ORIGINAL ARTICLE

Population prevalence of electrocardiographic abnormalities: results of the Polish WAW-KARD study

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KEY WORDS
electrocardiographic abnormalities, Minnesota code, population survey

ABSTRACT

BACKGROUND Electrocardiogram (ECG) is a very important instrument in the diagnostic workup of the heart disease, both in clinical and epidemiological studies.

AIMS The aim of the study was to evaluate ECG abnormalities in adult residents of Warsaw and to determine the time trends of ECG abnormalities in the years 1984 to 2012.

METHODS A total of 1081 individuals aged 20 years of older were examined in the years 2011 to 2012. All of them had resting ECG obtained, later coded using the Minnesota Code. To determine time trends, we additionally used the ECG data from Pol-MONICA studies.

RESULTS More than one-third of individuals had normal ECG, and that number increased to half of them when heart rate was ignored as the only abnormality (in young persons 44% and 69.8%, respectively, and in asymptomatic individuals 45.9% and 68.1%, respectively). The most prevalent abnormality in men was intraventricular conduction disturbances, and in women ST-segment depression and negative T-wave changes (repolarization changes). QRS-axis deviation and R wave of high amplitude were observed significantly more often in men compared with women. The frequency of ECG abnormalities and simultaneous occurrence of several ECG changes increased with the age of the study participants.

CONCLUSIONS Normal ECG was observed only in one-third of adult residents of Warsaw, and in half of those who were young or asymptomatic. The most frequent ECG abnormalities in men were intraventricular conduction disturbances and repolarization changes in women. Atrial fibrillation was the most prevalent arrhythmia. We did not find significant time trends for repolarization changes, conduction disturbances, and arrhythmia.

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INTRODUCTION Twelve-lead electrocardiogram (ECG) is an important, common, routine, repeatable, and inexpensive tool for the diagnostic workup of heart disease, both in clinical and epidemiological studies. The implementation of the Minnesota Code allowed comparison of results between studies.[1,2] Previously, the lack of precise criteria for ECG interpretation was one of the barriers for the wider use of ECG in epidemiological studies, primarily because the repeatability of ECG evaluations was low even in the same observer. The highest discrepancies were observed in the evaluation of discrete ischemic findings, and the smallest in the evaluation of arrhythmias.[3]

To the best of our knowledge, this is the first study to evaluate abnormal findings of resting ECG in the general population (adult residents of Warsaw).

The aim of the study was to evaluate the frequency and type of abnormal findings in resting ECGs of adult residents of Warsaw, and after taking into consideration 3 World Health Organization MONICA (Monitoring Trends and Determinants in Cardiovascular Disease) studies (1984, 1988, and 1993), to determine the time trends of abnormal findings in ECG of persons aged 35 to 64 years between the years 1984 to 2012.

WHAT'S NEW?

The present study provides an overview of electrocardiographic (ECG) abnormalities in a randomly selected general population of Warsaw, Poland, including a population of young individuals. To our best knowledge, this is the first analysis on a general city population in Poland since the World Health Organization MONICA (Monitoring Trends and Determinants in Cardiovascular Disease) study carried out from 1984 to 1993. We found a relatively high percentage of abnormal ECGs. Only one-third of the Warsaw population, and half of both asymptomatic as well as young participants, had a normal ECG. On ECGs in men, the most frequent abnormalities were intraventricular conduction disturbances, and in women, repolarization changes. Atrial fibrillation was the most frequent arrhythmia.

METHODS For the Polish contribution to the pilot study (EHES-JA, European Health Examination Survey – Joint Action)[4] and WAW-KARD,[5] a total of 2140 permanent residents of Warsaw aged 20 years or older were selected using the national personal identity number (PESEL) electronic register. The study sample was stratified according to sex and district.

At the beginning of 2011, 207 residents of the eastern districts of Warsaw, aged 20 to 74 years, were examined. Then, from June 2011 to August 2012 next 870 persons, 660 residents of the eastern districts of the city, aged 20 years of older, and 210 residents of the western districts of the city, aged 74 years or older, were examined. All participants signed a written informed consent form prior to data collection and the study was accepted by the Field Bioethics Committee of the Institute of Cardiology in Warsaw.

The respondents underwent resting ECG and blood sampling, and were required to fill in general, dietary, and psychological questionnaires.

We identified a group of young persons aged 20 to 35 years. In order to evaluate the frequency of abnormal ECG in persons free from cardiovascular diseases (CVDs), we selected a respondent group without any history of self-reported coronary artery disease, heart failure, hypertension, or arrhythmia.

To determine the time trends of abnormal findings, we used the ECG data set from Pol-MONICA studies performed in: 1984 (1254 men and 1298 women), 1988 (682 men and 699 women), and 1993 (721 men and 739 women),[6] and a subpopulation from WAW-KARD limited to residents of eastern districts of Warsaw aged 35 to 64 years. In total, there were 165 such persons in the WAW-KARD study (84 men and 81 women).

Resting electrocardiogram Resting ECGs (with standard limb and precordial ECG leads) were assessed using Sentinel software version 8.5 (Snoqualmie, Washington, United States), resulting in a 12-lead ECG with a paper speed of 25 mm/s. ECGs were coded using the Minnesota Code by 2 independent coders and a supervisor to solve any discrepancies. All 3 persons had experience in ECG coding from previous population studies and all of them were blinded to the health status of the examined persons. The following categories were considered in coding: Q and QS pattern (1-X-X), QRS axis deviation (2-X), R wave of high amplitude (3-X), ST-segment depression (4-X), T-wave pattern (5-X), atrioventricular (AV) conduction defects (6-X), ventricular conduction defects (7-X-X), and arrhythmia (8-X-X). For the time trends analysis, the participants were divided into 3 groups based on the Minnesota Codes: repolarization changes (ST-segment depression elevation or T-wave pattern; codes, 4-X, 9–2, and 5-X, respectively), conduction defects (codes, 6-X or 7-X-X), and arrhythmias (codes, 8-X-X). As a normal heart rate, we assumed heart rate within 60 to 100 beats/min.[7]

We also analyzed the frequency of minor ECG changes defined with the following codes: Q, I-2-6, 1-2-8, 1-3-X; ST-segment depression, 4-3, 4-4; negative T wave, 5-3, 5-4.

Statistical analysis Analyses were performed using Statistical Analytical Software, version 9.2 (SAS, Cary, North Carolina, United States). The level of significance was set at a *P* value of less than 0.05. Continuous variables were presented as means (SD), and categorized variables as frequencies with 95% confidence interval (95% CI). The *t* test was performed to compare means. Frequencies of abnormal ECG findings between groups were compared using least squares test, and the significance of trends was established using the logistic regression model.

TABLE 1 Characteristics of the WAW-KARD population

Parameter	Men (n= 579)	Women (n = 502)	*P* value
Obesity[a]	185 (31.9)	178 (35.4)	0.23
Hypertension[b]	312 (54.0)	222 (44.3)	0.001
Smoking habit[c]	108 (18.6)	77 (15.3)	0.15
Hyperlipidemia[d]	477 (82.4)	399 (79.5)	0.22
Diabetes[e]	64 (11.1)	43 (8.5)	0.15

Data are presented as number (percentage).

a waist, men ≥102 cm, women ≥88 cm;
b blood pressure >140/90 mm Hg or antihypertensive treatment;
c at least 1 cigarette/d;
d total cholesterol ≥5.0 mmol/l or low-density lipoprotein cholesterol ≥3.0 mmol/l or triglycerides ≥1.7 mmol/l or on hypolipidemic treatment;
e glucose ≥7.0 mmol/l or hypoglycemic treatment

RESULTS In the WAW-KARD study, 1081 persons aged 20 years of older were examined (579 men and 502 women) (TABLE 1). Men represented 53.6% of the study population. The mean (SD) age of both men and women did not differ significantly

(57.1 [15.7] years versus 56.7 [15.7] years, $P = 0.62$). Hypertension was observed significantly more often in men than in women. There were no differences according to analyzed risk factors (TABLE 1).

A completely normal resting ECG (without abnormal findings according to the Minnesota Code and with heart rate within 60–100 bpm) was found in more than 30% of the participants, and the frequency was comparable between men and women (35.9% and 38.6%, respectively). If heart rate abnormalities were ignored, normal ECG was observed in more than 50% of the participants. The mean heart rate of men and women did not differ and was approximately 64 bpm (TABLE 2). In about 1% of ECGs, both in men and women, supraventricular rhythm (other than sinus rhythm) was the dominant rhythm, and, additionally, in 4% of ECGs, atrial fibrillation was the dominant rhythm (TABLE 3).

The most frequently observed findings on ECG in men were intraventricular conduction disturbances, whereas in women ST-segment depression and negative T waves were most frequent. QRS-axis deviation and R wave of high amplitude were observed more often on the ECGs of men as compared with women. Moreover, in men, arrhythmias were twice more frequent and ischemic changes appeared twice less frequently than in women (TABLE 2).

Atrial fibrillation was the most frequently observed arrhythmia on ECG (3-fold more frequently in men compared with women), and the most prevalent AV conduction defect was AV conduction prolongation (PR interval

TABLE 2 Prevalence of electrocardiographic abnormalities defined by the Minnesota Code in the adult Warsaw residents by sex

Parameter	Men (n = 579)	Women (n = 502)	*P* value
Age, y, mean (SD)	57.1 (15.7)	56.7 (15.7)	0.62
Q and QS pattern (1-1-1 to 1-3-6)	8.0 (5.9–10.0)	5.4 (3.2–7.6)	0.10
• I, aVL, V_6	0.5 (0.1–1.0)	–	–
• II, III, aVF	4.2 (2.7–5.7)	2.6 (1.0–4.2)	0.17
• V_1–V_5	3.5 (2.0–4.9)	2.8 (1.3–4.4)	0.54
QRS axis deviation (2–1 to 2–5)	9.5 (7.4–11.7)	5.6 (3.3–8.0)	0.02
• left	8.9 (6.8–10.9)	5.0 (2.8–7.3)	0.01
• right	0.6 (0.0–1.4)	0.6 (0.0–1.2)	0.85
High R waves (3–1 to 3–4)	3.3 (2.1–4.5)	0.6 (0.4–1.8)	0.002
ST-segment depression (4-1-1 to 4–4)	6.6 (4.1–9.0)	14.3 (11.6–17.0)	<0.001
• I, aVL, V_6	5.2 (3.1–7.3)	9.9 (7.6–12.2)	0.004
• II, III, aVF	1.9 (0.4–3.4)	5.4 (3.8–7.1)	0.002
• V_1–V_5	3.5 (1.4–5.5)	10.5 (8.3–12.6)	<0.001
T-wave pattern (5–1 to 5–4)	8.5 (5.9–11.1)	14.9 (12.1–17.7)	0.001
• I, aVL, V_6	6.9 (4.7–9.2)	10.3 (7.8–12.2)	0.052
• II, III, aVF	2.8 (1.1–4.4)	6.2 (4.4–8.0)	0.006
• V_1–V_5	5.6 (3.3–7.8)	11.5 (9.1–13.9)	0.001
AV conduction defect (6–1 to 6–8)	5.2 (3.2–7.2)	7.4 (5.3–9.6)	0.13
Ventricular conduction defect (7-1-1 to 7–8)	11.5 (8.7–14.0)	11.1 (8.3–13.9)	0.84
Arrhythmias (8-1-18-9)	9.4 (7.3–11.5)	4.4 (2.2–6.7)	0.002
ST-segment elevation (9–2)	1.7 (0.9–2.5)	–	–
Normal ECG (no abnormal findings by the Minnesota code)	56.3 (52.2–60.3)	57.1 (52.8–61.5)	0.77
Normal ECG (no abnormal findings by the Minnesota code + heart rate within 60–100 bpm)	35.9 (32.0–39.9)	38.6 (34.3–42.9)	0.36
Heart rate, bpm, mean (SD)	64.1 (11.6)	64.0 (9.3)	0.92

Data are presented as frequencies and 95% confidence interval (CI) unless indicated otherwise.

Abbreviations: AV, atrioventricular; ECG, electrocardiogram

TABLE 3 Prevalence of conduction defects and arrhythmias defined by the Minnesota Code in a population of adult Warsaw residents by sex

Parameter	Men (n = 579)	Women (n = 502)	*P* value
AV conduction defects			
Wenckebach phenomenon (6-2-3)	0.2 (0.0–0.5)	–	–
AV conduction prolongation (6-3)	2.6 (1.3–3.9)	1.2 (0.2–2.2)	0.09
Short PR interval (6-5)	1.0 (0.2–1.9)	4.8 (2.9–6.7)	<0.001
Artificial pacemaker (6-8)	1.4 (0.4–2.3)	1.4 (0.3–2.4)	1.00
Ventricular conduction defect			
LBBB (7-1-1)	0.2 (0.0–0.5)	0.6 (0.0–1.3)	0.29
RBBB (7-2-1)	2.3 (1.0–3.5)	0.4 (0.0–1.0)	0.008
Incomplete RBBB (7-3)	2.3 (1.0–3.5)	2.4 (1.1–3.8)	0.91
Intraventricular block (7-4)	3.0 (1.6–4.3)	1.0 (0.1–1.9)	0.02
RR' in V_1 or V_2 precordial lead (7-5)	3.1 (1.7–4.6)	6.4 (4.3–8.6)	0.01
LAH (7-7)	0.3 (0.0–0.8)	–	–
Arrhythmias			
Frequent atrial or junctional premature beats (8-1-1)	1.9 (0.8–3.0)	1.0 (0.1–1.9)	0.22
Frequent ventricular premature beats (8-1-2)	2.1 (0.9–3.3)	0.8 (0.0–1.6)	0.08
Atrial fibrillation (8-3-1)	4.3 (2.7–6.0)	1.4 (0.4–2.4)	0.005
Supraventricular rhythm (8-4-1)	1.0 (0.2–1.9)	1.2 (0.2–2.2)	0.75

Data are presented as frequencies and 95% CI.

Abbreviations: LAH, left anterior hemiblock; LBBB, left bundle branch block; RBBB, right bundle branch block; others, see TABLE 2

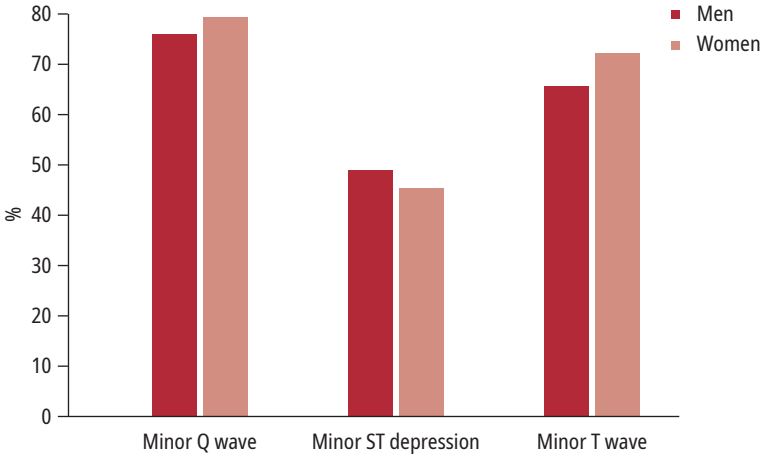

FIGURE 1 Frequency of minor changes in specific types of electrocardiographic abnormalities by sex

over 200 ms) in men, and a short PR interval in women (TABLE 3).

The frequency of abnormal findings on ECG increased with age of the study participants, especially changes in ST segment and T wave, arrhythmias, and, in men only, conduction disturbances (TABLE 4).

Among persons without self-reported CVD (mean age 48.0 [13.8] years), only 45.9% (46.2%, of men and 45.6% of women) had normal ECG results (no Minnesota Codes and heart rate within 60–100 beats/min), and this proportion increased to 68.1% if the presence of abnormal heart rate was ignored (data not shown).

As to the analysis of ECG results of young people, because there was a small number of participants in this group (116), we analyzed the frequency of abnormal findings in the whole group instead of doing so on a gender-specific basis. The proportion of individuals with normal ECG was 44.0%, but if we did not take heart rate into account, it raised to 69.8% (TABLE 5). The most frequently observed abnormalities in the ECGs of young persons were ventricular and AV conduction defects and ST-segment depression. We observed only the following conduction defects: short PR interval, AV conduction prolongation, RR' in V_1 or V_2, incomplete right bundle branch block. With regards to arrhythmia, the following were observed: frequent atrial or junctional premature beats and persistent supraventricular rhythm (TABLE 5).

Both in persons under 35 and above 35 years of age, more than 50% of abnormalities like abnormal Q waves, ST-segment depression, and negative T wave were represented by minor changes (FIGURE 1).

The frequency of simultaneous occurrence of several changes on ECG increased with age (FIGURE 2). None of the young men had simultaneously 3 types of any abnormal findings on ECG,

TABLE 4 Prevalence of electrocardiographic abnormalities in a population of adult Warsaw residents by age groups

Sex	Age, y, range (n)	Q or QS pattern	QRS axis deviation	High R amplitude	ST-segment depression	T wave pattern	AV conduction defect	Ventricular conduction defect	Arrhythmias	ST-segment elevation
Men	20–35 (64)	4.7 (0.0–10.0)	6.3 (0.2–2.3)	3.1 (0.0–7.5)	–	–	1.6 (0.0–4.7)	4.7 (0.0–10.0)	3.1 (1.3–7.5)	4.7 (0.0–10.0)
	36–50 (133)	6.0 (1.9–10.1)	4.5 (0.9–8.1)	3.8 (0.5–7.0)	3.0 (0.0–5.9)	3.8 (0.5–7.0)	2.3 (0.0–4.8)	8.3 (3.5–13.0)	4.5 (0.9–8.1)	2.3 (0.0–4.8)
	51–65 (196)	5.1 (2.0–8.2)	8.2 (4.3–12.0)	3.1 (0.6–5.5)	7.1 (3.5–10.8)	8.2 (4.3–12.0)	5.1 (2.0–8.2)	6.6 (3.1–10.1)	6.1 (2.7–9.5)	1.5 (0.0–3.3)
	>65 (183)	13.7 (8.6–18.7)	15.8 (10.5–21.2)	3.3 (0.7–5.9)	10.9 (6.4–15.5)	15.3 (10.0–20.6)	8.7 (4.6–12.9)	21.3 (15.3–27.3)	18.6 (12.9–24.3)	0.5 (0.0–1.6)
P value	–	0.01	0.003	0.99	0.005	<0.001	0.03	<0.001	<0.001	0.17
Women	20–35 (52)	3.8 (0.0–9.3)	–	–	11.5 (2.6–20.5)	7.7 (0.2–15.2)	7.7 (0.2–15.2)	11.5 (2.6–20.5)	1.9 (0.0–5.8)	–
	36–50 (120)	2.5 (0.0–5.3)	3.3 (0.0–6.6)	–	5.8 (1.6–10.1)	4.2 (0.5–7.8)	8.3 (3.3–13.4)	6.7 (2.1–11.2)	3.3 (0.1–6.6)	–
	51–65 (174)	7.5 (3.5–11.4)	7.5 (3.5–11.4)	1.1 (0.0–2.7)	10.9 (6.2–15.6)	13.2 (8.1–18.3)	6.9 (3.1–10.7)	14.4 (9.1–19.6)	1.7 (0.0–3.7)	–
	>65 (151)	6.0 (2.1–9.8)	7.3 (3.1–11.5)	0.7 (0.0–2.0)	25.8 (18.8–32.9)	27.8 (20.6–35.0)	7.3 (3.1–11.5)	10.6 (5.6–15.6)	9.3 (4.6–14.0)	–
P value	–	0.29	0.10	0.59	<0.001	<0.001	0.97	0.23	0.006	–

Data are presented as frequencies and 95% CI unless otherwise indicated.

Abbreviations: see TABLES 2 and 3

TABLE 5 Prevalence of electrocardiographic abnormalities defined by the Minnesota Code in a population of young residents of Warsaw (20–35 years)

Parameter	Young persons (n = 116)
Age, y, mean (SD)	31.0 (3.1)
Q and QS pattern (1-1-1 to 1-3-6)	4.3 (0.6–8.1)
QRS axis deviation (2–1 to 2–5)	3.5 (1.8–10.7)
High R amplitude (3–1 to 3–4)	1.7 (0.0–4.1)
ST segment depression (4-1-1 to 4–4)	5.2 (1.1–9.3)
T wave pattern (5-1 to 5-4)	3.5 (0.1–6.8)
AV conduction defect (6-1 to 6-8)	4.3 (0.6–8.1)
Ventricular conduction defect (7-1-1 to 7-8)	7.8 (2.8–12.7)
Arrhythmias (8-1-1 to 8-9)	2.6 (0.0–5.5)
ST elevation (9-2)	2.6 (0.0–5.5)
Normal ECG (no abnormal findings by Minnesota code)	69.8 (61.4–78.3)
Normal ECG (no abnormal findings by Minnesota code + heart rate within 60-100 beats/min)	44.0 (34.8–53.1)
Heart rate, beats/min, mean (SD)	62.2 (12.3)
Conduction disturbances and arrhythmias	
AV conduction prolongation (6-3)	0.9 (0.0–4.7)
Short PR interval (6-5)	3.5 (0.1–6.8)
Incomplete RBBB (7-3)	0.9 (0.0–2.6)
RR' in V1 or V2 (7-5)	6.9 (2.2–11.6)
Frequent atrial or junctional premature beats (8-1-1)	0.9 (0.0–4.7)
Supraventricular rhythm (8-4-1)	1.7 (0.0–4.1)

Data are presented as frequencies and 95% confidence intervals (CIs) unless otherwise indicated.

Abbreviations: see TABLES 2 and 3

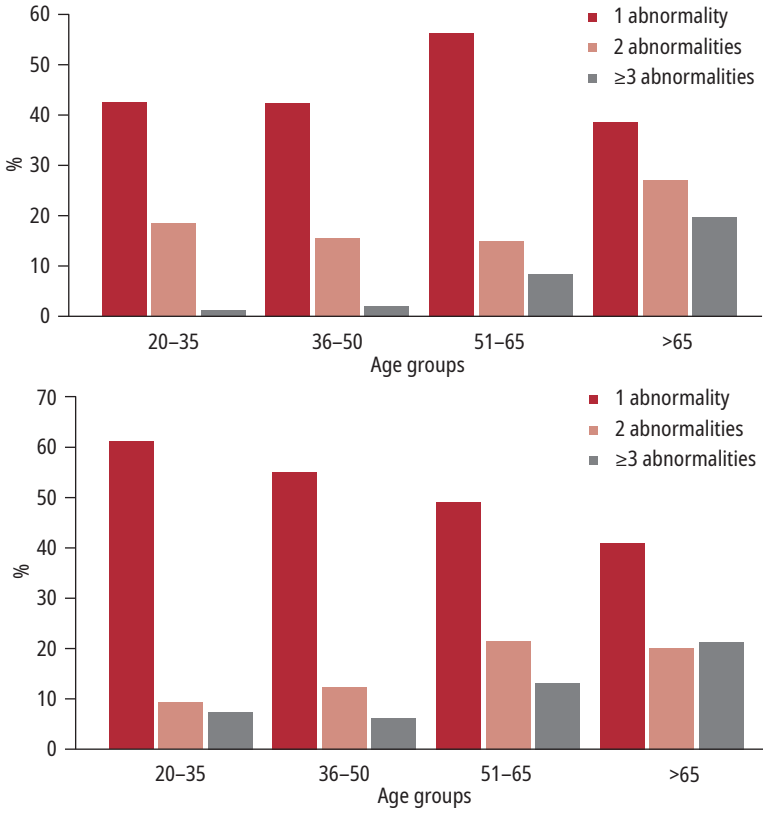

FIGURE 2 Simultaneous occurrence of several changes on resting electrocardiogram by age

whereas this was observed in 19.0% of ECGs of men aged 65 years or older (in women 7.7% and 20.5%, respectively).

After analyzing the time trends (1984–2012) of the prevalence of abnormal findings on resting ECGs of residents of eastern districts of Warsaw aged 35 to 64 years, we did not find a trend for the 3 categories analyzed (repolarization changes, conduction disturbances, and arrhythmia), although the increase in prevalence of arrhythmias was associated with a trend of borderline significance both in men and women (FIGURE 3).

DISCUSSION Resting ECG is an important instrument for the detection, prediction, and prevention of cardiovascular incidents, especially when information regarding illness history is unavailable (eg, for a patient in an emergency room without any medical documentation). There are a few reports from different populations concerning the prevalence of abnormal findings in resting ECGs evaluated by the Minnesota Code.[8-10]

The comparison of results of the WAW-KARD study with that of other studies is not a simple task, even when using the Minnesota Code, which standardizes the approach

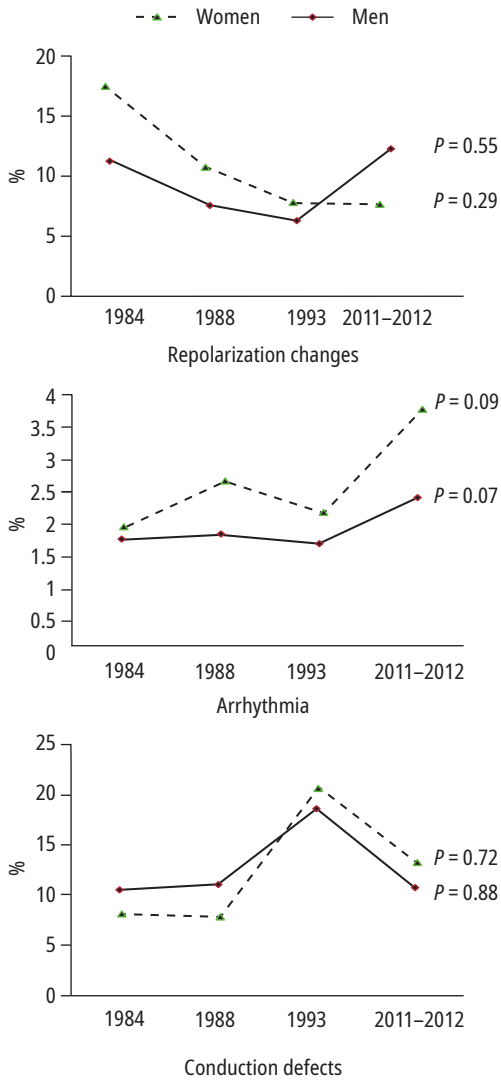

FIGURE 3 Time trends in the prevalence of electrocardiographic abnormalities; *P* values are presented for time trends.

to the evaluation of ECGs in epidemiological studies. The plurality of abnormal ECG definitions adopted by researchers and different age ranges of the study groups pose a challenge.

In the WAW-KARD study, as expected, a reduction in the frequency of normal ECG and an increase in the simultaneous occurrence of several ECG changes was observed with older age. Additionally, men and women differed in terms of ECG findings. In men, we observed more frequently R waves of high amplitude, QRS-axis deviation, and arrhythmias, and in women, repolarization changes like ST-segment depression and negative T waves.

In general, Q/QS pattern, ST-segment depression, or negative T waves were the most frequently observed ECG findings in the study population. About 28% of men and women (women more frequently) had some kind of Q wave and repolarization changes on their ECG, but more than 50% of them were minor ones, and in case of Q waves, about 70%. Even minor ST segment changes or simply low-amplitude (but not flat) T waves appear to carry significant excess risk of mortality.[11] On the other hand, in the fourth Copenhagen City Heart Study, an observation was made that in the general population, even minor Q waves on an ECG were associated with death or hospitalization, regardless of age, hypertension, or diabetes.[12] It is a well-known phenomenon that repolarization changes are more prevalent in women than in men. There are several factors influencing the prevalence of these changes, that is, hyperventilation, hyperkinetic circulation, mitral valve prolapse, and additionally female hormones. Liao et al,[9] in the Chicago Heart Association Detection Project in Industry study, suggested the need for a differentiation of the criteria for ST-segment depression and negative T waves for women and for men.

Comparing our present results with Polish data obtained from resting ECGs of 5618 persons examined in 3 Pol-MONICA studies, we found that abnormal ECGs were more prevalent in WAW-KARD than in MONICA, but one should take into account that the WAW-KARD population was older than the MONICA population (mean [SD] age, 57.1 [15.7] years vs 49.5 [8.5] years, respectively).[8] The characteristics of ECG abnormalities observed in men and women were similar in both studies: ST-segment depression and negative T wave were more frequently found in women, intraventricular disturbances and axis deviation were more prevalent in men.

After analyzing our results obtained for individuals aged 65 years or older in comparison with data from another Polish cohort of 469 residents of Kraków aged 70 years or older,[13] we found a similar frequency of normal ECGs (men 21.8%, women 29.8% in WAW-KARD vs 26.4% and 25.9% in the residents of Kraków). In conjunction with this, our respondents (slightly younger than those examined in Kraków) had a lower frequency of Q waves, ST depression, but a much higher frequency of negative T waves as compared with the Kraków population. Both populations has similar frequencies of the remaining ECG abnormalities.

We found approximately 36% of completely normal ECGs in men and 39% in women. When abnormal heart rate was not considered as the only abnormality, this frequency increased to 56% and 57%, respectively. Comparing our results with other European populations, namely, the Belgian population (data from 47 358 individuals aged 25–74 years from 4 large epidemiological studies conducted in the 1980s and 1990s), we found that both populations had different frequencies of abnormal findings observed on resting ECGs.[10] In general, the particular types of ECG changes, like repolarization changes, arrhythmia, AV conduction defects, were more prevalent in Polish than in Belgian populations, and a similar prevalence was observed in the case of high-amplitude R wave, axis deviation, and bundle branch blocks. It seems

that the main factors influencing results could be the fact that both populations were separated by a period of about 20 years, and that they differed in age-limits (Belgian population, 25–74 years; Warsaw population, 20 years or older). Moreover, the population of the WAW-KARD study is a large-city population.

In another European cross-sectional study of Spanish workers aged 16 to 74 years, the prevalence of normal ECG was 77.2% as compared with more than 50% in our study, but the Spanish respondents were much younger than the respondents in our population (mean [SD] age 40.0 [10.5] years).[14]

Data from our study concerning the prevalence of normal resting ECG did not differ from results obtained worldwide. For example, in a study including 3567 residents of Sao Paolo with the mean (SD) age of 51 (6) years, the proportion of normal ECGs was 46.2% (in WAW-KARD less than 40%, but increased to about 57% if abnormal heart rate was ignored).[15] However, the Brazilian population was younger than the Polish population.

Analyzing individuals without self-reported CVD, we found that resting ECG abnormalities were relatively common. Only slightly less than half of asymptomatic participants of WAW--KARD study had normal ECG. In a British study of 4739 consecutive, apparently healthy, individuals with mean (SD) age of 62.8 (6.2) years, the proportion of entirely normal ECG was higher (about 68%).[16] If we ignored the presence of an abnormal heart rate, we had the same proportion of normal ECGs, but it should be noted that our population of asymptomatic participants was much younger (mean [SD] age, 48.0 [13.8] years) than the British population.

Usually, young people are not screened for CVD, unless they have heart symptoms, positive family history of premature CVD, or do top-level athletics (in most European countries, including Poland, ECG screening of competitive athletes is recommended).[17] Therefore, there is no data concerning abnormal findings on ECGs of persons under 35 years of age. In a British study including people younger than than 35 years of age (from 14 to 35 years, athletes and nonathletes), 42.5% of nonathletes had normal ECG.[18] In the young population of WAW-KARD, which was slightly older than in the British study, completely normal ECG was also observed in more than 40% of both men and women, and in more than 65% when the heart rate was not considered. In contrast, Swiss researchers analyzed ECGs of 43 401 persons with a mean (SD) age of 19.2 (1.1) years and came to the conclusion that ECG abnormalities were found in a relatively large proportion of young individuals. The main abnormal findings on ECGs from a young Swiss population, similarly to our results, were conduction defects, especially ventricular conduction defects, incomplete right bundle branch block in particular.[19]

Study limitations Data obtained from the general population of the residents of Warsaw cannot be extrapolated to the whole Polish population. The number of persons aged 20 to 35 years was small, which prevented the analysis of male and female populations separately in this age group. A limitation of the Minnesota Coding is observer bias, since even rigid criteria for classification of the ECG findings do not guarantee similar coding by different individuals,[20] although it seems that in our study this problem was minimized because of the involvement of 2 trained and experienced coders and a supervisor.

Conclusions The WAW-KARD study demonstrated that only one-third of adult residents of Warsaw had a normal ECG, but when we ignored heart rate as the only abnormality observed, the proportion raised to half of the residents. Among individuals without self-reported CVD, only about 50% had a normal ECG. Similarly, nearly half young participants had a normal ECG, and the proportion rose to two-thirds after ignoring heart rate. The most frequently observed abnormalities on ECGs were intraventricular conduction disturbances in men and repolarization changes in women. In general, more than half of Q wave, ST-segment depression, and negative T wave cases were minor changes. Atrial fibrillation was the most frequently observed arrhythmia. With older age of the examined persons, frequency of simultaneous occurrence of several changes in one ECG increased. We did not find significant time trends (from 1984 to 2012) for 3 analyzed categories of ECG abnormalities (repolarization changes, conduction disturbances, and arrhythmia), although the rising trend for the prevalence of arrhythmia was of borderline significance.

ARTICLE INFORMATION

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CONFLICT OF INTEREST None declared.

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