1.5	1.4	1.2	1.3	1.2
Diabetes	1.6	1.9	2.1	1.6	1.5	1.4	1.5	1.7
Total.	1.2	1.4	1.6	1.5	1.2	1.2	1.2	1.3

	Men Melanesian	Men Indian	Women Melanesian	Women Indian
ANCOVA:				
Main effects:				
Diabetes status	$P = 0.001$	$P < 0.001$	$P = 0.001$	$P = 0.001$
Q-wave or ST-segment changes	$P = 0.052$	N.S.	N.S.	N.S.
Interaction:	N.S.	$P = 0.011$	N.S.	N.S.
Coviarate: Age	N.S.	N.S.	$P = 0.02$	$P = 0.001$

TABLE 8

MEAN VALUES OF BODY MASS INDEX (BMI) ADJUSTED FOR AGE BY Q-WAVE OR ST-SEGMENT CHANGES, DIABETES STATUS, ETHNIC ORIGIN AND SEX

Diabetes status	Men				Women			
	Melanesian		Indian		Melanesian		Indian	
	Q-wave or ST-segment changes		Q-wave or ST-segment changes		Q-wave or ST-segment changes		Q-wave or ST-segment changes	
	No	Yes	No	Yes	No	Yes	No	Yes
Normal	26.2	27.9	22.5	24.7	27.9	29.7	23.7	24.4
IGT	28.6	32.3	24.3	26.3	29.4	31.6	26.0	29.3
Diabetes	26.9	25.2	23.8	25.6	29.3	33.6	27.8	27.7
Total	26.4	28.1	22.9	25.0	28.3	30.4	24.8	25.8
ANCOVA:								
Main effects:								
Diabetes status	$P = 0.001$		$P < 0.003$		$P = 0.017$		$P < 0.001$	
Q-wave or ST-segment changes	$P = 0.014$		$P < 0.001$		$P = 0.001$		$P = 0.07$	
Interaction:	N.S.		N.S.		N.S.		N.S.	
Covariate: Age	N.S.		N.S.		N.S.		$P = 0.001$	

Among men in both ethnic groups the highest body mass index (BMI) levels were found in those with IGT (Table 8). Diabetic women appeared to have the highest BMI mean values except Indian women with Q-wave or ST-T-segment changes. Overall, BMI was found to be significantly higher in people who had ECG abnormalities than in those with a normal ECG, regardless of glucose tolerance status.

Discussion

The results of the cardiovascular and metabolic survey in 1980 showed that ECG changes suggestive of coronary heart disease were common in the population of Fiji. The age-adjusted prevalences of such ECG changes in both Melanesian and Asian Indian men and women were higher than in many European and American populations [18,24–29]. ECG abnormalities were more common in women than men. This finding is consistent with data from other population studies [24–27]. The reasons for such a sex differential are not well known.

ST-segment depression and/or T-wave abnormalities on the resting ECG are among the most common findings in screening of adult populations. The association of ST-T abnormalities, and especially that of Q-wave changes, with increased CHD mortality has been shown in several studies [10,18,24,26–33]. Most of these studies have dealt with men only. A recent report from the U.S.A. suggested that in a cross-sectional situation the prevalence of ST-T abnormalities was higher in women than men [27]. Univariate analysis during an 11.5-year follow-up showed a positive association of such ECG changes with the mortality from CHD for both genders. The risk of CHD death was, however, much greater in men than women, and when adjusting for several coronary risk factors in a multivariate analysis ST-T abnormalities remained significantly related to death from CHD in men but not women. The conclusion of the authors of the U.S.A. study was that the criteria for normal ECG remain the same for men and women for the present, since the exact nature and range of the sex differences in normal ECG variation are not known, but that further research is needed to clarify whether different criteria for ST-T abnormalities may be appropriate for the two genders [27].

In the present analysis we compared the levels of putative coronary risk factors in people with and without ECG abnormalities. The most important confounding factor, age, was controlled for by the analysis of covariance. As diabetes is known to increase the risk of coronary heart disease, we also stratified the study material using the WHO criteria for the diagnostic classification of diabetes [20]. This made it possible to investigate whether the risk factors were associated with the ECG abnormalities in the same way in people with diabetes as in those with IGT or normal glucose tolerance and whether adjustments for other risk factors altered the estimates of the effects of IGT and diabetes or coronary disease.

The age-adjusted prevalence of ischaemic ECG abnormalities was highest in people with diabetes, second highest in those with IGT and lowest in those with normal glucose tolerance, except in Asian Indian women. As many as 39.7% of Asian Indian women with IGT had an abnormal ECG. Overall, in diabetic subjects, this prevalence varied between 23 and 36% in different ethnic and gender groups. In diabetic Melanesian men ECG abnormalities were 2.8 times and in Asian Indian men 4.1 times more common than in men with normal glucose tolerance. In women the differential was smaller due to the high prevalence of ECG abnormalities in women with normal glucose tolerance, which was about twice that of such men in both ethnic groups. A similar but smaller gender differential was found in the prevalence of ECG abnormalities in people with IGT.

Some prospective studies have suggested that diabetic women run a greater relative risk of coronary heart disease than diabetic men [1,2]. Our cross-sectional data, in accordance with the results of a recent study in Finland [13], do not unequivocally show such a difference between genders. The Finnish study used a cross-sectional case–control study design and the diabetic patients were newly diagnosed. In our study, too, the majority of diabetic subjects were first diagnosed as being diabetic during the survey [7].

As the WHO criteria for diabetes are relatively new (first given in 1980 and revised in 1985) there are not many reports on the prevalence of and risk factors for coronary heart disease in people with IGT based on the WHO definition [20]. It has been debated whether mild, asymptomatic hyperglycaemia will result in damage to the heart [18]. Follow-up studies of populations applying the new WHO criteria are needed to answer this question. In our present cross-sectional analysis the relative excess of ischaemic ECG abnormalities in people with IGT was almost the same as that in diabetic subjects. Analysis of risk factor levels, however, suggested that the origin of the ECG abnormalities may be different between these two groups. There is little doubt that frank glucose intolerance, i.e., diabetes, is accompanied by a number of physical and metabolic changes, and that such changes may be considered a possible cause for the relatively weak association of the other recognised factors with ECG changes in the diabetic subjects.

Hypertension has frequently been associated with an increased risk of ECG changes, in both diabetic [14] and non-diabetic [34] people. In our study the overall systolic and diastolic blood pressure mean values adjusted for age were significantly higher in people with ECG abnormalities than in those without. This difference was, however, very small, and sometimes diabetic subjects with ECG abnormalities had even lower blood pressure levels than those without ECG changes.

The highest blood pressure mean values were usually found in people with both IGT and an abnormal ECG. Whatever pathophysiologic processes are involved in the asymptomatic elevation of blood sugar and blood pressure simultaneously, it seems likely that if these two conditions are both present the risk of coronary heart disease is increased. This needs to be confirmed in prospective studies, but our findings were consistent across all four ethnic and gender groups in our cross-sectional analysis.

The finding that plasma uric acid was elevated in people who had ECG abnormalities suggesting coronary heart disease is in accord with the data from some studies [35–39] while it differs from others [40,41]. Our data may provide some explanation for the conflicting results between earlier studies as we included two different ethnic groups in our study. The mean level of plasma uric acid as well as its contribution to the ECG abnormalities was quite different in the two ethnic groups living in the same island of Fiji. Thus, one can expect marked differences in this respect between diverse populations living in different geographical areas. An interesting finding was that plasma uric acid was raised in non-diabetic people with ECG abnormalities, but in diabetic subjects such an increase could hardly be detected. It is known that plasma uric acid levels are generally reduced in diabetic patients [42–49], and therefore, one could argue that this decrease might be large enough to remove some of the excess risk associated with high plasma uric acid concentrations.

Plasma cholesterol concentration had no clear impact on the prevalence of ECG abnormalities in our study populations. The overall mean levels were relatively low, about 4.5 mmol/l, which is equal to the 'ideal population mean' recommended by the WHO Expert Committee [50]. Thus, our results confirm the opinion of the Committee and also the opinion of the recent NIH Consensus Development Conference [51], both of them stating that serum cholesterol has no major effect on the occurrence of coronary heart disease if the population mean is 4.5 mmol/l or less.

The overall mean BMI level was higher in people with ECG abnormalities than in those without. Part of this association may be an artefact as obesity causes some false-positive ECG changes. In our study the association was visible across ethnic and gender groups, even though the mean BMI levels were very different between these groups. In practically all subgroups in our study, BMI values were especially increased among the people with IGT who had ECG abnormalities.

There is some evidence that the strength of the relationship between hypertension and cardiovascular complications declines with increasing obesity [34]. This means that non-obese hypertensive subjects have an especially high relative risk of cardiovascular diseases. Unfortunately, there are no prospective data concerning IGT that could show whether the risk in non-obese subjects with IGT differs from that in obese ones. Our data suggest that it is indeed obesity which is associated with an increased occurrence of ischaemic ECG abnormalities in people with IGT. Obesity is also one of the strongest determinants of hypertension and elevated plasma uric acid levels. Because these three factors were elevated in people with IGT who had ECG abnormalities, we might argue that obesity may increase the risk of cardiac complications in people with IGT.

In conclusion, our present data show that the conventional risk factors, blood pressure, obesity and plasma uric acid, play an important role in the risk of coronary heart disease in the Melanesian and Asian Indian populations of Fiji in both men and women. These risk factors seem to contribute to ECG abnormalities in both non-diabetic and diabetic subjects. The coronary risk factor profiles in diabetic subjects did not differ much from those in people with normal glucose tolerance and therefore, it is likely that glucose intolerance per se has some additional impact on the risk of ECG abnormalities.

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