

Comparison of electrocardiographic findings between Northern and Southern Chinese population samples

Xuxu Rao,^a Xigui Wu,^b Aaron R Folsom,^c Xiaging Liu,^a Hongye Zhong,^b O Dale Williams^d and Jeremiah Stamler^e

Background	Cardiovascular disease is rare in China, but there are few data on the prevalence of electrocardiographic (ECG) abnormalities in Chinese populations.
Methods	The ECG surveys were carried out in four Chinese population samples, in a total of 9666 adults aged 35–54 in Beijing and Guangzhou, China from 1981 to 1984. Twelve-lead resting ECG tracings were coded by the Minnesota Code.
Results	Prevalence per 1000 of abnormal ECG ranged from 77.4 to 209.8, and was higher for men than women and higher for Guangzhou than Beijing. Prevalence per 1000 of major abnormalities in Guangzhou was 29.8 for men and 78.4 for women, higher than the 18.4 and 29.6 for counterparts in Beijing. The ECG changes attributed in 'Western' populations to coronary heart disease (CHD), such as large Q waves (Minnesota Code 1–1, 1–2) and ST-T abnormalities, were similar between Beijing and Guangzhou men, but Guangzhou women had much higher prevalence of ST-T abnormalities than Beijing women. Other ECG abnormalities such as A-V block, left branch bundle block, and left ventricular hypertrophy were rare in people of both sites.
Conclusions	Compared with similar data from the US, these Chinese populations had a relatively low prevalence of ECG abnormalities putatively related to CHD. This corresponds with the low incidence of CHD in the Chinese population. However, within the Chinese populations of this study, a high abnormality rate appeared in a population with low incidence of CHD and hypertension (Guangzhou women). Reasons why ECG abnormalities do not parallel prevalence levels of CHD and hypertension remain to be elucidated.
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Surveys employing the electrocardiogram (ECG) provide important information relevant to the cardiovascular disease pattern of a population.¹ There have been some ECG surveys carried out in Chinese populations, most published in Chinese.

The People's Republic of China—United States (PRC-USA) Collaborative Study on Cardiovascular and Cardiopulmonary Epidemiology was initiated in 1981. This joint research study

employed cross-sectional and prospective studies on four PRC samples from urban and rural populations in, or close to, Beijing in the north and Guangzhou in the south. Selection of these sites was based on previously observed North-South differences in prevalence of some cardiovascular risk factors. This article reports baseline ECG results, derived from Minnesota Code² measurements. It compares ECG patterns and the prevalence of ECG abnormalities among the northern and southern Chinese populations samples, male and female. This North-South focus was based on the more favourable blood pressure and serum cholesterol levels in the South than the North.

Population Samples and Methods

Study samples and response rates

The PRC-USA study was implemented through the Cardiovascular Institute of the Chinese Academy of Medical Science and Fu Wai Hospital, Beijing and the Guangdong Provincial

^a Guangzhou Cardiovascular Institute, Guangzhou, People's Republic of China.

^b Cardiovascular Institute and Fu Wai Hospital, Chinese Academy of Medical Sciences, Beijing, PRC.

^c University of Minnesota School of Public Health, Minneapolis, Minnesota, USA.

^d School of Public Health, Department of Biostatistics, University of Alabama at Birmingham, AL, USA.

^e Northwestern University, Chicago, Illinois, USA.

Reprint requests to: Sandra H Irving, Collaborative Studies Coordinating Center, 137 E Franklin Street, Suite 203, Chapel Hill, NC 27514, USA. E-mail: Sandy_Irving@unc.edu

Cardiovascular Institute, Guangzhou in the PRC and the National Heart, Lung, and Blood Institute in the US. Details of the surveys have been published.^{3,4} The four Chinese population samples were of adults aged 35–54 years. The urban populations were from industrial groups: five of the 16 factories of the Capital Iron and Steel Complex in Beijing and the Guangzhou Shipyard Company in Guangzhou. These samples included mainly blue-collar (manual) workers. The rural populations were from agricultural districts: all residents of Shijingshan District in the periphery of Beijing and 14 of 21 villages in the Dashi township of Panyu County (near Guangzhou). For practical considerations, ‘chunk’ samples were used rather than random samples. In each population sample, about half were men and half women.

A baseline survey, including data collection on risk factors for major cardiovascular and cardiopulmonary diseases, was completed in the fall of 1983–1984. In north China (Beijing), a survey was also done in 1981–1982 with ECG recording, which was not redone in 1983–1984. Thus data for northern China are from 1981–1982 and from southern China 1983–1984. Overall response rates were 88% in Beijing and 87% in Guangzhou.

Data collection

The ECG used were Cardisunny model 503FB in Beijing and Cardiofax model SB-613D in Guangzhou. Technicians were trained and certified, and equipment was calibrated, according to detailed protocols and training manuals. Methods used in the PRC-USA study were standardized with those used in similar US co-operative studies and in studies sponsored by the World Health Organization.

Resting standard 12-lead ECG were recorded with participants supine. Five QRS complexes of each ECG lead were recorded with the recorder set at a sensitivity of 10 mm/mV and a paper speed of 25 mm/sec. Sensitivity and speed were calibrated weekly.

ECG coding

All ECG tracings were mounted at each local study city (Beijing and Guangzhou) and initially read locally with use of the Minnesota Code.⁴ The ECG coding supervisors and coders were trained and certified in the ECG Coding Laboratory, University of Minnesota, School of Public Health, Minneapolis, Minnesota, or in a Minnesota Code training course in China. Each ECG was coded independently by two certified coders, and results were compared. If they disagreed, a third coder, or the local supervisor, also coded the ECG. Identical codes by at least two of three coders or the supervisor were accepted as the final codes. A set of 437 ECG tracings coded in Beijing and Guangzhou was sent to the ECG Coding Laboratory at the University of Minnesota for recoding. Comparison showed 97% agreement in total codings.

To minimize systemic bias in major codes between North and South sites and to implement recently modified Minnesota coding methods (mainly for measurement of T wave amplitude), ECG coded in the first round with Codes 1–, 4–, and 5–, 220 tracings in Beijing and 470 in Guangzhou, were recoded by the other site’s coders and supervisors. Two hundred random ECG tracings without Codes 1–, 4–, and 5– from each site were also exchanged and reread. In this latter sample, no major and only two minor 1–, 4–, or 5– codes were found upon recoding. After the second round of codings, final codes 1–, 4–, and

5– were determined and the baseline ECG databases were revised for analysis.

Data analysis

For statistical analysis, men and women in each population were grouped by age (35–39, 40–44, 45–59, 50–54 years). For each age group, algebraic means and standard errors of variables were calculated. Overall adjusted means were computed twice, once adjusted for age, city, setting, and city by setting interaction and again adjusted for age, city, setting, body mass index (BMI), systolic blood pressure (SBP), work labour intensity (heavy versus other), and city by setting interaction. Adjusted means were computed through the SAS procedure GLM and pairwise comparisons were tested for statistical differences. Prevalence rates per 1000 of major and minor abnormalities were computed by adjusting for age, city, setting, BMI, SBP, and work labour intensity.

Major abnormalities were defined as Minnesota Codes 1–1, 1–2; 4–1, 4–2; 5–1, 5–2; 6–1, 6–2; 7–1, 7–2, 7–4; or 8–1, 8–3. Minor abnormalities included those with no major abnormality and codes 1–3; 2–1, 2–2; 3–1, 3–2; 4–3; 5–3; 6–3; or 9–1. (See Table 4 for an explanation of Minnesota Codes.) An abnormal ECG was defined as an ECG with any major or minor abnormality. The criteria for left ventricular hypertrophy (LVH) were Code 3–1 plus (Code 4–1, 4–2 or 4–3) or (Code 5–1, 5–2 or 5–3).

Results

Selected characteristics of the study population samples are described in Table 1.

Heart rate, QRS axis, and maximal R amplitude

Heart rate

Mean heart rate did not differ appreciably with age over the range 35–54 years (Table 2). Among men, adjusted mean heart rate ranged from 70.3 to 64.3 per min, in order from high to low: Beijing urban, Guangzhou urban, Beijing rural, and Guangzhou rural. All of these groups differed significantly in adjusted mean heart rate ($P < 0.01$), except for urban men in Beijing and Guangzhou. For women, there were no significant differences in adjusted mean heart rates between groups, except for the Guangzhou rural women, who had a significantly lower adjusted mean heart rate than the other three ($P < 0.01$).

QRS axis

With age, mean QRS axis generally became more leftward for seven of the eight groups, except for Guangzhou rural women (Table 3). Mean QRS axis was more rightward for men than women. For men, after adjustment of means for age, BMI, SBP, and labour intensity, there were statistically significant between-population differences in QRS axis for Beijing (urban or rural) compared with the Guangzhou rural setting; for women, most between-population differences were reduced with adjustment and were statistically significant only between Beijing rural and Guangzhou (urban or rural).

Maximal R amplitude

There were no apparent trends with age for maximal R amplitude in leads V4, 5, 6 (data not shown). Mean values were greater in men than women, in rural than urban, and in Guangzhou than Beijing, similar to the pattern of the QRS axis distribution

Table 1 Number of participants with ECG and participant characteristics by gender, city, and setting, 1981–1984

Gender	Item	Beijing		Guangzhou	
		Urban	Rural	Urban	Rural
Men	No. with ECG	1754	930	1168	852
	Mean age (years)	45.2	45.3	43.3	44.2
	BMI ^a (kg/m ²)	23.6	22.3	20.6	19.8
	Heavy labour (%)	39.5	88.6	58.1	87.4
	High BP (%) ^b	17.4	11.6	4.9	2.3
Women	No. with ECG	1368	1423	1088	1083
	Mean age (years)	45.8	42.3	43.8	43.7
	BMI (kg/m ²)	24.3	22.9	21.8	19.6
	Heavy labour (%)	6.0	74.3	22.3	67.1
	High BP (%) ^b	16.2	6.1	5.5	1.5

^a Body mass index.

^b Systolic blood pressure ≥160 or diastolic blood pressure ≥95 mmHg or taking antihypertensive medication in past 2 weeks.

Table 2 Unadjusted and adjusted means and standard errors (SE) of heart rate (beats/minute) by gender, age group, city, and setting, 1981–1984

Gender	Age group	Beijing						Guangzhou					
		Urban			Rural			Urban			Rural		
		N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE
Men	35–39	331	69.5	0.6	194	66.7	0.7	388	69.7	0.5	210	63.2	0.8
	40–44	474	70.2	0.5	199	66.4	0.7	326	68.3	0.6	249	63.2	0.6
	45–49	466	70.7	0.5	270	66.7	0.6	223	68.7	0.7	214	63.2	0.8
	50–54	483	70.3	0.5	267	66.8	0.7	231	69.0	0.6	179	63.0	0.9
	All ^a	1754	70.2 ^{1,2,3}	0.2	930	66.6 ^{1,4,5}	0.3	1168	69.0 ^{2,4,6}	0.3	852	63.2 ^{3,5,6}	0.4
	Adjusted ^{a,b}	1198	70.3 ^{1,3}	0.3	512	66.6 ^{1,4,5}	0.5	1166	69.6 ^{4,6}	0.3	850	64.3 ^{3,5,6}	0.4
Women	35–39	173	71.9	0.7	568	71.5	0.4	240	75.0	0.7	362	66.6	0.5
	40–44	363	72.6	0.5	384	72.2	0.5	336	73.3	0.5	257	67.8	0.6
	45–49	455	72.5	0.5	251	73.6	0.7	371	72.5	0.6	212	66.8	0.7
	50–54	377	74.5	0.6	220	74.6	0.8	141	71.7	1.0	252	64.5	0.6
	All ^a	1368	73.0 ³	0.3	1423	72.5 ⁵	0.3	1088	73.2 ⁶	0.3	1083	66.5 ^{3,5,6}	0.3
	Adjusted ^{a,b}	825	72.1 ³	0.4	842	72.6 ⁵	0.4	1075	72.6 ⁶	0.3	1082	67.2 ^{3,5,6}	0.3

^a Statistical tests done for six comparisons (Beijing (B), Guangzhou (G), Urban (U), Rural (R)) as follows: ¹BU versus BR $P < 0.01$, ²BU versus GU $P < 0.01$, ³BU versus GR $P < 0.01$, ⁴BR versus GU $P < 0.01$, ⁵BR versus GR $P < 0.01$, ⁶GU versus GR $P < 0.01$.

^b Adjusted for age, body mass index, systolic blood pressure, labour intensity, and city*setting.

Table 3 Unadjusted and adjusted means and standard errors (SE) of QRS axis (degrees) by gender, age group, city and setting, 1981–1984

Gender	Age group	Beijing ^a						Guangzhou					
		Urban			Rural			Urban			Rural		
		N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE
Men	35–39	308	56.4	1.2	188	61.5	1.4	388	62.4	1.7	210	62.8	1.9
	40–44	445	55.2	1.0	187	59.9	1.6	326	62.4	1.7	249	58.2	2.3
	45–49	423	51.4	1.0	255	57.5	1.3	223	56.5	2.3	214	57.7	2.3
	50–54	446	47.8	1.0	246	54.6	1.4	231	51.3	2.3	179	55.6	2.8
	All ^b	1622	52.4 ^{1,2,3}	0.5	876	58.1 ¹	0.7	1168	59.1 ²	1.0	852	58.7 ³	1.2
	Adjusted ^{b,c}	1106	58.5 ³	0.9	476	59.6 ⁵	1.3	1166	55.8	0.8	850	54.1 ^{3,5}	1.1
Women	35–39	166	55.1	1.5	552	56.3	0.8	240	59.2	1.8	362	56.3	1.3
	40–44	352	50.5	1.1	370	58.0	1.0	336	53.9	1.5	257	56.4	1.5
	45–49	433	49.9	1.0	242	54.6	1.4	371	51.5	1.4	212	57.7	1.8
	50–54	360	47.3	1.2	209	51.8	1.5	141	47.2	2.5	252	56.2	1.6
	All ^b	1311	50.0 ^{1,2,3}	0.6	1373	55.8 ¹	0.5	1088	53.4 ^{2,6}	0.8	1083	56.6 ^{3,6}	0.8
	Adjusted ^{b,c}	780	54.9	1.0	807	57.0 ^{4,5}	0.8	1075	53.4 ⁴	0.8	1082	52.4 ⁵	0.8

^a Axis missing on 303 in Beijing.

^b Statistical tests done for six comparisons (Beijing (B), Guangzhou (G), Urban (U), Rural (R)) as follows: ¹BU versus BR $P < 0.01$, ²BU versus GU $P < 0.01$, ³BU versus GR $P < 0.01$, ⁴BR versus GU $P < 0.01$, ⁵BR versus GR $P < 0.01$, ⁶GU versus GR $P < 0.01$.

^c Adjusted for age, body mass index, systolic blood pressure, labour intensity, and city*setting.

across the populations. In both men and women, all pairwise differences in mean R amplitude in V4, 5, 6 were still statistically significant after adjustment for covariates (except Beijing rural versus Guangzhou urban men).

Frequencies of Minnesota codes

The frequencies of individual Minnesota codes for each gender and population group are listed in Table 4.

Abnormal Q waves

Abnormal Q waves (Codes 1–1, 2, 3) were infrequent in every group and the numbers are too small for meaningful statistical comparisons. However, for the most part, prevalence of Q waves was slightly more for men than women.

ST segment depression

An ST segment depression (Codes 4–1, 2, 3, 4) was infrequent in men and women and again, the numbers were too small for

Table 4 Frequency (prevalence per 1000) of ECG codes in men and women

ECG finding	Minnesota ECG Code	Men: No. (Prevalence)				Women: No. (Prevalence)			
		Beijing		Guangzhou		Beijing		Guangzhou	
		Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
Q waves	1								
	-1	3 (1.7)	0 (0.0)	2 (1.7)	3 (3.5)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
	-2	4 (2.3)	1 (1.1)	1 (0.9)	0 (0.0)	1 (0.7)	1 (0.7)	1 (0.9)	0 (0.0)
	-3	6 (3.4)	3 (3.2)	8 (6.8)	4 (4.7)	3 (2.2)	1 (0.7)	1 (0.9)	2 (1.8)
Axis deviation	2								
Left	-1	54 (30.8)	21 (22.6)	33 (28.3)	29 (34.0)	18 (13.2)	15 (10.5)	20 (18.4)	14 (12.9)
Right	-2	2 (1.1)	1 (1.1)	6 (5.1)	0 (0.0)	3 (2.2)	1 (0.7)	2 (1.8)	1 (0.9)
High amplitude R waves	3								
Left type	-1	88 (50.2)	59 (63.4)	78 (66.8)	127 (149.1)	31 (22.7)	34 (23.9)	21 (19.3)	55 (50.8)
Right type	-2	4 (2.3)	0 (0.0)	1 (0.9)	0 (0.0)	0 (0.0)	5 (3.5)	1 (0.9)	0 (0.0)
S-T depression	4								
S-T-J ≥ 1 mm, horiz. or downward segment	-1	2 (1.1)	1 (1.1)	0 (0.0)	1 (1.2)	3 (2.2)	2 (1.4)	5 (4.6)	3 (2.8)
S-T-J 0.5–1 mm, horiz. or downward segment	-2	2 (1.1)	1 (1.1)	2 (1.7)	1 (1.2)	13 (9.5)	8 (5.6)	6 (5.5)	11 (10.2)
No S-T-J plus segment downward	-3	5 (2.9)	3 (3.2)	1 (0.9)	0 (0.0)	12 (8.8)	6 (4.2)	3 (2.8)	10 (9.2)
S-T-J ≥ 1 mm, upward segment	-4	1 (0.6)	0 (0.0)	7 (6.0)	3 (3.5)	4 (2.9)	7 (4.9)	14 (12.9)	6 (5.5)
T-wave negativity	5								
≥ 5 mm	-1	0 (0.0)	0 (0.0)	0 (0.0)	2 (2.3)	1 (0.7)	0 (0.0)	1 (0.9)	3 (2.8)
-1 mm to -5 mm	-2	6 (3.4)	9 (9.7)	10 (8.6)	6 (7.0)	26 (19.0)	19 (13.4)	35 (32.2)	97 (89.6)
0 mm to -1 mm	-3	16 (9.1)	12 (12.9)	4 (3.4)	6 (7.0)	32 (23.4)	23 (16.2)	25 (23.0)	31 (28.6)
A-V conduction defect	6								
Complete block	-1	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Partial block	-2	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.2)	1 (0.7)	0 (0.0)	0 (0.0)	0 (0.0)
P-R ≥ 0.22 sec	-3	10 (5.7)	11 (11.8)	7 (6.0)	8 (9.4)	6 (4.4)	3 (2.1)	5 (4.6)	4 (3.7)
Accelerated conduction	-4	3 (1.7)	1 (1.1)	0 (0.0)	2 (2.3)	0 (0.0)	1 (0.7)	0 (0.0)	0 (0.0)
Ventricular blocks	7								
Left bundle	-1	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.7)	2 (1.4)	1 (0.9)	0 (0.0)
Right bundle	-2	11 (6.3)	2 (2.2)	8 (6.8)	6 (7.0)	5 (3.7)	3 (2.1)	5 (4.6)	5 (4.6)
Incomplete right bundle	-3	19 (10.8)	3 (3.2)	23 (19.7)	21 (24.6)	11 (8.0)	1 (0.7)	12 (11.0)	8 (7.4)
Intra-ventricular block	-4	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Arrhythmias	8								
Premature beats	-1	13 (7.4)	4 (4.3)	16 (13.7)	10 (11.7)	10 (7.3)	11 (7.7)	13 (11.9)	16 (14.8)
Ventricular tachycardia	-2	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (1.5)	0 (0.0)	0 (0.0)	0 (0.0)
Atrial fibrillation, flutter	-3	5 (2.9)	0 (0.0)	1 (0.9)	2 (2.3)	5 (3.7)	0 (0.0)	1 (0.9)	0 (0.0)
Supra-vent. tachycardia	-4	2 (1.1)	0 (0.0)	2 (1.7)	1 (1.2)	2 (1.5)	2 (1.4)	4 (3.7)	1 (0.9)
Ventricular rhythm	-5	0 (0.0)	0 (0.0)	2 (1.7)	1 (1.2)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
A-V nodal rhythm	-6	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Sinus tachycardia	-7	12 (6.8)	4 (4.3)	7 (6.0)	5 (5.9)	18 (13.2)	21 (14.8)	19 (17.5)	5 (4.6)
Sinus bradycardia	-8	16 (9.1)	16 (17.2)	12 (10.3)	61 (71.6)	6 (4.4)	3 (2.1)	5 (4.6)	20 (18.5)
Low QRS amplitude	9								
	-1	17 (9.7)	2 (2.2)	4 (3.4)	3 (3.5)	12 (8.8)	9 (6.3)	5 (4.6)	5 (4.6)
S-T segment elevation	9								
	-2	6 (3.4)	21 (22.6)	171 (146.4)	192 (225.4)	2 (1.5)	0 (0.0)	5 (4.6)	13 (12.0)

Table 5 Adjusted^a prevalence (per 1000) of major^b and minor^c ECG abnormalities, by gender, city, setting, 1981–1984

Gender	Setting	Beijing N	Guangzhou N	Major		Minor		Total	
				Beijing Prev	Guangzhou Prev	Beijing Prev	Guangzhou Prev	Beijing Prev	Guangzhou Prev
Men	Urban	1198	1166	17.7	29.2	77.2	117.1	94.9	146.3
	Rural	512	850	20.0	30.6	119.0	179.1	139.0	209.8
	All	1710	2016	18.4	29.8	89.7	143.3	108.1	173.1
Women	Urban	825	1075	21.1	55.4	56.3	64.1	77.4	119.4
	Rural	842	1082	37.9	101.4	56.2	76.6	94.2	178.0
	All	1667	2157	29.6	78.4	56.3	70.4	85.9	148.8
All	Urban	2023	2241	19.1	41.8	68.7	91.7	87.8	133.4
	Rural	1354	1932	31.2	70.2	80.0	121.7	111.1	192.0
	All	3377	4173	23.9	54.9	73.2	105.6	97.1	160.5

^a Adjusted for age, body mass index, systolic blood pressure and labour intensity.

^b Major abnormalities: 1–1, 1–2, 4–1, 4–2, 5–1, 5–2, 6–1, 6–2, 7–1, 7–2, 7–4, 8–1, 8–3.

^c Minor abnormalities: 1–3, 2–1, 2–2, 3–1, 3–2, 4–3, 5–3, 6–3, 9–1 and no major abnormalities.

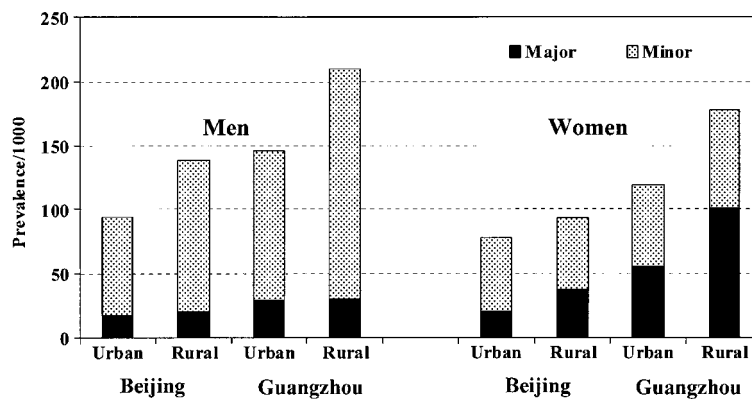


Figure 1 Prevalence per 1000 of adjusted^a major and minor ECG abnormalities in men and women by city and setting

^a = Adjusted for age, BMI, SBP, and labour intensity.

statistical comparisons among subgroups. However, the prevalence of ST depression tended to be higher for women than men. The highest prevalence (13.0 per 1000) of major ST depression (Codes 4–1, 2) was in Guangzhou rural women, who also had the lowest prevalence of hypertension in the PRC-USA collaborative study.

T wave findings

The pattern of T wave findings (Codes 5–1, 2, 3) was similar to that for ST changes. The T wave changes were more frequent in women than in men. The highest prevalence (121.0 per 1000) occurred in Guangzhou rural women, approximately 3–4 times the prevalence in Beijing rural and urban women.

A-V block

We found A-V block (Codes 6–1, 2, 3) was very rare in both Beijing and Guangzhou and severe A-V block (Codes 6–1, 2) was found only once for each city. The prevalence of first-degree A-V block was also low and in both cities.

Ventricular blocks

Complete left bundle branch block (Code 7–1) was rare, with only three cases in Beijing and one in Guangzhou. Complete

right bundle branch block (Code 7–2) was also rare, and the prevalence was slightly higher in men than women. Incomplete right bundle branch block (Code 7–3) was more prevalent than either code 7–1 or 7–2, and the prevalence was higher in Guangzhou than in Beijing, and in men than women.

Premature beats

The prevalence of premature beats (Code 8–1) ranged from 4.3 to 14.8 per 1000, and appeared to be similar in men and women. There were 10 cases of atrial fibrillation or flutter in Beijing and four in Guangzhou.

Major and minor ECG abnormalities

Adjusted prevalence rates of major and minor ECG abnormalities are shown in Table 5 and Figure 1. Prevalence of major plus minor abnormalities ranged from 77.4 to 209.8 per 1000 among genders, sites, and settings. As noted above, the major abnormality was primarily T wave inversion and the minor abnormalities were primarily left axis deviation, high amplitude R waves, ST-depression, and small T wave inversions. Prevalence of the overall sum of major and minor abnormalities was

higher for men than women ($P < 0.05$), higher for rural than urban groups ($P < 0.0001$), and higher for Guangzhou than Beijing ($P < 0.0001$). Guangzhou rural men and women had the highest prevalence rates of abnormal ECG.

Prevalence per 1000 of major abnormalities in men and women of Guangzhou was 29.8 and 78.4 respectively, higher than the 18.4 and 29.6 for Beijing counterparts. This difference between Beijing and Guangzhou was statistically significant for women ($P < 0.0001$) and for men ($P < 0.05$). In both Beijing and Guangzhou, prevalence of major codes was higher in women than men. This was more marked in Guangzhou. Among Guangzhou women, prevalence of major abnormalities was higher in the rural than the urban setting. For other gender-setting groups, the urban-rural difference was less marked. The urban-rural difference in major abnormalities was not significantly different for men but was for women ($P < 0.0001$).

Minor abnormalities were more frequent than major abnormalities. Prevalence was higher in men than women. For both urban and rural participants, minor abnormalities were more prevalent in Guangzhou than Beijing. The differences in minor abnormalities between Guangzhou and Beijing and between urban and rural participants were statistically significant ($P < 0.0001$) for men but not for women.

Left ventricular hypertrophy

Left ventricular hypertrophy by Minnesota Code criteria was rare (not shown in Tables). Similar to T wave abnormalities, prevalence of LVH was highest in Guangzhou rural women (10.2 per 1000) among the eight populations.

Discussion

Epidemiological ECG surveys are often employed for estimating frequencies of heart disease,¹ such as coronary or hypertensive heart disease, which are common in industrial countries and becoming more common in China in recent years. However, ECG patterns in populations may also be affected by physiological, anthropometric, geographical, and ethnic factors.^{5,6}

Resting heart rate has typically been reported to decrease with age.⁷⁻⁹ We found little association between age and heart rate, possibly because the age range was narrow in this study. On the other hand, the customary age-related decline in exercise levels, a determinant of heart rate, may be less among Chinese. Mean heart rates were faster in women than in men, in the urban than in the rural setting, and in Beijing than in Guangzhou, with the exception of urban women. People who are thinner and/or undertake more physical exercise usually have lower heart rates. These characteristics were more common in rural participants, and particularly in Guangzhou rural participants, corresponding with their lower heart rates.

Mean QRS axis and R wave amplitude in V4, 5, 6 may be similarly affected by body build and/or labour intensity level. Mean QRS axis was more rightward in the lower BMI and heavier labour subgroups: that is, more rightward in rural than urban setting, in Guangzhou than Beijing, and in men than women. The differences in mean QRS axis between population subgroups shrank after adjustment for BMI, work labour intensity, and other factors. This suggests that variations of mean QRS axis were partly attributable to body build and physical exercise differences.

The distribution of adjusted mean maximal R amplitude in V4, 5, 6 among population subgroups was similar to that of the mean QRS axis. It is commonly accepted that maximal R amplitude in V4, 5, 6 is inversely associated with the thickness of chest adipose tissue in the chest. We did not have direct measures of chest adiposity; however, high amplitude R waves and low BMI were correlated, both being most prevalent in the Guangzhou rural sample. However, after adjustment for BMI, work labour intensity, and other variables, differences between subgroups still existed, suggesting that other factors related to geography or existing diseases also may contribute to maximal R amplitude differences.^{5,6}

The presence of ECG abnormalities has been associated with greater age, blood pressure, and BMI.¹⁰ In our study, the overall rate of abnormal ECG was higher in men than women, and higher in Guangzhou than Beijing. Rates of ECG major abnormalities were also higher in Guangzhou than Beijing, and were higher in women than men. Different ECG patterns for men and women have been reported in many studies.¹¹⁻¹³ Usually, men have higher frequencies of abnormal Q waves, left axis deviation, and high amplitude R waves, whereas women have higher prevalence of ST-T changes. Our findings are concordant with most previous reports. Except for ST depression and T wave changes, men had higher prevalence than did women of most ECG abnormalities, including A-V conduction defects (6-), arrhythmias (8-), ST segment elevation (9-2), abnormal Q waves, left axis deviation, and high amplitude R waves. However, the prevalence of most of these was very low, and therefore differences between genders were small. On the other hand, frequencies of ST and T wave findings were high, and the greater prevalence in women than men explained the higher major abnormality rate in women.

In western countries, the rate of abnormal ECG usually parallels that of coronary heart disease (CHD) or hypertension. In China, Guangzhou has a lower prevalence of hypertension than Beijing,¹⁴ and mortality rates of CHD are significantly lower for Guangzhou than Beijing.¹⁵ Therefore, it was unexpected that major and minor ECG abnormalities were more common in Guangzhou than Beijing. The higher prevalence of ST depression and negative T waves in Guangzhou was especially notable. In fact, the highest prevalences of negative T waves and ECG with LVH were in Guangzhou rural women, who had the lowest prevalence of hypertension among the four study populations. It is difficult to attribute ST depression and negative T waves to hypertension or coronary disease in these populations. The reason for a higher rate of abnormalities in Guangzhou than Beijing is unclear. It seems unlikely that systematic differences in coding ECG is a major explanation because ECG with Codes 1, 4, or 5, and a random sample of normals were exchanged and recoded by both Beijing and Guangzhou coders. Physical and/or pathological factors may contribute to the Beijing-Guangzhou difference. For example, the rate of left ventricular high R amplitude in Guangzhou rural men (149.1 per 1000) was more than two times that (63.4 per 1000) in Beijing rural men. A reasonable explanation is that Guangzhou residents, especially rural men, have a thinner body build which usually associates with higher R amplitude. Another hypothesis for this unexpected phenomenon is that other heart diseases, such as viral myocarditis, cardiomyopathy, and rheumatic heart disease are more common in southern China. However, this is

Table 6 Prevalence (per 1000) of ECG abnormalities generally attributed to coronary heart disease in Chinese and US populations

	Men			Women		Men and women		
	This study	9 Pop China ¹¹	Railroad USA ¹⁶	This study	9 Pop China ¹¹	This study	Nanjing ⁸ China	Tecumseh USA ¹²
No. with ECG	4704	14 944	2087	4962	12 936	9666	11 869	4609
Study year	1981–1984	1981–1984	1958–1960	1981–1984	1981–1984	1981–1984	1981–1985	1959–1960
Age range (years)	35–54	35–59	40–59	35–54	35–59	35–54	20–79	20–79
Q wave (1–1, 1–2)	3.0	4	29.2	0.6	3	1.8	5	13
ST depression (4–1, 4–2)	2.1	6	12.9	10.3	14	6.2	29	34
T-wave negativity (5–1, 5–2)	7.0	8	14.3	36.7	27	21.8	19	22
A-V block (6–1, 6–2)	0.2	1	0.0	0.2	0.2	0.2		
LBBB ^a (7–1)	0.0	1	5.7	0.8	1	0.4	1	3
RBBB ^b (7–2)	5.7	8	8.1	3.6	5	4.7	11	3
Premature beats (8–1)	9.1	6	8.6	10.1	8	9.6	7	18
Atrial fibrillation or flutter (8–3)	1.7	2	2.4	1.2	2	1.5	4	4

^a Left bundle branch block.

^b Right bundle branch block.

speculation, and further research is necessary. Nevertheless, it is apparent that while the prevalence of ST-T abnormalities may validly reflect the frequencies of CHD and hypertension in populations where these diseases are frequent, ST-T abnormalities may have a different interpretation in populations with low prevalence of CHD and hypertension.

Table 6 compares the prevalence of abnormal ECG among several general populations of the same ages. An expectation confirmed in this study was a much lower prevalence of significant Q waves and significant ST depression in Chinese than in western populations. Similarly, negative T waves were less frequent in these Chinese men than in American men. However, for Chinese women in this study, the prevalence of T wave negativity was quite high (36.7 per 1000) and higher than for US women. Other items possibly reflecting coronary disease, such as complete left bundle branch block, premature beats, and atrial fibrillation/flutter, were also lower in these Chinese samples than in American populations.

In summary, prevalence of ECG with abnormalities attributed to CHD was lower in this and other Chinese study populations than in American populations, in line with the lower prevalence of CHD in China. Reasons why ECG abnormalities do not parallel the prevalence of hypertension (and probably CHD) in these Chinese samples warrant further study.

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