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Electrocardiographic Findings Among the Total Adult Population of a Large Religious Isolate

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SUMMARY

Electrocardiograms were recorded as part of a survey of 1,303 men and 1,348 women past 15 years of age belonging to a large religious isolate inhabiting regions of northwestern U.S.A. and southwestern Canada. The ECGs were classified according to the Minnesota Code and the abnormalities were related to constitutional characteristics, blood pressure, and serum cholesterol.

Major codable ECG items included abnormal Q waves (54 cases), abnormal left axis deviation (44 cases), bundle-branch block (left 10, right 10), T-wave abnormalities (257 cases), prolonged P-R interval (80 cases), and occasional premature beats (143 cases) and showed no significant sex differences. ST-segment depressions were more common among females ($P < 0.005$). The males showed a significantly higher frequency of increased R-wave amplitude ($P < 0.005$) and more qualitative T-wave changes ($P < 0.005$).

In general, abnormal ECG features were associated with age, sex, and blood pressure, but not with serum cholesterol, body weight and height, skin-fold thickness, or arm girth. A notable exception was the negative relationship of body weight to high amplitude R waves in young males.

In clinical practice, age and sex stratifications will improve the diagnostic power of the ECG.

Additional Indexing Words:
Minnesota Code   Tecumseh study   Premature beats   Age and sex
Body measurements   Blood pressure   Serum cholesterol

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THE DISCRIMINATIVE value of the electrocardiogram (ECG) in clinical interpretation can be improved by knowledge of the incidence of electrocardiographic findings among large numbers of people and of their relationships, if any, to other biologic data. Until recent studies,[1-6] most epidemiologic electrocardiographic criteria have been based upon data obtained from hospital and clinical populations and cannot be applied with confidence to all segments of general populations.

The purpose of this report is to analyze the electrocardiographic findings and their interrelationships with other variables of the total adult population of an inbred human agrarian religious isolate, to be referred to as the H group, and to make a comparison with other epidemiologic studies.

The members of this highly moral Christian

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sect trace their origins to 1528 in the Tyrolean Alps. They practice communal living on the basis of the New Testament and have maintained themselves "genetically isolated" from the rest of the world. They inhabit regions of northwestern U.S.A. and southwestern Canada. A description of the population and the results of some genetic studies have been presented elsewhere.[7]

Methods

Two thousand six hundred and fifty-one ambulatory subjects (1,303 males and 1,348 females) over 15 years of age were studied. These individuals comprise 86% of their age group of the S and L subsects of the H group. The field studies were made from 1958 to 1964. The subjects were examined on their farms in rooms provided by them.

Height and weight were measured (without shoes and with light clothes). During a routine physical examination, skinfold thickness was measured in the triceps area and under the scapula with a Lange caliper. Arm girth measurements were taken at the level of the upper two thirds of the right arm. Electrocardiograms were recorded on a direct-writing, single-channel electrocardiograph (Sanborn, Visette, model 300) at a paper speed of 25 mm/sec. The subjects were in a supine position. Blood pressures were determined by the cuff method with a mercury sphygmomanometer at the completion of the recording of the electrocardiogram. Serum cholesterol levels of casual blood specimens were determined by the Schoenheimer and Sperry method.[8]

The electrocardiograms were classified according to the Minnesota Code.[9] Reproducibility of results of independent readings according to the Minnesota Code has been determined.[9] Interobserver variation was measured by comparing independent rapid readings of 100 randomly selected ECGs by one of us (A.N.G.) and by another observer, also experienced in the application of this system. Intra-observer variation (A.N.G.) was determined from independent readings made 3 months apart, of 200 other randomly selected ECGs. For the major ECG items discussed in the present report (Q and QS, high amplitude R waves, ST and T [subdivisions 1 and 2] axis deviation, A-V conduction, ventricular conduction, and premature beats), the intra-observer and interobserver agreements were 98.6 and 99.2%, respectively. The lowest frequency of agreement was 95.5 and 97% for intra-observer and interobserver readings of T waves, respectively. This high degree of agreement is probably due to the fact that the randomly selected records had relatively few codable items.

The overall agreement is comparable to that of Blackburn and associates[9] and indicates that a satisfactory result is obtained with a single rapid reading, particularly for items of greatest interest (Q and QS, S-T and T). A higher disagreement was found for some minor ECG items in the miscellaneous category (IX-P wave abnormalities, QRS notching and slurring, and qualitative T-wave findings), of which only the last is mentioned in the discussion.

The data were analyzed with the aid of the 1620 IBM computer. For each ECG abnormality, comparisons were made between the observed and predicted means for a number of variables known to be influenced by age. In each case, predicted means were calculated according to the formula

$$P_i = \Sigma_j k_j \bar{x}_{ij}$$

where

k_j = the proportion of individuals in the jth age class in the abnormal group.

$\bar{x}_{ij}$ = the mean for the ith variable in the jth age class of the normal or control group (Defined as the entire population minus the particular abnormal group being compared).

P_i = the predicted mean for the ith variable in the abnormal group. Since for any variable, the age class means are independent, the standard error of P_i, S_{P_i}, may be obtained from the formula:

$$S^2{}_{P_i} = \sum_j k_j{}^2 S^2{}_{\bar{x}_{ij}}$$

where

$$S^2{}_{\bar{x}_{ij}} = \text{the variance of } \bar{x}_{ij}.$$

Student's *t*-test was then applied in the usual way using the observed and predicted means and the respective variances as described in the preceding paragraph. Discrepancy between the number of ECG recordings and the number of individuals for whom data and the other variables are available is due to our computer program design in which if data for one of the variables were missing, the data for that subject were ignored in the comparison of the physical measurements of the affected and normal individuals.

Results

Data Other Than ECG

Body weight increased significantly and height decreased slightly with age in both

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Table 1

Means of Physical Variables, Blood Pressure and Serum Cholesterol of the H Group According to Age and Sex

Age group (yr)	N	Weight (lb)		Height (inches)		P index*		Blood pressure (mm Hg)				Arm girth (cm)		Skinfold (mm)		Cholesterol (mg/100 ml)	
								Systolic		Diastolic							
		M	±SE	M	±SE	M	±SE	M	±SE	M	±SE	M	±SE	M	±SE	M	±SE
Males																	
16–19	114	141	1.76	66	0.28	12.8	0.04	123	1.49	72	0.81	28	0.22	7	0.35	167	2.66
20–29	385	156	1.10	67	0.15	12.5	0.03	128	0.77	76	0.50	29	0.13	8	0.25	194	1.83
30–39	278	167	1.44	67	0.14	12.2	0.03	127	0.87	78	0.60	31	0.18	9	0.31	214	2.34
40–49	165	174	2.25	67	0.18	12.0	0.05	131	1.75	83	1.00	31	0.23	9	0.38	223	3.60
50–59	116	181	2.51	66	0.18	11.8	0.05	143	2.30	86	1.05	31	0.29	11	0.80	226	3.83
60+	87	171	2.88	66	0.25	11.9	0.07	152	3.14	85	1.57	30	0.30	10	0.53	222	4.12
Total	1145	163	0.79	67	0.08	12.3	0.02	131	0.60	79	0.34	30	0.09	9	0.16	206	1.25
Females																	
16–19	115	122	1.53	62	0.21	12.5	0.05	123	1.27	72	0.73	25	0.22	14	0.56	182	2.99
20–29	419	129	1.02	62	0.12	12.4	0.03	121	0.60	73	0.42	26	0.14	16	0.36	196	2.00
30–39	266	146	1.83	62	0.13	11.8	0.05	124	0.94	76	0.61	28	0.23	22	0.58	213	2.68
40–49	188	155	2.21	62	0.14	11.6	0.06	135	1.79	82	1.01	29	0.32	24	0.73	218	3.20
50–59	92	176	2.87	61	0.20	11.0	0.07	158	3.10	88	1.43	33	0.41	30	0.86	243	4.91
60+	66	164	3.68	60	0.26	11.1	0.08	169	4.02	89	1.58	31	0.49	27	1.21	238	5.57
Total	1146	142	0.89	62	0.07	11.9	0.03	130	0.70	77	0.35	28	0.12	20	0.29	208	1.34

Abbreviations: M ±SE = mean ± standard error; N = number of subjects; P index = ponderal index = height in inches/$\sqrt[3]{\text{weight in lb.}}$

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Table 2

Distribution of the Classified Electrocardiographic Findings According to Age and Sex

Minnesota Code ECG category	Males: Age (yr) and no. of males in each age group 16–19 131	20–29 424	30–39 320	40–49 190	50–59 130	60+ 108	Males Total 1303	Females: Age (yr) and no. of females in each age group 16–19 139	20–29 479	30–39 319	40–49 215	50–59 107	60+ 89	Females Total 1348	Grand total males and females 2651
I, 1	0	1	1	1	0	6	9	0	3	0	0	2	0	5	14
I, 2	0	5	2	5	4	5	21	0	2	1	0	2	7	12	33
I, 3	0	1	1	0	0	0	2	1	1	0	0	1	2	5	7
Total I	0	7	4	6	4	11	32	1	6	1	0	5	9	22	54
Rate total I (%)	0	1.7	1.3	3.1	3.1	10.2	2.5	0.7	1.2	0.3	0.0	4.7	10.1	1.6	2.0
II, 1	0	3	1	3	8	12	27	0	1	1	3	1	11	17	44
Rate II, 1	0	0.7	0.3	1.6	6.2	11.1	2.1	0.0	0.2	0.3	1.4	0.9	12.4	1.3	1.7
III, 1	53	114	52	17	10	13	259	12	16	11	4	6	7	56	315
Rate III, 1	40.5	26.9	16.3	8.9	7.7	12.0	19.9	8.6	3.3	3.4	1.9	5.6	7.9	4.2	11.9
IV, 1	1	1	0	0	3	4	9	1	0	2	4	1	3	11	20
IV, 2	0	2	1	2	3	5	13	2	11	0	8	4	8	33	46
IV, 3	9	11	7	3	4	7	41	16	47	24	19	17	17	140	181
Total IV	10	14	8	5	10	16	63	19	58	26	31	22	28	184	247
Rate total IV (%)	7.6	3.3	2.5	2.6	7.7	14.8	4.8	13.7	12.1	8.2	14.4	20.6	31.5	13.7	9.3
V, 1	0	0	0	0	2	0	2	0	0	0	0	0	3	3	5
V, 2	2	11	3	3	4	17	40	1	8	4	5	8	9	35	75
V, 3	0	13	17	12	17	15	74	4	26	19	22	12	20	103	177
Total V	2	24	20	15	23	32	116	5	34	23	27	20	32	141	257
Rate total V (%)	1.5	5.7	6.2	7.9	17.7	29.6	8.9	3.6	7.1	7.2	12.6	18.7	36.0	10.5	9.7
VI, 3	1	13	12	7	7	9	49	4	8	4	5	5	5	31	80
Rate VI, 3 (%)	0.8	3.1	3.8	3.7	5.4	8.3	3.8	2.9	1.7	1.3	2.3	4.7	5.6	2.3	3.0
VII, 1	0	0	0	0	1	2	3	0	0	1	0	4	2	7	10
VII, 2	0	1	0	0	0	6	7	0	1	0	1	1	0	3	10
VII, 3	5	10	4	1	2	2	24	4	9	5	4	0	1	23	47
Rate VII, 3 (%)	3.8	2.4	1.3	0.5	1.5	1.9	1.8	2.9	1.9	1.6	1.9	0.0	1.1	1.7	1.8
VIII, 1	0	1	3	0	1	4	9	1	0	1	2	0	4	8	17
Rate VIII, 1 (%)	0	0.2	0.9	0.0	0.8	3.7	0.7	0.7	0	0.3	0.9	0.0	4.5	0.6	0.6
VIII, 3	0	0	1	0	0	0	1	0	0	0	0	0	2	2	3
VIII, 6	1	0	0	0	0	0	1	1	1	1	0	0	0	3	4
VIII, 7	14	26	8	2	1	2	53	39	67	19	21	9	5	160	213
Rate VIII, 7 (%)	10.7	6.1	2.5	1.0	0.8	1.9	4.0	28.1	14.0	6.0	9.8	8.4	5.6	11.9	8.0
IX, 1	0	1	0	1	2	2	6	2	4	3	8	2	1	20	26
IX, 2	8	27	21	13	8	5	82	1	7	5	4	2	1	20	102

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APB*	1	7	4	1	5	7	25	2	8	2	0	1	6	19	44
Rate APB (%)	0.8	1.7	1.3	0.5	3.8	6.5	1.9	1.4	1.7	0.6	0.0	0.9	6.7	1.4	1.7
NPB*	0	6	1	1	1	7	16	0	4	2	2	1	5	14	30
Rate NPB (%)	0	1.4	0.3	0.5	0.8	6.5	1.2	0.0	0.8	0.6	0.9	0.9	5.6	1.0	1.1
VPB*	1	6	8	6	3	11	35	1	4	5	6	8	10	34	69
Rate VPB (%)	0.8	1.4	2.5	3.1	2.3	10.2	2.7	0.7	0.8	1.6	2.8	7.5	11.2	2.5	2.6

*APB, NPB, and VPB = occasional atrail, nodal, and ventricular beats, respectively.

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sexes (table 1). Blood pressure levels were higher in the older age groups, particularly in the females. Arm girth and skinfold thickness increased with age, and serum cholesterol levels increased with age in both sexes and in most age categories were higher in the females than in males.

ECG Data

The classification of the ECGs according to age and sex is presented in table 2. More than one ECG abnormality was present in many individuals. Some of the combinations present and the frequencies of individuals with isolated abnormalities are listed in table 3. Because the several abnormalities occurred in many combinations, a great number of which were rare, it was decided to limit the analysis to individual ECG items regardless of the presence of any other coded items.

For comparison purposes, the prevalence rates of several ECG items as reported in the Tecumseh population study[2] have been included in figures 1 through 3.

The relationships of the ECG items to body build characteristics, blood pressure, and serum cholesterol are presented in table 4.

Q and QS Items: Categories 1,1 through 1,3 (Fig. 1 and Table 2)

A total of 54 subjects (32 males and 22 females) had abnormal Q waves. Sex differences were not significant.

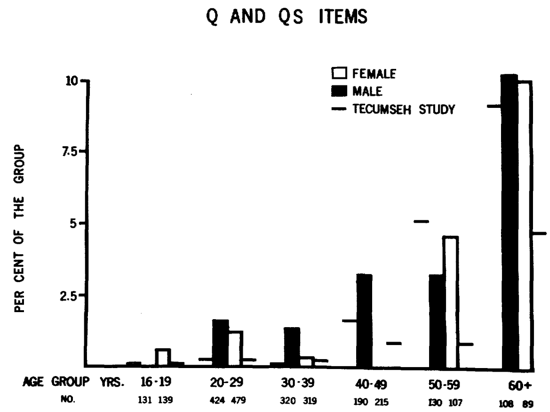

Figure 1

Comparison of frequency and age distribution of Q and QS items in the present and Tecumseh studies.

Table 3

Number of Subjects with Various Combinations of Some ECG Items: Single and Paired Combinations

ECG category	I, 1–3	II, 1	III, 1	IV, 1–2	IV, 3	V, 1–2	V, 3	VI, 3	APB	NPB	VPB	Other*	Total	%†
I, 1–3	16	0	5	1	0	2	7	0	1	0	0	22	54	30
II, 1		20	1	0	0	1	3	2	2	1	1	13	44	45
III, 1			239	0	13	5	6	6	8	4	3	25	315	76
IV, 1–2				18	0	9	14	0	0	1	2	21	66	27
IV, 3					84	10	28	9	0	2	4	31	181	46
V, 1–2						18	0	0	0	0	4	31	80	23
V, 3							87	1	2	1	3	25	177	49
VI, 3								50	2	0	0	10	80	63
APB									18	0	1	10	44	41
NPB										12	0	9	30	40
VPB											33	18	69	48

* Combinations involving more than two of the listed ECG items.
† Percentage of the total with indicated abnormality who have only this abnormality.

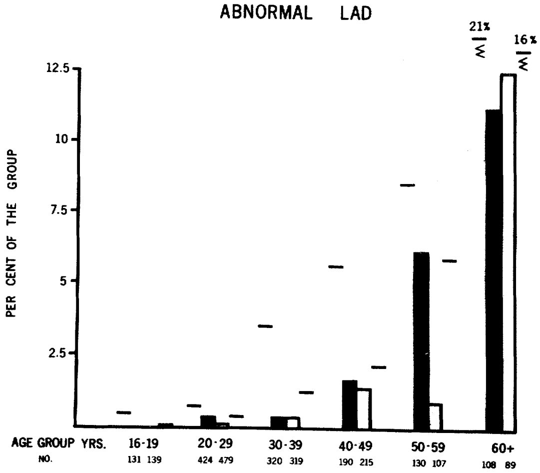

Figure 2

Comparison of frequency and age distribution of abnormal left axis deviation. Same key as in figure 1.

The subjects who exhibited QS items consistent with myocardial infarction had higher systolic and diastolic blood pressures than those with a normal ECG (table 4). However, the differences in serum cholesterol between the affected and normal individuals were not significant.

Axis Deviation: Categories II,1 and II,2 (Fig. 2 and Table 2)

Only 27 males and 17 females had left axis deviation of more than minus 30°, category II, 1 (LAD). In both sexes, this abnormality was

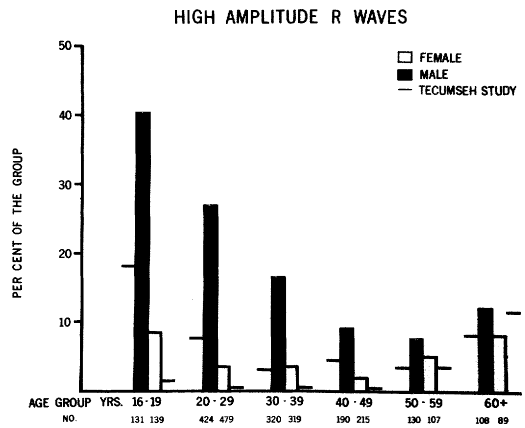

Figure 3

Comparison of frequency of age distribution of high amplitude R waves.

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present with higher frequency in the older age groups. There was not a significant relationship between LAD and the other variables.

Right axis deviation (category II, 2) was infrequent, occurring only in nine subjects (seven males and two females).

High Amplitude R Waves (HAR): Category III,1 (Fig. 3 and Table 2)

HAR was more common among males than among females ($P < 0.005$). Its frequency in males declined from more than 40% among the youngest to 7.7% in the sixth decade and tended to rise again in the seventh decade. A similar trend occurred in the females, but the prevalence was much lower. The same trend and relative frequencies between the sexes were observed in the Tecumseh study,[2] but at an overall lower rate (fig. 3).

The subjects were considered in two age groups, those less than 40 years (III, 1a) and 40 and over (III, 1b). The systolic blood pressure was elevated ($P < 0.001$) among young males with HAR (III,1a, table 4), but the difference was only 5 mm Hg and, therefore, unlikely to be of clinical significance. The young males with HAR also had a significantly lower body weight. Mean systolic blood pressure was also significantly elevated ($P < 0.01$) among the 16 older females with HAR (III,1b, table 4). Here the difference was 45 mm Hg and, therefore, likely to be of clinical significance.

ST-Segment Items: Categories IV,1 through IV,3 (Table 2)

As in the Tecumseh study,[2] ST-segment changes were more common among females than among males ($P < 0.005$).

ST-segment depression was associated with higher systolic and diastolic blood pressure in both sexes (table 4). The mean differences in systolic blood pressures of both sexes were about 30 mm Hg for categories IV,1 and IV,2 (table 4) and about 30 mm for males and only 9 mm for females in category IV,3. It seems unlikely that the small mean difference in blood pressure (9 mm) of the females in category IV, 3 can account for the depression of the S-T segment. Because of the high frequency of sinus tachycardia in the females and the known secondary effects of tachycardia on the ST-T complex, the relationship between category IV, 3 and sinus tachycardia was considered. Approximately 40% of the females with minor ST-segment changes (IV, 3) also had sinus tachycardia, which was more prevalent among females than among males ($P < 0.005$) (table 2, VIII, 7). The frequency of minor ST-segment changes increased significantly with age while the frequency of sinus tachycardia decreased steadily with age. This divergency indicates that sinus tachycardia and minor ST-segment changes are not causally related, at least in the older groups. The cause of the sinus tachycardia in younger females is not known, but possibly may be due to nervousness or embarrassment or both.

T-Wave Items: Categories V,1 through V,3 (Table 2)

The frequency of codable T-wave items increased with age. Sex differences were not significant.

T-wave inversion of at least 1 mm (categories V, 1 and V, 2) was in general associated with higher systolic and diastolic blood pressures in both sexes (table 4).

Atrioventricular Heart Block: Categories VI,1 through VI,3 (Table 2)

None of the subjects exhibited second or third degree A-V heart block (VI, 1 and VI, 2). First degree heart block (VI,3, P-R interval of more than 0.21 sec) occurred in 80 subjects and as in the Tecumseh study[2] had a higher frequency among the older age groups. No sex differences were noted.

Intraventricular Block: Categories VII,1 through VII,3 (Table 2)

Seven females and three males had complete left bundle-branch block (VII, 1), in nine of whom it occurred after the fifth decade of life. A similar number of subjects had complete right bundle-branch block (VII, 2) (seven males and three females). Eight of these subjects were more than 40 years old. Incomplete right bundle-branch block (VII, 3) was present in 47 subjects (24 males and 23 females), and its frequency decreased slightly with age.

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Table 4

Relationship of ECG Abnormalities to Other Variables: Observed and Predicted Means for Each Variable

Variable	I, 1–3		II, 1		III, 1a		III, 1b		IV, 1–2		IV, 3	
	Obs	Pred	Obs	Pred	Obs	Pred	Obs	Pred	Obs	Pred	Obs	Pred
Males												
Age	47.0		51.5		24.7		52.7		48.9		35.0	
Weight	176.0	167.7	173.4	170.3	151.7	155.6*	175.6	172.6	174.1	167.0	159.5	159.9
Height	66.2	66.4	65.2	66.2	66.7	67.0	66.4	66.2	66.1	66.2	65.7	66.7*
Ponderal index	11.9	12.1	11.8	12.0	12.6	12.5	11.9	12.0	11.9	12.1	12.2	12.3
Arm girth	30.9	27.2	30.7	27.2	29.0	27.6*	31.0	27.8	30.0	26.9	29.6	27.3
Skinfold thickness	10.6	8.1	9.8	8.7	7.4	7.6	8.9	8.6	10.5	8.2	9.3	7.8
Serum cholesterol	229.7	218.7	205.0	223.9	189.6	195.3	227.4	225.9	239.6	218.6	208.7	204.1
Systolic blood pressure	153.5	132.1†	147.5	135.5	130.1	125.2‡	144.9	133.9	167.9	133.9†	157.9	128.4‡
Diastolic blood pressure	92.4	80.5‡	84.0	82.0	75.4	76.2	85.1	82.4	89.7	81.1	88.4	78.1‡
Number	29		22		197		37		17		35	
Females												
Age	44.8		55.5		25.1		54.4		44.4		34.2	
Weight	161.7	152.6	165.6	159.9	129.9	133.9	178.6	166.5	150.8	152.0	138.8	144.6*
Height	61.7	61.3	60.9	60.9	61.8	62.1	60.7	61.0	60.9	61.5	61.5	61.9
Ponderal index	11.5	11.6	11.1	11.3	12.2	12.2	10.8	11.2	11.5	11.6	12.0	11.9
Arm girth	29.4	27.6	30.8	29.0	25.7	24.2	32.5	29.5	28.5	27.3	27.1	25.9
Skinfold thickness	23.3	22.4	25.1	25.2	17.9	16.1	27.6	26.4	22.3	21.9	19.1	19.3
Serum cholesterol	234.3	218.6	232.0	223.6	191.8	198.8	214.6	231.8	221.1	215.8	210.8	209.9
Systolic blood pressure	158.1	138.4	167.7	143.6	125.7	122.0	191.1	146.8†	163.1	135.5‡	138.7	129.4‡
Diastolic blood pressure	87.3	80.3	87.0	83.0	74.7	73.9	98.8	85.1	87.4	80.2	80.6	77.4†
Number	19		13		30		16		36		115	

*, †, ‡ Significant differences between observed and predicted means are indicated as follows: * $P < 0.05$; † $P < 0.01$; ‡ $P < 0.001$.

Abbreviations: Obs = observed means; Pred = predicted means; a = less than 40 yr of age; b = more than 40 yr of age. Other abbreviations as in table 2. Units of measurement same as in table 1.

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The prevalence of complete intraventricular block was similar in the Tecumseh[2] and the present studies, and in both studies the frequency of right bundle-branch block was identical with that of left bundle-branch block.

Arrhythmias

(1). Frequent Premature Beats (Category VIII, 1). The frequency increased with age and there were no significant sex differences (table 2). In contrast, in the Tecumseh study, frequent premature beats were prevalent more frequently (1.9 vs. 0.65%), and were twice as common among men as among women.

2. Occasional Premature Beats (Table 2 and Fig. 4). ECGs with occasional premature beats were classified into atrial, A-V nodal, and ventricular according to classical

V, 1–2		V, 3		VI, 3		APB		NPB		VPB		Normal
Obs	Pred	Obs	Pred	Obs	Pred	Obs	Pred	Obs	Pred	Obs	Pred	Obs
Males (continued)												
45.3		45.4		41.0		42.6		42.8		45.6		34.6
166.6	164.7	181.5	169.6†	175.5	166.8	176.6	164.3	167.9	163.7	171.8	167.0	164.2
65.6	66.4	66.5	66.5	67.2	66.7	66.9	66.5	67.1	66.5	67.1	66.5	66.9
12.0	12.2	11.8	12.1*	12.1	12.2	12.0	12.2	12.2	12.2	12.2	12.1	12.3
30.3	26.8	31.3	27.9*	31.7	27.7*	31.3	27.0	30.5	26.7	30.0	27.2	28.1
10.8	7.9	11.1	8.7*	10.1	8.4	11.0	7.9	9.4	7.7	10.5	8.1	8.2
216.2	214.6	228.1	220.0	214.8	215.2	193.8	213.1	205.3	213.4	204.3	217.1	209.2
159.8	132.3‡	150.2	131.9‡	133.0	130.4	145.3	131.2	148.3	132.4	135.9	131.5	127.7
88.5	80.0*	87.7	80.8‡	76.8	79.7	83.6	79.4	83.5	79.8	83.4	80.1	78.5
36		68		44		22		13		34		699
Females (continued)												
45.0		39.6		38.6		34.9		44.6		47.5		32.2
162.1	154.0	145.8	151.0	139.3	144.0	143.7	142.2	145.8	151.0	165.2	158.0	142.5
61.3	61.4	61.0	61.7*	61.1	61.6	61.5	61.7	61.4	61.5	61.4	61.3	62.0
11.4	11.6	11.7	11.7	11.9	11.7	11.8	11.9	11.7	11.7	11.3	11.5	12.0
29.7	27.6	28.4	26.8	27.6	26.7	27.0	25.9	27.9	27.2	29.8	28.1	25.5
24.3	22.5	21.5	21.2	20.1	20.8	18.5	19.1	21.3	21.9	24.2	23.6	18.5
229.6	219.2	227.0	215.8	219.0	213.7	216.4	207.5	222.5	214.9	218.0	223.3	207.6
160.0	137.3†	139.1	132.7*	145.5	133.5*	140.0	130.0	141.5	134.5	156.8	139.4*	126.6
87.3	80.7	80.0	79.4	84.5	79.2	77.8	76.8	82.9	79.5	88.0	81.9	76.5
32		84		28		17		11		31		832

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criteria.[10] There were no significant sex differences. The frequency was low (≤3%) in the younger age groups.

3. *Other Arrhythmias.* Atrial fibrillation occurred in only three subjects (one male and two females). Only four subjects (one male and three females, all younger than 39 years) had A-V nodal rhythm. Incomplete A-V dissociation (without heart block) was found in two cases, and ventricular parasystole in a 56-year-old hypertensive woman on digitalis and antihypertensive medication.

Miscellaneous Items

Low voltage (IX, 1) was more common among females (table 2), while qualitative T-wave findings (IX, 2) were more prevalent among males, especially in the younger age groups (table 2). Prolongation of the Q-T interval was not present in the younger age groups. Wolff-Parkinson-White complexes were diagnosed in three subjects. Dextrocardia was present in one female and two male subjects.

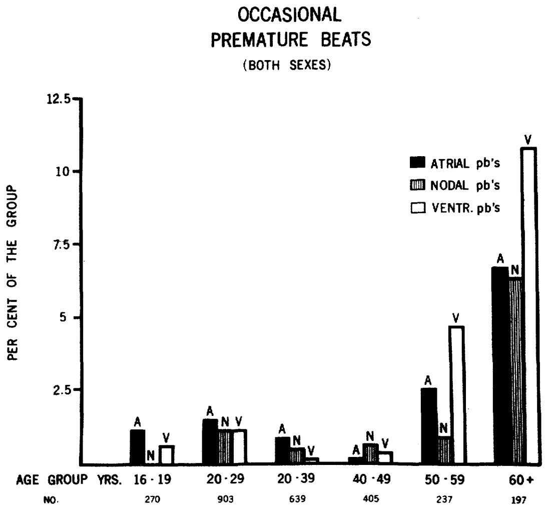

Figure 4

Comparison of frequency and age distribution of occasional premature beats (pb's).

Discussion

Although many large scale studies of highly selected subjects have been made in the past two decades,[1, 5, 6] only a few studies of total populations have been reported. The Tecumseh[2, 11] and this study share the same methods of analysis of the ECG, and both are representative of a total population. However, the populations under study are different. Tecumseh is a community in Southern Michigan, which "may be considered representative in its social and economic structure of a small, midwestern city and, within limits, of similar communities in the country as a whole."[12] On the other hand, the members of the H group form a genetic isolate, in that they marry only members of the H group. They live communally on large farms with about 20 families per farm. Women usually become pregnant soon after marriage and in general are pregnant or lactating until menopause. The median completed family size is over 10 children. The men are relatively short and stocky and perform heavy manual work from the time of their adolescence. The diet and work patterns in this community are fairly uniform, which is in sharp contrast to the pattern of living in the Tecumseh population.

Age

Major ECG items increased in frequency progressively with age: abnormal Q waves, left axis deviation, ST-segment and T-wave changes, bundle-branch block, prolonged P-R interval, and premature beats. These findings are in agreement with those reported for the community of Tecumseh.[2, 12] The relationship between anatomic and electrocardiographic age trends has been emphasized previously by Simonson[13] and by Blackburn et al.[14]

Sex Differences

Significant differences in the ECG have been found between the sexes for normal values[2, 15] as well as for codable items.[2] In this study, differences between the sexes were also found for several ECG items as follows: HAR and qualitative T-wave changes were more common among males, ST-segment depression and low QRS voltage were more common among females, and no sex differences were noted for T-wave items and prolonged P-R interval (table 2). However, in contrast to the Tecumseh study, there were no significant sex differences in the prevalence of Q waves, LAD, and premature beats (figs. 1, 3, and 4).

Blood Pressure

The major ECG items showed a striking association with increased blood pressure (table 4), more distinctly with the systolic than with the diastolic. This is in agreement with the findings of the Tecumseh[2] and other studies.[16]

Body Build Characteristics

In general, there was a lack of strong relationship between ECG findings and body build characteristics (table 4). A lower body weight was associated with HAR only in young males (see below). Significant differences were found for height in three ECG items, but the actual differences were less than 1 inch; hence their biologic significance appears doubtful.

Abnormal Left Axis Deviation

The prevalence of LAD was significantly lower in the H group than in the Tecumseh

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population[2] (1.7 versus 4.9%; fig. 2). Although a progressive leftward shift of the frontal QRS axis occurs with age, "healthy" individuals, including those aged 60 to 90 years, do not attain a QRS axis of minus 30°.[17] LAD was associated with increased blood pressure in the Tecumseh study, and this suggests that axis deviation of such a degree is an abnormal finding and may be evidence of heart disease.[18] Furthermore, some of these cases may represent left anterior hemiblock.[19]

High Amplitude R Waves

HAR of the left type is a sensitive index of left ventricular hypertrophy but lacks diagnostic specificity for it.[2] Hypertension is by far the most common cause of left ventricular hypertrophy. Rautaharju and Blackburn[20] found a significant correlation between QRS voltages and blood pressure levels. Although the mean blood pressure levels in the H population are comparable to those of the Tecumseh population, the prevalence of HAR is higher in the males (20 and 6%, respectively). It appears unlikely that the small differences in blood pressure alone can account for the increased prevalence of HAR among young subjects, and especially for the unusually high prevalence (40.5%) among the young males. Another explanation may be found in the analysis of two factors known to influence QRS voltage, that is, body build and heavy physical work. Regarding the former, Kilty and Lepeschkin[21] showed that tall and thin subjects (high ponderal index) had higher QRS voltages than those with lower ponderal indices. Although we found that males with HAR were thinner than those with normal QRS voltages, the differences in ponderal indices did not attain statistical significance (table 4). Heavy physical work and physical fitness[22, 23] were then considered to explain the high frequency of HAR in this population. The heavy work performed by the young males in this agrarian community could account for the increased frequency of HAR. It is of interest that Maccabiah athletes studied by two of us (H.K.H. and A.N.G.)[23] had similar ponderal indices to those of the males in this study and also had high QRS voltages.

The lower association with other ECG items (76% of the subjects with HAR had it as the only abnormality, whereas 30 and 45%, respectively, of those with Q waves and LAD had them as the only abnormality) is further evidence that HAR among young males in this population is a normal finding and does not indicate heart disease.

Clinical electrocardiographers will readily appreciate that criteria for the diagnosis of left ventricular hypertrophy should take into account constitutional variables such as age, sex, body build, and perhaps physical fitness, to improve their specificity.[24, 25]

ST-Segment Depression

The frequency of ST-segment items in the present study was significantly different from that given in the Tecumseh report (9.3 and 4.0% respectively).[2] Although a similar proportion of subjects had categories IV, 1 and IV, 2 in both studies, in the present one more subjects were classified as IV, 3. Although the reason for this difference in the frequency of the IV, 3 item is not known, it is important to point out that among the H group, even the less marked changes (IV, 3) were associated with higher blood pressure (table 4).

Premature Beats

The Minnesota Code considers premature beats to be a codable item when they comprise at least 10% of recorded beats.[9] In the present study, the association of *occasional* premature beats (less than 10% of the total) with age, blood pressure, and other codable ECG items suggests that they too may be associated with heart disease and should be coded. Lyle[26] concluded from a study of 11,000 employees, that premature beats are associated with a definite but small increased mortality risk. Very recently, in a follow-up study of the Tecumseh population, an increased prevalence of coronary heart disease and higher incidence of sudden death were found in persons with antecedent ventricular premature systoles.[27]

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Comparison with the Tecumseh Study

To summarize the comparison with the Tecumseh study, there were similarities (that is, association of the major ECG items with blood pressure and similar sex differences) and points of contrast (that is, the relationship with serum cholesterol and different prevalence rate and sex distribution for several ECG items). These differences suggest that multiple factors (genetic, environmental, social, and occupational) are involved. The influence of blood glucose was not studied in the H group. Obviously, more research is needed to clarify the implications of these differences.

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References

1. Hiss RG, Lamb LE: Elctrocardiographic findings in 122,043 individuals. Circulation **25**: 947, 1962
2. Ostrander LD Jr, Brandt RL, Kjelsberg MO, et al: Electrocardiographic findings among the adult population of a total natural community, Tecumseh, Michigan. Circulation 31: 888, 1965
3. Biörk G, Blomqvist G, Hall P, et al: Coronary heart disease in a population in the south of Sweden. Acta Med Scand **179**: 663, 1966
4. Kannel WB, Kagan A, Dawber TR, et al: Epidemiology of coronary heart disease. Geriatrics **17**: 675, 1962
5. Epstein FH, Pollack AA, Ostrander LD Jr: An electrocardiographic survey in Peru. Amer J Med Sci **247**: 687, 1964
6. Srikantia SG, Padmavati S, Gopalan C: The electrocardiogram in some Indian population groups. Circulation **29**: 118, 1964
7. Steinberg AG, Bleibtreu HK, Kurczynski TW, et al: Genetic studies on an inbred human isolate. *In* Proceedings of the Third International Congress of Human Genetics, edited by Crow JF, Neel JV. Baltimore, Johns Hopkins Press, 1967, pp 267-290
8. Schoenheimer R, Sperry WM: A micromethod for the determination of free and combined cholesterol. J Biol Chem **106**: 745, 1934
9. Blackburn H, Keys A, Simonson E, et al: The electrocardiogram in population studies: A classification system. Circulation **21**: 1160, 1960
10. Katz LN, Pick A: Clinical Electrocardiography: Part I. The Arrhythmias. Philadelphia, Lea and Febiger, 1956, p 40
11. Ostrander LD Jr: Serial electrocardiographic findings in a prospective epidemiological study. Circulation **34**: 1069, 1966
12. Epstein FH, Ostrander LD Jr, Johnson BC, et al: Epidemiological studies of cardiovascular disease in a total community—Tecumseh, Michigan. Ann Intern Med **62**: 1170, 1965
13. Simonson E: The electrocardiogram in coronary heart disease. Minnesota Med **38**: 871, 1955
14. Blackburn H, Vasquez CL, Keys A: The aging electrocardiogram: A common aging process or latent coronary artery disease? Amer J Cardiol **20**: 618, 1967
15. Simonson E, Blackburn H, Puchner TC, et al: Sex differences in the electrocardiogram. Circulation **22**: 598, 1960
16. Blackburn H, Parlin RW, Keys A: The interrelations of electrocardiographic findings and physical characteristics of middle-aged men. Acta Medica Scand Suppl. **460**: 316, 1966
17. Gorman PA, Calatayud JB, Abraham S, et al: Effects of age and heart disease on the QRS axis during the seventh through tenth decades. Amer Heart J **67**: 38, 1964
18. Harlan WR Jr, Gatrbiel A, Osborne RK: Longitudinal study of healthy young men followed over an 18 year period. Bull Med Project MR 005 13-3001, Subtask 2, Report No. 5, Naval School of Aviation, Pensacola, Florida, 1962
19. Rosenbaum MB, Elizari MV, Lazzari JO: Los Hemibloques. Buenos Aires, Ed. Paidos, 1968
20. Rautaharju PM, Blackburn H: Relationship of elevated blood pressure to ECG amplitudes and spatial vectors in otherwise "healthy" subjects. Amer Heart J **61**: 156, 1961
21. Kilty SE, Lepeshkin E: Effect of body build on the QRS voltage on the electrocardiogram in normal men: Its significance in the diagnosis of left ventricular hypertrophy. Circulation 31: 77, 1965
22. Rautaharju PM: Voltage Changes in the Electrocardiogram as Caused by Vigorous

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Training. Third World Congress of Cardiology, Abstract of Communications, Brussels, 1958, p 411

23. HELLERSTEIN HK, DUPERTIUS CW, GOLDBARG AN, ET AL: Correlation of electrocardiograms and constitutional characteristics of 277 Maccabiah athletes. (Submitted for publication)
24. OSTRANDER LD JR: Epidemiological study of the electrocardiographic diagnosis of left ventricular hypertrophy. Circulation 33: 270, 1966
25. SIMONSON E: Differentiation between Normal and Abnormal in Electrocardiography. St. Louis, C. V. Mosby Co., 1961
26. LYLE AM: Coronary disease as an underwriting problem. Trans Soc Actuaries 15: 324, 1963
27. CHIANG BN, PERLMAN LV, OSTRANDER LD JR, ET AL: Relationship of premature systoles to coronary heart disease and sudden death in the Tecumseh epidemiologic study. Ann Intern Med 70: 1159, 1969

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