MAYO CLINIC

Comparison of Electrocardiographic and Echocardiographic/Deformational Imaging Screening in a Cohort of Elite High School Athletes

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ABSTRACT

Introduction: The use of electrocardiography (ECG) in athletic screening has been studied widely. In trained athletes, ECG aberrations are common, including increased QRS voltages and repolarization alterations. These findings often prompt evaluation for underlying cardiac pathology. We sought to determine the correlation between atypical ECG findings with results from echocardiography and deformational imaging in a cohort of elite high school athletes.

Methods: We prospectively performed a standard 15-lead ECG immediately followed by standard two-dimensional (2D), spectral Doppler, tissue Doppler, and 2D longitudinal strain analyses in 103 high school students (age 15.9±1.5 yrs, 55 males), including 78 highly-trained athletes and 25 healthy non-athlete controls. Longitudinal 2D strain was performed to evaluate 17 regional (apical, mid, and basal) myocardial segments and global longitudinal left ventricular (LV) myocardial strain. ECG-based assessment for left ventricular hypertrophy (LVH) and right ventricular hypertrophy (RVH) was compared to imaging data.

Results: Overall, 24/75 (32%) athletes had ECG findings suggesting RVH or LVH (or both), compared to 1/28 (4%) controls (p<0.01). No patients had significant structural heart disease by echocardiography. LV dimensions and LV mass were significantly greater in athletes (p<0.001). Similarly, ECG deflections in the lateral precordial leads were increased in athletes, including R-wave deflections in lead V6 (p<0.03) and total R+S wave deflection in lead V4 (p<0.02). Traditional R- and S-wave measurements in lead V1 did not correlate in either cohort with increasing LV wall thickness, LV mass, LV end-diastolic diameter, LV tissue Doppler, or global longitudinal 2D strain. Instead, the total R+S wave deflection in lead V4 correlated with LV posterior wall thickness (p<0.0002), LV mass (p<0.0006), LV end-diastolic diameter (p<0.0001), and global longitudinal 2D strain (p<0.05).

Conclusion: As expected, athletes had a higher incidence of atypical ECG findings compared to healthy controls. However, R- and S-wave deflections in the lateral precordial leads correlated better with echo-measured LV wall thickness and function than lead V1. Determining the overlap between the magnitude of R+S wave deflections in V4 in the elite athlete's heart compared to patients with clinically evident hypertrophic cardiomyopathy may help define a more sensitive and specific ECG screen for this disease.

BACKGROUND

- Athletic screening methodologies including the use of electrocardiography (ECG) have been studied widely.
- ECG aberrations are common in trained athletes, including increased QRS voltages and alterations of repolarization. These patients often meet criteria for left ventricular hypertrophy (LVH) or right ventricular hypertrophy (RVH), or both. These findings often prompt evaluation for underlying cardiac pathology including hypertrophic cardiomyiopathy (HCM).
- The potential role of newer echocardiographic modalities such as deformational imaging in athletic screening is unclear
- We sought to determine the correlation between atypical ECG findings with results from echocardiography and deformational imaging in a cohort of elite high school athletes.

Figure 3

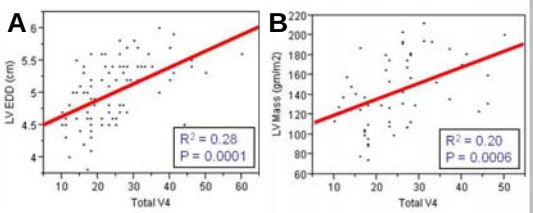


Figure 3: Bivariate analysis comparing echocardiographic measures of (A) LV end-diastolic diameter and (B) LV Mass to the total deflection seen on a 12-lead ECG in lead V4 .

STUDY AIM

To determine correlations between atypical ECG findings with results from echocardiography/deformational imaging in a cohort of elite high school athletes

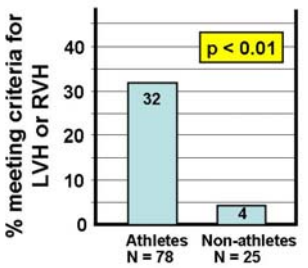
STUDY DESIGN

- In this prospective study, we performed a standard 15-lead resting ECG immediately followed by standard two-dimensional, spectral Doppler, tissue Doppler, and 2D longitudinal strain analyses in a cohort of students at an elite athletics-oriented institution.
- The students included 78 highly-trained athletes and 25 non-athlete controls (**Table 1**).
- Longitudinal strain was performed to evaluate 17 regional (apical, mid and basal) myocardial segments and global longitudinal left ventricular myocardial strain.
- We compared standard criteria for LVH and RVH to 2D and deformational imaging data.

Table 1: Demographics

Demographic	Student Cohort
No. of Patients	103
Age (years)	16 ± 1.5
Gender (F/M)	48/55
Athletes/Non-Athletes	78/25

Figure 1: Atypical ECG findings



RESULTS

- No patients had significant structural heart disease by echocardiography.
- Of the 75 athletes, 24/75 (32%) athletes had ECG findings suggesting RVH or LVH (or both), compared to 1/28 (4%) non-athlete controls (p<0.01, **Figure 1**).
- LV dimensions and LV mass were significantly greater in athletes (p<0.001).
  - ECG deflections in the lateral precordial leads were increased in athletes, including R-wave deflections in lead V6 (p<0.03) and total R+S wave deflection in lead V4 (p<0.02) (**Table 2**).
- Traditional R- and S-wave measurements in lead V1 did not correlate in either cohort with increasing LV wall thickness, LV mass, LV end-diastolic diameter, LV tissue Doppler, or global longitudinal 2D strain.
- The total R+S wave deflection in lead V4 correlated with LV posterior wall thickness (p<0.0002), LV mass (p<0.0006), LV end-diastolic diameter (p<0.0001), and global longitudinal 2D strain (p<0.05) (**Figure 2**).

Table 2

Cohort	M/F	Age (yrs)	BMI (m^2)	LV Mass (g/m^2)	LVEDD (mm)	HR (bpm)	SV1 (mm)	RV6 (mm)	R+S V4 (mm)	Ave GLPSS
Athletes (N = 78)	45/33	16 ± 1	23 ± 2	147 ± 34	51 ± 5	65 ± 11	12 ± 5	18 ± 8	26 ± 11	-20 ± 2
Non-Athletes (N = 25)	10/15	16 ± 2	24 ± 4	130 ± 38	48 ± 5	73 ± 13	13 ± 4	14 ± 5	20 ± 7	-21 ± 2

Table 2: Comparison of athlete and non-athlete cohorts. BMI = Body Mass Index. LVEDD = LV end-diastolic diameter. SV1 =deflection of S-wave in lead V1. RV6 = deflection of R-wave in lead V6. R+S V4 = Total QRS deflection in lead V4. GLPSS = average global longitudinal LV strain (%).

CONCLUSIONS

- As expected, athletes had a higher incidence of atypical ECG findings compared to healthy non-athlete controls.
- R- and S-wave deflections in the lateral precordial leads correlated better with echo-measured LV wall thickness and function than lead V1
  - The total R+S wave deflection in lead V4 provided the best correlation with echocardiographic measures of LV size and thickness.
- Determining the overlap between the magnitude of R+S wave deflections in V4 in the elite athlete's heart compared to patients with clinically evident HCM may help define a more sensitive and specific ECG screen for this disease.

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