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DETECTION OF CARDIAC ARRHYTHMIAS AMONG PEOPLE PRACTICING SPORT IN A NON-PROFESSIONAL WAY.

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A - Koncepcja i projekt badania, B - Gromadzenie i/lub zestawianie danych, C - Analiza i interpretacja danych, D - Napisanie artykułu, E - Krytyczne zrecenzowanie artykułu, F - Zatwierdzenie ostatecznej wersji artykułu

Abstract (in English):
Aim: Sudden cardiac death (SCD) is the most frequent medical cause of sudden death in athletes. As it is commonly known, long-term training leads to hemodynamic changes and heart remodeling. ECG is a simply to perform, cardiological test which can detect arrhythmias and pathological or physiological changes for athletes. Main aim of this study was to show which arrhythmias appear in non-professional athletes. Another was to assess the usefulness of ECG as a screening test in this population.
Material and methods: Study population consisted of 261 white amateur and recreational athletes (69 women, 192 men), aged 20 to 68 years. 261 resting ECG and 148 ECG after the end of competition were done. Moreover, participants completed the questionnaire about basic socio demographicdata, medical history, training data and supplementation.

Results: The most common ECG findings are: early repolarization (ER), incomplete right bundle branch block, right bundle branch block, non-specific intraventricular conduction disorders, atrioventricular block. Furthermore, 56 athletes had electrocardiographic features of left ventricular hypertrophy in resting ECG.
Conclusions: We found some harmless disorders which required further diagnostics. ECG is a useful tool for screening athletes. Currently, in order to take part in amateur sports competitions, only the competitor's declaration of good health is required. Verification of these statements by doctors with an additional ECG test will allow for the first selection of athletes who require more detailed diagnostics. ECG disorders are common in the population of training people but fortunately most of them are connected with physiological heart remodeling.

Keywords: electrocardiogram, arrhythmia, sports cardiology, preparticipation screening.

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Authors (short)
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1. Introduction

Sudden cardiac death (SCD) is the most frequent medical cause of sudden death in athletes. In some cases, SCD may be the first clinical manifestation of serious cardiovascular disease, in previously asymptomatic patients. Moreover, long-term training leads to hemodynamic changes and heart remodeling. It is estimated that sudden cardiac death (SCD) affects 1 in 50 000 athletes. Higher risk of SCD is noticed in competitive athletes compared to nonathlete counterparts or recreational sports participants. Arrhythmias are one of the most common causes of sudden cardiac death in athletes, for example arrhythmogenic right ventricular cardiomyopathy (ARVC) ranks second place among cardiac causes of death in athletes - it was assessed to be the cause of 30% of deaths of young athletes [1]. Electrocardiography (ECG) allowed to identify to 63% of athletes at risk of SCD. Among athletes with hypertrophic cardiomyopathy (HCM) more than 96% have changes in ECG like pathologic Q waves, ST depression, left bundle branch block, left axis deviation, left atrial enlargement. ECG can also detect other pathological or in the case of athletes physiological changes-

sinus bradycardia and I, II (Mobitz type I) atrioventricular (AV) blocks are common occurrences in the population of athletes.These occurrences are connected with increased vagal tone caused by regular physical activity. Most of them are asymptomatic but sometimes it can lead to some dangerous effects. Another one is Fitness-Related Atrial Fibrillation / Flutter.

In the general population those arrhythmias mainly occur in elderly people. The prevalence increases with age. However young athletes are also at risk due to remodeling of athletes' hearts. One of the most common changes in endurance athletes is early repolarization (ER). It can be observed even in 40% athletes. ER can be related with idiopathic ventricular fibrillation, especially if it occurs in leads from inferior and lateral walls of the heart. Long-term training leads to hemodynamic changes and heart remodeling. This occurrence is commonly called Athlete's heart. Typically, both ventricles and atrias are enlarged, often also early diastolic filling is enhanced. This is physiological adaptation to physical effort but sometimes can lead to pathological complications. Effect of this adaptation is also the increase of cardiac output. There is described in the literature that the effect of activity on cardiac structure is greater than that of systolic BP and similar to that of age [2]. This remodeling can be reversible - de-training may lead to the reduction of hypertrophy but normalization of heart mass may not be complete, even after many years [3]. In 2012 a group of experts developed guidelines called "Seattle Criterias" on how to interpret ECG abnormalities in athletes. They divided ECG changes into physiologcial and pathological. But there are not enough recommendations on how to interpret the ECG in athletes.

Athletic training can be a significant risk in athletes with undetected heart failure (HF). It is important to pay attention to the symptoms of HF, medical history, risk factors, ECG changes and, if indicated, use currently available laboratory tests such as NT-proBNP. Interestingly, in the case of patients hospitalized for HF, an increase in other markers that may have prognostic significance was also observed - including an increase in the concentration of catestatin, RDW, or procalcitonin [4–6]. However, in our study, we focused on assessing ECG changes.

Main aim of this study was to show which arrhythmias appear in non-professional athletes. Another was to assess the usefulness of ECG as a screening test in this population.

2. Materials and Methods

Observational study was conducted during the ENEA Bydgoszcz Triathlon 06-07/07/2019 (⅛ triathlon, ¼ triathlon, ½ triathlon) and PKO Run 12/05/2019 (10 km run and half-marathon). Study population consisted of 261 white amateur and recreational athletes (69 women, 192 men), aged 20 to 68 years (average 37; SD±9; for woman minimal -20, average 36.59: SD± 9, maximal 59; for man minimal 20, average 37.78, SD±9, maximal 68). 261 resting ECG and 148 ECG after the end of competition (some of the participants didn't come back to carry out the second ECG) were made. In the first step participants completed the questionnaire about basic socio demographic data, medical history, training data and supplementation (accurate data is shown in the table No 1). Next the resting ECG examination was performed on the day of the competition or the day before. After the end of the competition (within one hour) an ECG was performed again. A quick analysis was performed immediately after exercise to rule out life-threatening emergencies. Complete analyzes were made after the end of competition. Athletes with abnormal changes were informed by an email. They got a short information about abnormalities and the information for their doctors. The study was

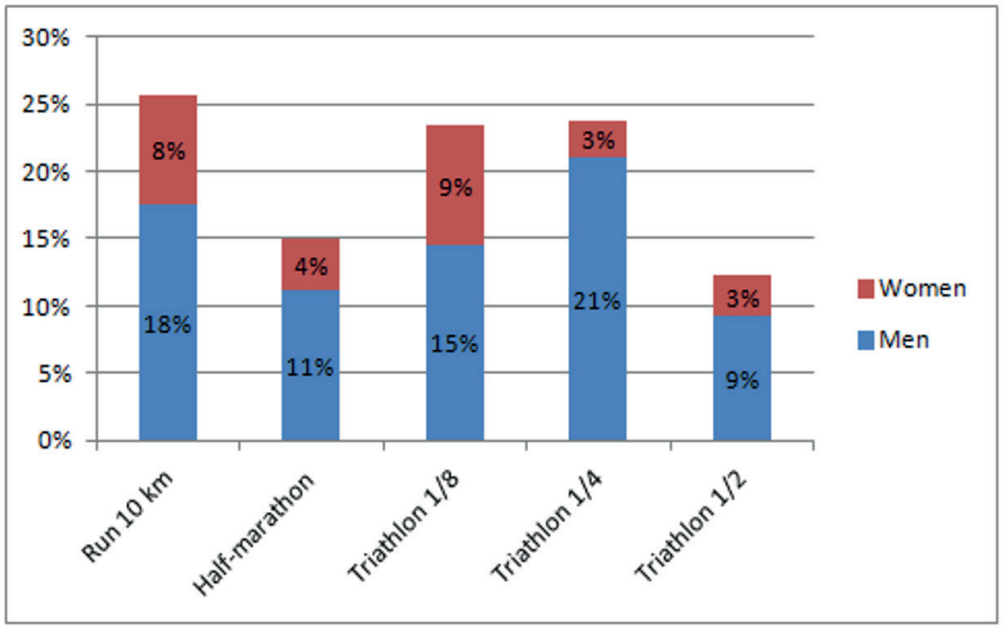
approved by the Bioethics Committee (KB417/2019). Statistical analysis was performed using the Statistical Package for the Social Sciences Statistics 19.0.1(IBM, USA). Normally distributed variables were presented as mean ± standard deviation (SD) and non-normally distributed variables were presented as median and range. The differences between the groups with a normal distribution were analyzed using the Student's t-test. In the case of samples that were not normally distributed the Mann-Whitney U test was used. Qualitative variables were analyzed using the chi-square test ($\chi 2$). The significance coefficient $p < 0.05$ was assumed as statistically significant.

Table 1. Characteristics of the study participants – education, place of residence, symptoms and diseases.

	Men N=192	Women N=69	All N=261
Education			
High	146 (76.04%)	56 (81.16%)	202 (77.39%)
Secondary	40 (20.83%)	11 (15.94%)	51 (19.54%)
Vocational	6 (3.13%)	2 (2.90%)	8 (3.07%)
Primary	0 (0.00%)	0 (0.00%)	0 (0.00%)
Place of residence			
Village	28 (14.58%)	16 (23.19%)	44 (16.86%)
City < 50 tys.	15 (7.81%)	7 (10.14%)	22 (8.43%)
City 50-100 tys.	15 (7.81%)	3 (4.35%)	18 (6.90%)
City 100-500 tys.	94 (48.96%)	28 (40.58%)	122 (46.74%)
City > 500 tys.	40 (20.83%)	15 (21.74%)	55 (21.07%)
Symptoms			
Diagnosis of arrhythmia	7 (3.65%)	1 (1.45%)	8 (3.07%)
Palpitations	19 (9.90%)	23 (33.33%)	42 (16.09%)
Dizziness	34 (17.71%)	30 (43.48%)	64 (24.52%)
Fainting	13 (6.77%)	15 (21.74%)	28 (10.73%)
Paroxysmal sweats	10 (5.21%)	8 (11.59%)	18 (6.90%)
Diseases			
Hypertension	10 (5.21%)	3 (4.35%)	13 (4.98%)
Thyroid diseases	4 (2.08%)	14 (20.29%)	18 (6.90%)
Cholesterol disorders and / or medicines to decrease cholesterol	3 (1.56%)	3 (4.35%)	6 (2.30%)
Kidney diseases	5 (2.60%)	1 (1.45%)	6 (2.30%)
Diabetes mellitus	2 (1.04%)	0 (0.00%)	2 (0.77%)
Myocardial infarction	0 (0.00%)	0 (0.00%)	0 (0.00%)
TIA / stroke	0 (0.00%)	0 (0.00%)	0 (0.00%)

Women more frequently have palpitations, dizziness, fainting ($p<0,05$), which may be related with thyroid disorders, which are also more common in the female population. The most common comorbidities are thyroid diseases (7%), and hypertension (5%) ($p<0,05$). Only 5% of participants are under the supervisionof a doctor due to training. About 1/3rd regularly measure their blood pressure, and 72% check heart rate. Most athletes don't smoke (92%), drink energy drinks (74%) or take diet supplements stimulating organisms (guarana, yerba mate) (81%). Coffee and tea are common stimulants, only 24% participants don't drink coffee, and 26% don't drink tea every day. Magnesium (61%) and potassium (27%) are the most commonly used diet supplements.

Figure 1. The number of competitors taking part in particular distances, divided into women and men.



3. Results

Table 2. Types of physical activity and number of participants.

	Men (N=192)	Women (N=69)	All (N=261)	p
Running	187 (97.40%)	67 (97.10%)	254 (97.32%)	>0,05
Swimming	141 (73.44%)	38 (55.07%)	179 (68.58%)	<0,05
Cycling	162 (84.38%)	49 (71.01%)	211 (80.84%)	<0,05
Tennis	9 (4.69%)	2 (2.90%)	11 (4.21%)	>0,05
Football	19 (9,90%)	1 (1,45%)	20 (7.66%)	<0,05
Volleyball	7 (3.65%)	1 (1.45%)	8 (3.07%)	>0,05
Basketball	7 (3.65%)	0 (0.00%)	7 (2.68%)	>0,05
Another sport	30 (15.63%)	20 (28.99%)	50 (19.16%)	>0,05
Gym	11 (5.73%)	2 (2.90%)	13 (4.98%)	>0,05
Circuit training	1(0.52%)	1(1.45%)	2 (0.77%)	>0,05
Another	18 (9.38%)	17 (24.64%)	35 (13.41%)	>0,05

Table 3. Questionnaire. Number and percentage of possible answers.

Question	Possible answer	Number of answers	(%)
Do you run?	yes	254	97.32%
Since when do you run?	< 6 months	14	5.51%
	6 months - 1 year	22	8.66%
	1 - 3 years	64	25.20%
	> 3 years	155	61.02%
How many times a week do you run?	1 x / week	40	15.75%
	2 - 3 x / week	176	69.29%
	4 - 6 x / week	35	13.78%
	everyday	3	1.18%

Question	Possible answer	Number of answers	(%)
How long was your last running session?	< 1 h	112	44.09%
	1 - 3 h	141	55.51%
	3 - 5 h	3	1.18%
	> 5 h	0	0.,00%
Do you swim?	yes	179	68.58%
Since when do you swim?	< 6 months	16	8.94%
	6 months - 1 year	19	10.61%
	1 - 3 years	53	29.61%
	> 3 years	90	50.28%
How many times a week do you swim?	1 x / week	101	56.42%
	2 - 3 x / week	75	41.90%
	4 - 6 x / week	2	1,12%
	everyday	1	0.56%
How long was your last swimming session?	< 1 h	142	79.33%
	1 - 3 h	36	20.11%
	3 - 5 h	1	0.56%
	> 5 h	0	0,00%
Do you ride a bike?	yes	211	80.84%
Since when do you ride a bike?	< 6 months	16	7.58%
	6 months - 1 year	13	6.16%
	1 - 3 years	44	20.85%
	> 3 years	137	64.93%
How many times a week do you ride a bike?	1 x / week	73	34.60%
	2 - 3 x / week	112	53,08%
	4 - 6 x / week	20	9,48%
	everyday	7	3.32%
How long was your last cycling session?	< 1 h	47	22.27%
	1 - 3 h	154	72.99%
	3 - 5 h	8	3.79%
	> 5 h	0	0,00%

Running, cycling and swimming are the most common activities among participants, regardless of starting discipline. Nearly 100% participants declare that they run regulary, independantly of sex. Men more often train swimming (73% vs 55%), cycling (84% vs 71%) and playing football (10% vs 1.5%). While women more often do other sports (29% vs 16%).

Table 4. Basic finds in ECG.

	Resting ECG N=261	ECG after competition N=148
Heart rate	median 64,00; range 35 – 110	Average 85,05; SD 14,824
Bradycardia	13 (4.98%)	1 (0.68%)
	Heart axis	
intermediate	244 (93.49%)	131 (88.51%)
leftward	6 (2.30%)	4 (2.70%)
rightward	5 (1,92%)	8 (5.41%)
northwest axis	1 (0.38%)	0 (0,00%)
variability axis	5 (1.92%)	5 (3.38%)
ER	165 (63.22%)	85 (57.43%)

AV I block	14 (5.36%)	9 (6.08%)
AV II block	0 (0.00%)	0 (0.00%)
AV III block	0 (0.00%)	0 (0.00%)
LBBB	0 (0.00%)	0 (0.00%)
iRBBB	40 (15.33%)	23 (15,54%)
RBBB	28 (10.73%)	14 (9.46%)
LAH	6 (2.30%)	4 (2.70%)
Intermittent LAH	1 (0.38%)	0 (0,00%)
LPH	4 (1.53%)	8 (5.41%)
Intermittent LPH	2 (0,77%)	2 (1,35%)
RBBB + LAH	1 (0,38%)	1 (0,68%)
RBBB + LPH	1 (0,38%)	2 (1,35%)
Non-specific intraventricular conduction abnormalities	23 (8,81%)	12 (8,11%)
Supraventriculare extrasystoles	5 (1,92%)	2 (1,35%)
Prolonged QT	8 (3,07%)	28 (18,92%)
Sokolow - Lyon index >= 35	29 (11,11%)	14 (9,46%)

ER- early repolarization, AV block - Atrioventricular block, LBBB - Left bundle branch block, RBBB = right bundle branch block, iRBBB - incomplete right bundle branch block, LAH - left anterior hemiblock, LPH - left posterior hemiblock.

Median heart rate in resting ECG was 64,00; range 35 – 110. Sinus bradycardia (< 50/min.) was observed in 13 participants (4.98%). Median heart rate after competition is 85/min. Bradycardia was noticed in 1 person. The most common ECG finding was early repolarization (ER). It is significantly more frequent in triathlonists than runners (75% vs 46%) and in males than females (67% vs 38%) ($p<0,05$). Prolonged QT (defined as QTc > 450 ms for male and > 460 ms for female) was found in a group of 8 athletes (3%) before competition (7 male, 1 female) and in 28 after (19%) (23 male, 5 female). Most of them were only slightly prolonged. QTc after activity was prolonged in 109 participants (74%) ($p < 0,05$). There were observed many atrio- and intraventricular conduction disorders. The most common were iRBBB (15%), RBBB (11%), non-specific intraventricular conduction disorders (9%), AV block (5%). RBBB appears in 28 (11%) and in 1 participant it coexists with LAH and in another one with LPH. Moreover, LPH occured after activity in one more person. iRBBB was observed in 40 (15%), non- specific intraventricular conduction changes in 23 (9%) AV I block in 14 (5%) participants in resting ECG. RBBB (1% vs 3%), AV I block (7% vs 0%) and non-specific intraventricular conduction disorders (12% vs 2%) were more often in male than females ($p < 0,05$). One participant had features of pre-excitation in ECG (PQ < 120 ms, widened QRS > 120 ms and delta wave).

During our study there were not observed any from the most dangerous disorders (LBBB, AV block II and III degree). Only 5 athletes before and 2 after competitions have single supraventricular extrasystoles.

In resting ECG 56 athletes have electrocardiographic features of left ventricular hypertrophy. It is defined as Sokołow-Lyon index >=35 (29 athletes, 11%) or R in aVL lead >=11 mm (3 athletes, 1%) and in case of people with intraventricular conduction disorders, specific criterias of hypertrophy in blocks - due to SENIT criteria (26 athletes, 10%).

Discussion

According to "Seattle Criterias" created by Drezner et. al, most of ECG findings during our study should be classified as normal for athletes. Occurences in these populations like: early repolarization, incomplete RBBB, bradycardia >30bpm, AVI block are physiological adaptations to regular exercise, considered normal variants in athletes and do not require further evaluation in asymptomatic athletes [7]. Relative occurrence of these ECG findings was also confirmed in multiple studies. In our study we found some potentially dangerous disorders. One patient had electrocardiographic features of pre-excitation syndrome, 8 patients before, and 27 after competitions had prolonged QT, but most of them only slightly prolonged. We also observed 28 RBBB before, and 14 after competitions. Compared to our study in 2019 in Italy, D'Ascenzi et al. conducted a study in similar protocol involving 301 athletes starting in 50 kilometers ultramarathon. They didn't observe any potentially dangerous arrhythmias or conduction disorders before nor after competition . In a low percentage of athletes right or left bundle branch blocks were observed. Also, ECG changes typical for "athletes heart" were observed [8]. Another similar study was performed in 2016 during PZU Gdańsk Maraton, including 40 amateur male runners. In this study, 1 patient before exercise and 2 patients after exercise had prolonged QTc intervals. Any other danger arrhythmias or conduction disorders were not observed. Also in this study, changes related with athletes heart remodeling were often noticed. In both studies some competitors inverted the T wave, which is also not related with training. This ECG pathology was not analyzed in our study [9]. Dores et al. performed a study analyzing pre-participation examination in a population of 3423 athletes. Based on the SC, approximately 80% of the overall population had alterations in the 12-lead ECG: normal/training-related in 2482 (72.5%) and abnormal/training-unrelated in 225 (6.6%) athletes. Comparing with our study, they also observed preexcitation syndrome (WPW) in 28 participants. Other pathologies observed there, like left atrial enlargement and inverted T wave were not analyzed in our study [10]. Harmon et al. conducted meta-analysis of 15 studies, including 47137 athletes. They described 160 potentially lethal cardiovascular conditions. Wolff-Parkinson-White (WPW) was the most frequently identified pathology (67.42%), followed by Long QT Syndrome (LQTS) (18.11%), hypertrophic cardiomyopathy (18.11%), dilated cardiomyopathy (11.7%), coronary artery disease (CAD)/myocardial ischemia (MI) (9.6%), and arrhythmogenic right ventricular cardiomyopathy (ARVC) (4.3%) [11]. Kusy et al. performed a study analyzing Echocardiographic results of sprint and endurance trained master athletes. They showed that the hearts of professional athletes do not go beyond the "gray zone" and preserve normal cardiac function. It also showed that physiologic adaptations, rather than pathologic abnormalities are expected in aging but still active athletes. EICR is shifted toward normal geometry in sprinters and toward concentric remodeling and hypertrophy in endurance runners [12]. Another problem which was not considered in our study is safety of pharmacotherapy in sport. Burdziński et al. analyzed that problem in case of non-professional divers and underlined importance of medical interview and remembrance of potentially influence of drugs side effects and physiology of physical activity [13].

Conclusions

The first aim of our study was to assess frequency of arrhythmias in non-professional athletes. We found some harmless disorders which required further diagnostics. ECG is a very useful tool for

screening the athlete 's population and it should be regularly considered for each training athlete. Currently, in order to take part in amateur sports competitions, only the competitor's declaration of good health is required. Verification of these statements by doctors with an additional ECG test will allow for the first selection of athletes who require more detailed diagnostics. ECG disorders are common in the population of training people but fortunately most of them are connected with physiological heart remodeling.

Conflicts of Interest

Authors declare no conflict of interest.

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