Electrocardiograms in healthy Polish schoolchildren: An observational study

Radosław Pietrzak, Jakub S Gąsior, Tomasz Książczyk, Agnieszka Tomik, Bożena Werner

Department of Pediatric Cardiology and General Pediatrics, Medical University of Warsaw, Warszawa, Poland

Editorial
by Halasz et al.

Correspondence to:
Radosław Pietrzak, MD, PhD, Department of Pediatric Cardiology and General Pediatrics, Medical University of Warsaw, Żwirki i Wigury 63A, 02–091 Warszawa, Poland, phone: +48 22 317 95 88, e-mail: radoslaw.pietrzak@wum.edu.pl

DOI: 10.33963/KP.a2022.0186

Received:
December 19, 2021

Accepted:
August 5, 2022

Early publication date:
August 8, 2022

ABSTRACT

Background: Electrocardiographic (ECG) examination has long been used to assess cardiovascular function in clinical practice. Age-related ECG changes are observed as the cardiovascular system matures from the neonatal period to adolescence.

Aim: This study aimed to evaluate effects of sex and age on ECG parameters in healthy schoolchildren.

Methods: The study included 336 healthy participants aged 5–12 years from the Masovian voivodeship. Children were divided into age groups of 5–8 and 9–12 years. Values for heart rate (HR), time intervals and amplitudes of P and QRS waves, and QRS axis for pediatric ECGs were estimated.

Results: Significant differences between boys and girls aged 5–8 years old were discovered for such parameters as PR interval, R-wave, S-wave, and the R/S ratio. Age-related decline in HR, Q-wave in V5 and V6, R-wave in V1–V4, and increase in QRS duration were noted. Girls presented a higher HR and shorter QRS than boys. HR, QRS axis, P wave amplitude in lead II, and amplitude of R and S in the precordial leads were different in our population than those previously reported.

Conclusions: Pediatric ECG tracings were estimated for the first time for healthy Polish schoolchildren. Sex-related differences in selected ECG parameters in the younger age group were noticed. Several parameters differed from those previously reported in other ethnic populations. These findings are clinically significant and suggest that diagnostic criteria for pediatric ECG should be revised to establish if they are justifiable for the entire population.

Key words: ECG, healthy children, reference values

INTRODUCTION

Electrocardiographic (ECG) examination has been used in clinical practice for reliable assessment of cardiovascular and cardiopulmonary function [1, 2]. Measuring ECG recordings and interpreting them using reference values is commonplace for clinicians and researchers conducting studies in the field of cardiology. As the myocardium and cardiovascular system undergo maturation and change from the neonatal period to adolescence, age-related ECG changes are observed, leading to challenges in interpreting the pediatric ECG [3–5]. It has been shown that selected ECG parameters may be influenced by sex due to cardiac and extracardiac factors [6]. Additionally, ethnic differences in ECG amplitudes were noticed [7].

For this reason, age- and sex-dependent ECG norms have been published for populations from Western Europe [8, 9], Africa [10], Asia [9, 11], and the Americas [8, 9, 12]. There are no studies on the characteristics of ECG parameters in children from Central and Eastern Europe. The most recent study to date, with a pediatric cohort and electronically recorded standardized leads, referred only to American and Canadian populations [13]. The only research based on Eastern European society presents ECG standards performed in the Russian population [14]. Therefore, this

WHAT'S NEW?

We performed an electrocardiographic (ECG) examination in healthy schoolchildren. Compared with literature data, there are differences between Polish and other ethnic populations in ECG parameters. These findings are clinically important and suggest that diagnostic criteria for pediatric ECG should be revised to establish if they are justifiable for the entire population.

study aimed to evaluate the effects of sex and age on ECG parameters in healthy Polish schoolchildren in comparison to the other published data on the rest ECG.

METHODS

Details and a description of the study group and the procedures performed before or during the ECG examinations have been published elsewhere [15]. The present study included 336 volunteer participants aged 5–12 years from the Mazovian Voivodeship (Poland); the inclusion criteria were as follows (1) age between 5 and 12 years; (2) absence of diseases and/or regular use of medications affecting the cardiopulmonary system; and (3) not being an active athlete in any sports. The parents/legal guardians were interviewed about children's diseases and/or medications (school health records concerning health status were additionally verified). During the initial analysis, 20 subjects with a history of a cardiovascular event, 3 children with a diagnosed chronic disease, and 2 subjects with incomplete ECG data were excluded from the analysis. The final study sample included 316 children (152 boys). The body mass status was measured using body mass index (BMI) defined as body mass in kilograms divided by height in meters squared. All parents or guardians had received printed information about the study protocol and aims of the research and gave their informed written consent. Ethical approval was obtained through the University Bioethical Committee (KB/74/2013).

ECG measurements

A 12-lead electrocardiogram was recorded using a PC with an integrated software system (Custo cardio 100; Custo med GmbH, Ottobrunn, Germany) at a sampling rate of 1000 Hz. The ECG recordings were performed at a 25 mm/s speed and 10 mV gain from 8:00 AM to 14:00 AM in the supine position in a quiet room (temperature between 22–28°C). Before the beginning of the ECG recording to familiarize the children with the study, they were in the supine position for 5 minutes. During the recordings, each child was encouraged to breathe normally and not to speak or move. Values of ECG parameters were calculated based on a computerized analysis of the obtained set of ECGs recorded at a high sampling rate. Before analysis, all ECGs were inspected by an experienced pediatric cardiologist. Corrected QT (QTc) intervals were obtained using the Bazett formula. In cases where artificially prolonged QTc values at an increased heart rate (HR) were obtained, values were individually corrected.

Data presentation

The study population was divided into age groups of 5–8 and 9–12 years. The median, 2nd, and 98th percentile were presented in lead-independent ECG measurement. The median and 98th percentile were shown for P-, Q-, R-, and S-waves in all leads. Zero amplitude values indicating absent Q, R, or S waves, were excluded from the statistical analysis of the data. All procedures were performed to compare results with other authors who presented normal/reference pediatric ECG limits [1, 2].

Statistical analysis

The Kolmogorov-Smirnov test was used to assess the normality of the distribution for the boys and the girls for two age groups (5–8 and 9–12 years). To identify sex (marked in the tables using * in superscript) and age († in superscript) effects and their interaction (‡ in superscript) with ECG parameters, two-way analysis of variance (ANOVA) and Tukey HSD test for unequal N were used. Due to skewed distributions of the data: P-wave (V1, V2), Q-wave (III, aVF, V5), R-wave (aVR, aVL), and S-wave (II, III, V5, V6), logarithmic transformation was carried out to perform two-way ANOVA. The threshold probability of $P < 0.05$ was taken as the significance level for all statistical analyses. Statistical calculations were performed using the software STATISTICA 10-StatSoft. Inc software (Tulsa, OK, US).

RESULTS

The anthropometric characteristics of the study group are presented in Table 1. There were no age and sex interactions. The main effect of age was observed for body mass ($F = 90.4$; $P < 0.001$), stature ($F = 200.1$; $P < 0.001$), and BMI ($F = 22.3$; $P < 0.001$). Body mass, stature, and BMI increased with age. Tables 2–7 contain results for lead-independent ECG measurements. There was a significant age and sex interaction for PR interval; R-wave II, aVF, V5, and V6; S-wave II, III, V1, V2, V5, and V6; R/S V2 and V6 (F between 4.0 and 11.7 for all; P between <0.001 and 0.45). Significant, independent age and sex effects were observed for the HR (age: $F = 16.8$; $P < 0.001$; sex: $F = 7.2$; $P = 0.008$), QRS duration (age: $F = 7.5$; $P = 0.006$; sex: $F = 5.0$; $P = 0.026$), and R/S V1 (age: $F = 14.3$; $P < 0.001$; sex: $F = 7.6$; $P = 0.006$). A significant age effect was observed for QTc interval; Q-wave V5 and V6; R-wave V1–V4 (F between 4.2 and 47.9 for all; P between <0.001 and 0.042). Significant sex effect was observed for R-wave III and aVR; S-wave I, aVR, aVL, aVF, V3, V4; R/S V5 (F between 5.4 and 28.1 for all; P between <0.001 and 0.021). No age and sex interactions and no main effects were observed for the

Table 1. Anthropometric characteristics for boys (upper row) and girls (lower row): median (2nd percentile–98th percentile)

Measure	Sex	Age, 5–8 years (40♂, 35♀)	Age, 9–12 years (112♂, 129♀)	Age, 5–12 years (152♂, 164♀)	Effect direction and *P*-value
Body mass, kg[a]	Boys	24.6 (17.0–42.6)	35.8 (21.7–70.0)	32.3 (19.0–67.4)	↑ with age (P <0.001)
	Girls	23.3 (15.3–37.8)	37.1 (21.2–67.6)	33.2 (17.2–66.9)	
Stature, cm[a]	Boys	124.0 (107.0–142.0)	143.5 (127.0–168.0)	139.0 (111.0–166.0)	↑ with age (P <0.001)
	Girls	122.0 (107.0–141.0)	143.0 (122.0–168.0)	139.0 (114.0–166.0)	
Body mass index, kg/m^2[a]	Boys	16.4 (12.9–23.2)	17.8 (13.2–26.8)	17.2 (13.2–26.3)	↑ with age (P <0.001)
	Girls	15.8 (11.9–21.4)	17.7 (13.1–27.1)	17.1 (12.7–25.1)	

♂ boys; ♀ girls; [a]independent age effect; ↑ increase of values/higher values

Table 2. Lead-independent ECG measurement for boys and girls: median (2nd percentile–98th percentile)

Lead	Age, 5–8 years		Age, 9–12 years		Effect direction and *P*-value
	Boys	Girls	Boys	Girls	
HR, beats/min[a, b]	89 (66–107)	92 (64–111)	80 (61–104)	86 (62–111)	↓ with age (P <0.001), ↑ in ♀ (P = 0.008)
P axis (°)	62 (17–79)	55 (–2–83)	59 (–10–79)	57 (4–78)	P = 0.17
PR, ms[‡c]	135(107–172)	123 (92–156)	137 (99–177)	135 (100–172)	Interaction (P = 0.014): 5–8 ♂ vs. ♀ (P = 0.026)
QRS axis (°)	83 (33–117)	82 (66–98)	81 (36–101)	82 (36–97)	P = 0.95
QRS, ms[a, b]	87 (75–100)	85 (76–104)	89 (76–106)	87 (76–102)	↑ with age (P = 0.006), ↑ in ♂ (P = 0.026)
QTc, ms[b]	421(380–449)	420 (380–447)	414 (370–452)	413 (73–445)	↓ with age (P = 0.002)

[a]Independent sex effect; [b]independent age effect; [c]interaction; ♂ boys; ♀ girls; ↓ decrease of values/lower values; ↑ increase of values/higher values; QTc intervals obtained using the Bazett formula, in cases where artificially prolonged QTc values at increased HR were obtained, the value was individually corrected by a pediatric cardiologist

Abbreviations: ECG, electrocardiogram; HR, heart rate

Table 3. P-wave amplitudes (mV) for boys and girls: median (98th percentile)

Lead	Age, 5–8 years		Age, 9–12 years		Effect direction and *P*-value
	Boys	Girls	Boys	Girls	
II	0.17 (0.29)	0.17 (0.28)	0.15 (0.28)	0.15 (0.30)	P = 0.34
V_1	0.10 (0.17)	0.09 (0.17)	0.09 (0.15)	0.09 (0.17)	P = 0.17
V_2	0.10 (0.18)	0.10 (0.25)	0.09 (0.17)	0.10 (0.19)	P = 0.71

Table 4. Q-wave amplitudes (mV) for boys and girls: median (98th percentile)

Lead	Age, 5–8 years		Age, 9–12, years		Effect direction and *P*-value
	Boys	Girls	Boys	Girls	
II	0.06 (0.20)	0.07 (0.27)	0.06 (0.23)	0.06 (0.19)	P = 0.43
III	0.11 (0.28)	0.11 (0.37)	0.08 (0.33)	0.10 (0.29)	P = 0.23
aVF	0.07 (0.22)	0.07 (0.30)	0.06 (0.26)	0.08 (0.21)	P = 0.62
V_5[a]	0.11 (0.29)	0.15 (0.24)	0.08 (0.36)	0.09 (0.30)	↓ with age (P = 0.009)
V_6[a]	0.10 (0.26)	0.15 (0.24)	0.08 (0.27)	0.09 (0.27)	↓ with age (P = 0.007)

[a]Independent age effect; ↓decrease of values/lower values

Table 5. R-wave amplitudes (mV) for boys and girls: median (98th percentile)

Lead	Age, 5–8 years		Age, 9–12 years		Effect direction and *P*-value
	Boys	Girls	Boys	Girls	
I	0.32 (0.68)	0.29 (0.73)	0.33 (0.75)	0.33 (0.86)	P = 0.82
II[c]	1.09 (1.85)	1.41 (2.48)	1.14 (2.06)	1.32 (2.05)	Interaction (P = 0.012): 5–8 ♂ vs. ♀ (P <0.001)
III[a]	0.89 (1.93)	1.25 (2.30)	0.97 (1.93)	1.07 (1.94)	↑ in ♀ (P <0.001)
aVR[a]	0.06 (0.43)	0.05 (0.23)	0.06 (0.44)	0.05 (0.35)	↑ in ♂ (P = 0.012)
aVL	0.14 (0.36)	0.09 (0.34)	0.10 (0.47)	0.11 (0.47)	P = 0.07
aVF[c]	0.95 (1.88)	1.34 (2.39)	1.03 (1.91)	1.20 (2.01)	Interaction (P = 0.019): 5–8 ♂ vs. ♀ (P <0.001)
V_1[b]	0.48 (0.97)	0.49 (0.92)	0.35 (0.76)	0.32 (0.84)	↓ with age (P <0.001)
V_2[b]	1.03 (1.85)	0.89 (1.93)	0.69 (1.32)	0.65 (1.28)	↓ with age (P <0.001)
V_3[b]	1.25 (2.67)	1.35 (2.57)	0.90 (1.95)	0.93 (2.11)	↓ with age (P <0.001)
V_4[b]	1.80 (2.88)	2.29 (3.41)	1.91 (3.35)	1.92 (3.39)	↓ with age (P =0.042)
V_5[c]	1.70 (2.96)	1.85 (3.18)	1.84 (3.18)	1.80 (3.32)	Interaction (P =0.045)
V_6[c]	1.23 (2.16)	1.39 (2.45)	1.43 (2.23)	1.45 (2.29)	Interaction (P = 0.022): 5–8 ♂ vs. ♀ (P = 0.030), in ♂ ↑ with age (P = 0.009)

[a]Independent sex effect; [b]independent age effect; [c]interaction; ♂boys; ♀girls; ↓decrease of values/lower values; ↑increase of values/higher values

Table 6. S-wave amplitudes (mV) for boys and girls: median (98th percentile)

Lead	Age, 5–8 years		Age, 9–12 years		Effect direction and *P*-value
	Boys	Girls	Boys	Girls	
I[a]	0.21 (0.54)	0.10 (0.42)	0.17 (0.51)	0.15 (0.36)	↑ in ♂ (P <0.001)
II[b]	0.28 (0.61)	0.11 (0.33)	0.21 (0.68)	0.14 (0.74)	Interaction (P = 0.003): 5–8 ♂ vs. ♀ (P = 0.002)
III[b]	0.17 (0.43)	0.10 (0.26)	0.13 (0.58)	0.14 (1.09)	Interaction (P = 0.007)
aVR[a]	0.70 (1.00)	0.91 (1.43)	0.80 (1.29)	0.87 (1.28)	↑ in ♀ (P = 0.006)
aVL[a]	0.50 (1.09)	0.59 (1.07)	0.49 (1.08)	0.53 (1.01)	↑ in ♀ (P = 0.021)
aVF[a]	0.22 (0.50)	0.11 (0.28)	0.18 (0.59)	0.14 (0.75)	↑ in ♂ (P = 0.020)
V_1[b]	0.68 (1.31)	1.06 (2.18)	0.90 (1.60)	0.92 (1.72)	Interaction (P <0.001): 5–8 ♂ vs. ♀ (P <0.001), in ♂ ↑ with age (P = 0.045)
V_2[b]	1.52 (2.71)	1.84 (2.61)	1.71 (2.71)	1.59 (2.77)	Interaction (P <0.001): 5–8 ♂ vs. ♀ (P = 0.032)
V_3[a]	1.36 (2.67)	1.03 (2.43)	1.16 (2.41)	0.92 (2.27)	↑ in ♂ (P <0.001)
V_4[a]	0.78 (1.86)	0.44 (1.62)	0.63 (1.95)	0.46 (1.48)	↑ in ♂ (P <0.001)
V_5[b]	0.41 (0.96)	0.15 (0.50)	0.32 (1.20)	0.22 (0.65)	Interaction (P = 0.011): 5–8 ♂ vs. ♀ (P <0.001), 9–12 ♂ vs. ♀ (P <0.001)
V_6[b]	0.18 (0.47)	0.05 (0.18)	0.17 (1.13)	0.11 (0.34)	Interaction (P = 0.009): 5–8 ♂ vs. ♀ (P <0.001), 9–12 ♂ vs. ♀ (P = 0.003)

[a]Independent sex effects; ‡interaction; ♂boys; ♀girls; ↑increase of values/higher values

Table 7. The R/S ratio for boys and girls: median (98th percentile)

Lead	Age, 5–8 years		Age, 9–12 years		Effect direction and *P*-value
	Boys	Girls	Boys	Girls	
V_1[a, b]	0.66 (2.08)	0.43 (1.95)	0.43 (1.59)	0.37(1.67)	↓ with age (P <0.001), ↑ in ♂ (P = 0.006)
V_2[c]	0.68 (2.14)	0.50 (1.52)	0.40 (0.98)	0.45(1.22)	Interaction (P = 0.002): 5–8 ♂ vs. ♀ (P = 0.017), in ♂ ↓ with age (P <0.001)
V_5[a]	4.23 (12.0)	11.1 (64.7)	5.42 (49.0)	7.39(100.5)	↑ in ♀ (P <0.001)
V_6[b]	7.18 (69.5)	20.0 (131.0)	8.44 (121.0)	13.5(102.0)	Interaction (P = 0.006): 5–8 ♂ vs. ♀ (P = 0.007)

[a]Independent sex effect; [b]independent age effect; [c]interaction; ♂boys; ♀girls; ↓decrease of values/lower values; ↑increase of values/higher values

P axis and QRS axis; P-wave II, V1, and V2; Q-wave II, III, and aVF; R-wave I, aVL (P between 0.07 and 0.95).

DISCUSSION

Knowledge of circulatory system changes during its maturation in normal development is essential for interpreting ECG leads in different age groups of the pediatric population. We present values for ECG parameters of school children aged 5–12 years from Poland, the Masovian voivodeship — sex-related differences in PR interval, R-wave, S-wave, and R/S ratio were observed in the younger age group. We found differences between Polish and other populations — the most important ones relate to HR, the amplitude of the P wave, the electrical axis of the QRS, and the QRS wave amplitude.

Previous studies determining normal thresholds for pediatric ECG were based on Western European, North American, Canadian, and Chinese populations. Mason et al. [8] collected data from various populations from the US and Europe and showed results in 10-year age cohorts from 0 to 99 years. Rijnbeek et al. [6] and Sun et al. [16] presented normal ECG thresholds for Dutch and Chinese children, respectively. The largest and most recent study (2020) of normative ECGs in pediatrics was conducted in the US and Canada [13]. Even the generally accepted pediatric reference ranges for ECG parameters published in Poland [17] are based on the mentioned earlier studies from Western societies. Therefore, they do not consider ethnic differences between Western and Central European populations detected in our study.

The heart rate is the most apparent manifestation of age and sex differences in pediatric ECG. It decreases with age and is higher in girls. Ethnic differences are also clear. In our population, the upper limits for HR were lower than in the other studies [6, 12, 13, 16]. For example, the 98th percentile for boys reached 107 bpm, for girls 111 bpm in the age group of 5–8 years, while in the American/Canadian populations [13], the upper limits for similar age groups (6–7 years) were 119 bpm for boys and 128 bpm for girls.

Another difference between our data and those previously published is P wave amplitude. The P wave is usually best studied in leads II or V1 and reflects the size of the right atrium. In the recent study, the upper limit for the amplitude of the P wave was up to 0.3 mV in lead II and 0.2mV in right precordial leads. In the literature, a P-wave amplitude greater than 0.25 mV in one of the leads is considered too high [16]. These results suggest that in diagnosing right atrial enlargement the amplitude criterion should be lead-dependent and reconsidered at least for lead II.

Regarding the PR interval, significant interactions between age and sex were found. Furthermore, it was estimated to be 170 ms for the 98th percentile for the age group 9–12 years, while according to the Polish guidelines [17], the upper limit for these children is 190 ms. Although the differences were significant, they are irrelevant from a clinical point of view since prolongation of the PR inter-

val is usually benign. It is often observed in young, active individuals and relates to the so-called athlete's heart.

An increase in QRS duration with age was broadly investigated [6, 18]. The far less known phenomenon is QRS width alteration with sex. It is broader in boys than in girls. Nevertheless, sex differences in QRS duration are relatively small and have no meaning in everyday practice. Maybe, the significance of these differences would be more apparent from a clinical point of view when analyzing long-term ECG monitoring [19].

Sex differences in the QRS axis are observed nominally. They are more evident in our population than in others. In boys, the 98th percentile for the QRS axis was 117° and was more shifted to the right than in girls (98°). Our population's upper limit for pathological right axis deviation was much lower than that of Western societies [17]. According to other studies, it does not depend on sex and reaches 140°. Pathological right axis deviation in school children is primarily one of the indicators of right ventricular hypertrophy. Therefore, applying our criteria would increase ECG sensitivity for the diagnosis of right ventricular pathology.

Age-related changes typical of the pediatric population must also be considered when analyzing the detailed morphology of the QRS complex. After we take into account all the temporal and spatial variability of the waves during depolarization of the ventricles, we obtain a wide range of different patterns of QRS shape, which are still within the scope of the norm. That makes ECG assessment in children challenging.

The first example of this variability is Q wave. A pathological Q wave is an indicator of septal hypertrophy or myocardial necrosis. This usually occurs in lead II, III, aVF, V5, and V6. It is considered pathological if it takes more than 30 ms and above -0.50 mV. In our population, the amplitude of Q at the 98th level did not exceed –0.37 mV, so the upper limit is lower than previously assumed in the literature [3].

Furthermore, the rise of R wave amplitude in V5–V6 and decrease of R wave amplitude in V1–V4, as well as a decrease of the R/S ratio in V1 with age, were noticed in our trial. All these changes are an expression of increasing mass and electrical activity of the left ventricular free wall muscle during normal development of the circulatory system.

In the recent study, R and S wave amplitudes were lower than the corresponding values in children in the Netherlands [6], US, and Canada [4] for both age groups and sexes. These discrepancies could be explained in two ways.

Firstly, they can be a consequence of different ECG sampling rates [6, 12]. The higher the sampling rate, the higher the amplitude of the wave. Nevertheless, the sampling rate in the study by Rijnbeek et al. [6] was high, similar to our study (sampling rate 1000 Hz), but our data align more with Davignon et al. [12] and Dickinson et al. [18], where the sampling rate was as low as 333 Hz.

Secondly, the suggested difference would come from the method of obtaining the data. During the manual ECG assessment, the amplitudes of QRS waves are lower than during automatic obtaining [12]. However, our tracings were analyzed automatically, as performed in the studies, where the amplitudes of R and S waves were higher than in a recent trial [6, 12]. In light of these data, we can assume that our results could be explained by ethnic differences between Western Europe and Polish pediatric populations that affect ECG derivation.

The shape and amplitude of the QRS waves varied significantly between boys and girls in most leads, which is consistent with the previous studies [6, 12]. This is most striking for the S wave in the left-sided precordial leads. For example, the upper limit of the S-wave in V6 is 0.47 mV and 0.18 mV for younger boys and girls, respectively. Considering these data, sex-dependent criteria may improve the sensitivity and specificity of the diagnosis of ventricular hypertrophy based on ECG in the pediatric population.

On the contrary, the apparent gap between boys and girls aged 5–8 years old for R-wave, S-wave amplitudes, and the R/S ratio in the precordial leads narrows in children aged 9–12 years. Presumably, these facts relate to non-lean body composition development during puberty. At the beginning of puberty in females, modest fat loss accompanied by muscle tissue enlargement is observed. These changes are more progressive in boys but occur 1–2 years later than in girls. Because of this gap in pubertal development, the differences in body composition between males and females seen up to the age of 8 start to be similar about the age of 9 years, which could be the reason for the narrowing of the gap in the ECG parameters. The differences re-appear later in adolescents when rapid development of the muscle tissue in males is seen [20].

To sum up, we ought to be aware that all the ECG tracings we observed can probably result from much more than the simple anatomical body composition of the chosen ethnic groups or sex. In trials in animals, the physiologic hormonal differences between males and females were the reason for altered molecular ionic activity in the cardiac fibers. These may influence the currents responsible for the heart's electrical function. Besides, even such habits as daily physical activity need to be considered in the analysis regarding heart rhythm and function [21]. All these variables can drive the broad diversity of the spatial and temporal picture of the ECG tracings even in the same age group of children and need further evaluation.

Limitations of the study

The sample size was relatively small; the children were only from the Mazovian voivodeship and lived mainly in urban areas. Discrepancies with other studies could reflect ethnical differences but also demographic changes in highly developed societies during the last decades, e.g., an increase in body weight or the age of puberty. Comparison of the data with all published norms was difficult due to various age intervals used in other trials.

CONCLUSIONS

Pediatric ECGs were estimated for healthy Polish schoolchildren. We presented a sex-related gap in selected ECG parameters in the younger age group that partially narrowed in older children. The values differed from those previously reported in other ethnic populations. These findings are clinically significant and suggest that diagnostic criteria for pediatric ECG should be revised to establish if they are justifiable for the entire population.

Article information

Conflict of interest: None declared.

Funding: None.

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