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Role of Exercise Stress Test in Evaluating Athletes with Premature Ventricular Beats: A Retrospective Study

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ABSTRACT

Background: In athletes, managing ventricular arrhythmias/premature ventricular contractions (VA/PVCs) is challenging, mainly because their detection, in some cases, even when initial diagnostic tests such as first-line studies and echocardiography do not reveal underlying cardiac pathology, indicates an increased risk of Sudden Cardiac Death. It remains unclear whether PVBs are more prevalent in athletes than less active individuals. Identifying the localization of VA/PVCs based on their morphology and assessing the impact of adrenergic stimulation on them is crucial for risk stratification and guiding further diagnostic studies.

Objectives: This study was designed to compare the prevalence and morphology of VA/PVCs recorded during resting and stress ECG in a cohort of apparently healthy young competitive athletes. It also aimed to determine the potential of exercise testing to increase the detection of PVBs in clinically asymptomatic arrhythmogenic heart disease, owing to its ability to induce adrenergic-dependent PVBs.

Methods: The retrospective cross-sectional study included 855 nonelite, competitive athletes (mean age 19±5.2 years, male/female ratio 746/109=6.8) who underwent Pre-Participation Evaluation at the Clinical Center for Sports Medicine and Rehabilitation of TSMU. Initially, athletes with at least one PVB on Resting and/or Exercise ECG were identified. Athletes with a positive Family History (FH) or/and Medical History (MH), Resting/Stress ECG abnormalities were excluded from our study. VA/PVCs were evaluated in terms of number, complexity, exercise inducibility, and morphologic features.

Results: According to our study, the prevalence of VA/PVCs in athletes with a normal MH/FH, baseline ECG and ECHO is 10.17% (0.1; 102:1000; annual 20.4:1000). VA/PVCs with infundibular and fascicular morphology is more common than "uncommon" ones (64% versus 36%), with fascicular morphology being more prevalent in our cohort than infundibular (35.6% versus 28.7%). According to our study data, the sensitivity of resting ECG to detect VA/PVCs compared to exercise test does not exceed 13.8 %, and its negative predictive value is low at 0.9. The effectiveness of exercise testing in detecting VA/PVCS increases by five times.

Conclusions: The prevalence of PVB/VA among young athletes without structural heart disease is low and similar to that among non-athletes, suggesting that VA/PVCs cannot be solely attributed to regular physical exercise. The rarest PVB is "wide" RBBB, so comprehensive evaluation is necessary when detecting it in athletes. Compared to resting ECG, exercise testing increases the screening potential for detecting VA/PVCs. Adrenergic stimulation suppresses "common" morphology extrasystoles more than "uncommon" ones. Therefore, we can use ETT to assess the risk in athletes and assign further diagnostic tests.

Keywords: Athlete; premature ventricular contraction; preparticipation screening; sports cardiology, sudden cardiac death.

BACKGROUND

The most common questions when dealing with arrhythmias in athletes revolve around the cause of the arrhythmia and the athlete's ability to continue sports activities. The relationship between sports and arrhythmias can be considered along three lines: sports as an arrhythmia trigger, arrhythmic substrate promoter, or substrate inducer.[1] Sport acts as an arrhythmia trigger, predisposing to life-threatening Ventricular Arrhythmia (VA) in the presence of underlying and pre-existing conditions. The relative risk of Sudden Cardiac Death (SCD) in athletes is three times higher than that of their non-athletic counterparts.[2] The second line of interaction is that Physical Activity (PA) may promote the development of the underlying arrhythmic substrate, accelerating the development of the phenotype and arrhythmic events. The third line is that sports, by remodeling the athlete's heart, induce a substrate for arrhythmias.

Moreover, the three mechanisms reinforce each other. Essentially, the athlete's heart is proarrhythmic.[1] In athletes, Ventricular Arrhythmia/Premature Ventricular Beats (VA/PVCs) are challenging to manage, as their detection in some cases (even when first-line studies and echocardiography did not reveal underlying cardiac pathology) indicates an increased risk of SCD.[3] It is unknown whether PVBs are more common in athletes than less active people. A recent study demonstrated that in most athletes with PVBs and no underlying heart disease, the arrhythmia frequency decreased or disappeared after 3–6 months of detraining.[4] This study allows us to hypothesize that PVB may be caused by remodeling the athlete's heart. However, Delise et al. did not find any differences in the behavior of VA during follow-up in a group of athletes who continued training versus a group of athletes who interrupted sports activity.

On the other hand, studies are comparing the prevalence of VA in athletes and sedentary controls, showing that a small proportion of athletes have VA/PVCs, and the prevalence of PVB does not differ between the above groups.[5,6] The results of the studies could be more consistent. According to recent studies,[7,8] determining the localization of PVB based on the morphology of the PVB and assessing the impact of the adrenergic stimulation is important for risk stratification and prescription of further diagnostic investigations. Therefore, considering the morphology, evaluating the prevalence of PVBs in the population mentioned above and the influence of adrenergic stimulation on them will be relevant.[9,10] Finally, PVBs detected on stress ECG may be the only phenotypic manifestation of cardiac pathologies that may indicate an increased risk of SCD that are difficult to identify by first-line studies and echocardiology (e.g., segmental cardiomyopathy, Catecholaminergic Polymorphic Ventricular Tachycardia, acute myocarditis, congenital and acquired coronary artery disease, Nonischemic Cardiac Scar). Therefore, it is important to determine the potential of exercise testing to increase PVB detection in clinically asymptomatic arrhythmogenic heart disease due to its ability to induce adrenergic-dependent PVB.[10]

METHODS

The retrospective cross-sectional study included 855 nonelite, competitive athletes (mean age 19±5.2 years, range 12 to 32; male/female ratio 746/109=6.8) who underwent Pre-Participation Evaluation (PPE) between May 2017 and May 2022 at the Clinical Center for Sports Medicine and Rehabilitation of TSMU. Study data were collected from medical records and electronic data from the ECG stress system program - Labtech Cardiospy (Hungary). Screening protocol includes medical history (MH), family history (FH), physical examination (PE), anthropometric measurements, resting 12-lead ECG (Labtech Cardiospy, Hungary), stress ECG recorded during the PWC170 submaximal cycle test (MONARK 928, Sweden), and transthoracic echocardiography (MEDISON Sono Ace Pico, South Korea).

A retrospective analysis of ECGs with PVCs was performed using a simultaneous display of frontal and horizontal plane leads. The morphology of PVC was confirmed manually and categorized as benign ("common") or non-benign ("uncommon") using recommended criteria [8]. "Common" morphology suggesting a Right Ventricular Outflow Tract (RVOT) or Left Ventricular Outflow Tract (LVOT) origin (i.e., Left Bundle Branch Block (LBBB)-like with a vertical axis pattern) or from the posterior fascicle of the LBB (i.e., narrow QRS, 120–130 msec and typical RBBB/superior axis configuration). PVB with a relatively narrow QRS and typical RBBB/inferior axis configuration, suggestive of the origin from the anterior fascicle of the LBB. The "uncommon" morphology of PVBs shows a wide QRS (>130 msec) with an "atypical" RBBB pattern (positive QRS complex in V1 but not resembling a typical RBBB) and variable QRS axis.[7,8,11]

Then, we analyzed athletes' medical records with PVCs on resting ECG and/or exercise ECGs.

Inclusion criteria: no history of medical problems (negative MH and FH, presence of even one PVC on Resting or/and Exercise ECG, normal echocardiogram.

Exclusion criteria: positive FH or/and MH, Resting/Stress ECG abnormalities (ECG patterns were analyzed according to the most recent international criteria),[12] and abnormal echocardiograms.

Statistical analysis: variables were expressed as Mean (M) ± Standard Deviation (SD) and n (%), respectively. The positive predictive value of two different PPE protocols.

RESULTS AND DISCUSSION

Our retrospective study (Fig.1) analyzed the PPE results of 855 (87% male and 13% female) competitive athletes and identified 91 (10.6 %) athletes, 84 male and seven female, with VA/PVCs on resting and/or stress ECG (annual 21:1000). Of those, 4 (0.5%), showed resting ECG abnormalities and/or significant echocardiogram findings and were excluded from our study. According to our study, the prevalence of VA/PVCs in athletes with a normal MH/FH, baseline ECG, and ECHO was 10.17% (0.1; 102:1000; annual 20.4:1000). The findings are consistent with similar studies. For example, A. Zorzi's study[5] evaluated the prevalence of VA/PVCs in young, healthy athletes based on 24-hour ECG monitoring (including a 30-minute exercise session) and found that 10% of healthy athletes had >10 isolated PVB or ≥ one complex VA. Other studies have mainly assessed the prevalence of VA/PVCs in young, healthy athletes based only on resting ECG,[13] and thus, the prevalence of VA/PNB was about 4 %. Our results are consistent with previous studies suggesting that frequent isolated PVBs in athletes most often have infundibular or fascicular morphological features.[11]

Regarding the morphology of VA/PVCs (Tab.1), the "common" morphology during resting and/or stress ECG was observed in 56 cases (56/851 – 6.6%; 56/87 – 64.3% accordingly), among them: infundibular morphology (LBBB/inf. axis) in 25 cases (25/851 – 2.9%; 25/87 – 28.7% accordingly), while fascicular morphology ("narrow" RBBB/inf-sup. axis) was observed in 31 ECGs (31/851 - 3.6%; 31/87 - 35.6% accordingly). The "uncommon" morphology of PVC/VA was detected in 31 athletes (31/851 - 3.6%; 31/87 - 35.6% accordingly); among them: "wide" RBBB morphology was found in 11 (11/851 - 1.3%; 11/87 – 12.6%), and LBBB/sup.-normal axis was found in 20 (20/851 – 2.3%; 20/87 – 23% accordingly). According to the obtained data, PVC/VA with infundibular and fascicular morphology is more common than "uncommon" ones (64% versus 36%), which is consistent with existing studies,[5,13] but unlike these

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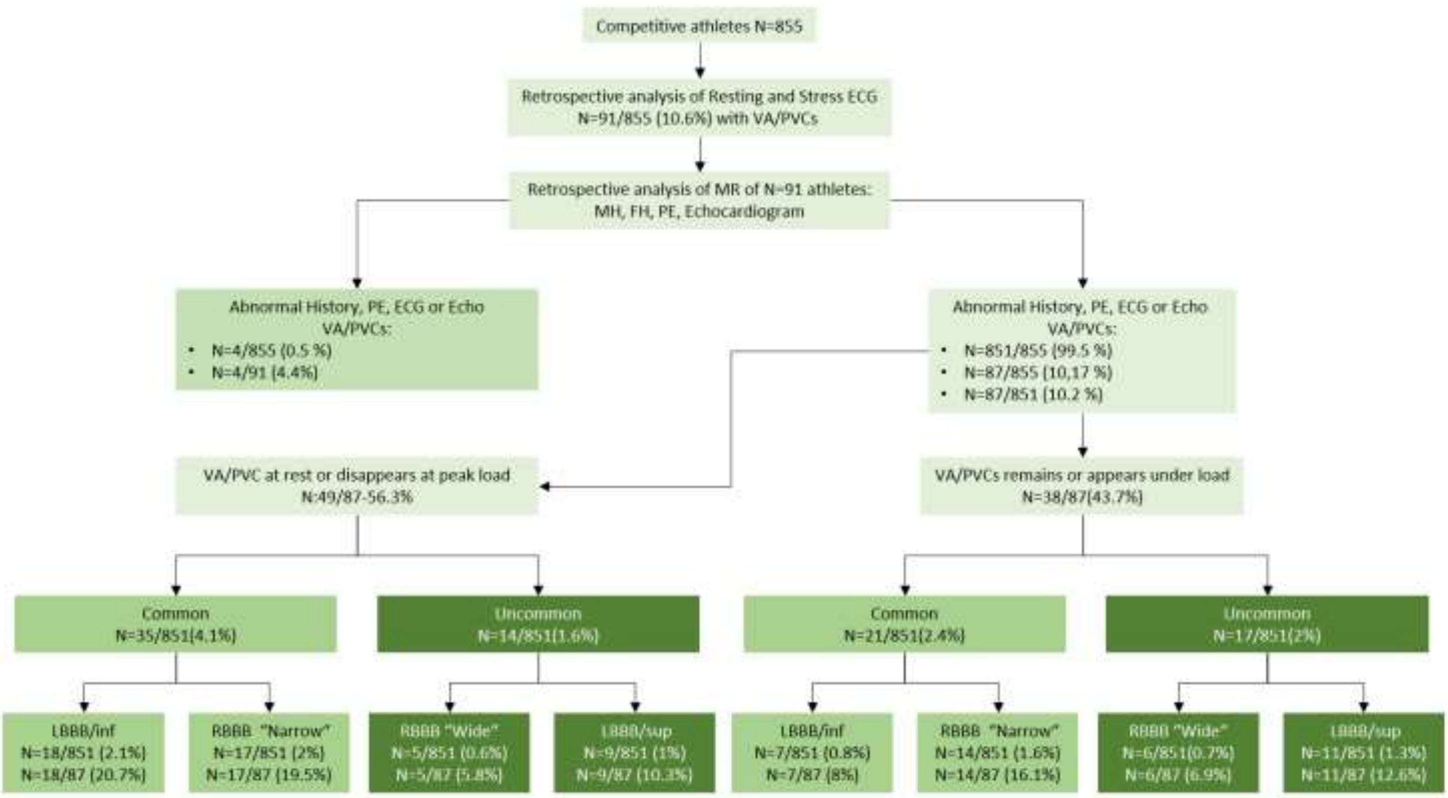
studies, fascicular morphology was more common in our cohort than infundibular (35.6% versus 28.7%). According to the data, extrasystoles with "wide" RBBB morphology are encountered least frequently (12.7%), so their detection in asymptomatic athletes requires comprehensive evaluation.

FIGURE 1. Schematic representation of the study protocol and the results



Abbreviations: ECG, electrocardiogram; Echo, echocardiogram; FH, family history; LBBB, left bundle branch block; MH, medical history; MR, medical records; PE, physical examination; RBBB, right bundle branch block; VA/PVCs, ventricular arrhythmias/premature ventricular contractions.

TABLE 1. The morphology of premature ventricular beats (PVBs) on resting and stress ECG

	COMMON N=56/851(6.6 %) N=56/87(64%)		**UNCOMMON N=31/851(3.6%) N=31/87(36%)**	
	LBBB inferior axis	**RBBB "narrow"**	**LBBB superior axis**	**RBBB "wide"**
VA/PVCs at Resting ECG/Dissappear on peack of EST N=49/851 (5.8%)	N=18/851 (2.1%) N=18/87 (20.7%)	N=17/851 (2%) N=17/87 (19.5%)	N=9/851 (1%) N=9/87 (10.3%)	N=5/851 (0.6%) N=5/87 (5.8%)
VA/PVCs reveal or stay during peack of EST N=38/851 (4.5%)	N=7/851 (0.8%) N=7/87 (8%)	N=14/851 (1.6%) N=14/87 (16.1%)	N=11/851 (1.3%) N=11/87 (12.6%)	N=6/851 (0.7%) N=6/87 (6.9%)

Abbreviations: ECG, electrocardiogram; Echo, echocardiogram; EST, exercise stress test; LBBB, left bundle branch block; RBBB, right bundle branch block; VA/PVCs, ventricular arrhythmias/premature ventricular contractions.

Regarding the complexity assessment results of VA, only 4 cases of couplets, always during physical exercise, were observed. The morphology of the couplets is presented in Table 2, showing that in 3 cases, their morphology was a "common" type. Notably, in this cohort of athletes, we did not detect triplets, episodes of unstable ventricular tachycardia, or polymorphic VA/PVB. Since the exercise test in our study was part of the pre-competition screening, we had the opportunity to assess the potential of exercise testing in increasing the detection of VA/PVB during screening (Tab.3). The sensitivity of resting ECG to detect VA/PVB compared to exercise test, according to our study

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data, does not exceed 13.8%, and its negative predictive value is low - 0.95, which is explained by the low sensitivity of the test and the low prevalence of VA/PVB (≈10%). The effectiveness of the exercise test in detecting VA/PVB increased five times in athletes with VA/PVB; the exercise test allows not only determining the morphology of PVB but also evaluating the effect of exercise, which is important for risk stratification and diagnostic test assignment. We also evaluated the effect of exercise on VA/VPB of various morphologies (Fig.1). This scheme clearly shows a general trend: adrenergic stimulation more often suppresses VA/PVB with "common" morphology (35/56 – 63%) than with "uncommon" morphology (14/31 – 45%). 63% versus 45%, and conversely, VA/PVB with "uncommon" morphology more often occurs at peak exercise – 54% (17/31) versus 37% (21/56).

TABLE 2. Results of premature ventricular contraction/ventricular arrhythmia (PVC/VA) complexity assessment

	Total number of couplets n=4 (4.6%)
Narrow RBBB	2 (2.3 %)
Wide RBBB	1 (1.15 %)
LBBB/inferior axis	1 (1.15 %)

Abbreviations: LBBB, left bundle branch block; RBBB, right bundle branch block.

TABLE 3. Assessment of exercise stress test (EST) effectiveness for detection of premature ventricular contraction/ventricular arrhythmia (PVC/VA) in athletes complexity assessment

	Number of athletes with PVC/VA
Only Resting ECG	12
During Stress ECG or/and Recovery period	75

Abbreviations: ECG, electrocardiogram; PVC/VA, premature ventricular contractions/ventricular arrhythmias.

CONCLUSIONS

The prevalence of VA/PVB among young athletes without structural heart disease is low and similar to the prevalence among non-athletes, so PVC/VA cannot be considered a consequence of regular physical exercise.

Our study showed that:

- "Bundle" and "infundibular" PVC/VA with "common" morphology are more common (especially "bundle") than "uncommon" ones. The rarest form is a"narrow" RBBB, so comprehensive evaluation is necessary "when detecting it in athletes;
- Exercise testing increases the "screening potential" for detecting PVC/VA compared to resting ECG;
- Adrenergic stimulation suppresses "common" morphology extrasystoles more than "uncommon" ones. Therefore, we can use EST to assess the risk in athletes and assign further diagnostic tests.

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