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Comprehensive cardiac mri protocol of athletes' hearts at 3 T: preliminary results

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Introduction

High-level athletic training is associated with increased left ventricular (LV) and right ventricular (RV) chamber sizes and LV wall thickness/mass. Sudden cardiac death (SCD) in healthy, young athletes is associated with cardiac abnormalities, including hypertrophic cardiomyopathy (HCM), anomalous coronary arteries, aortic dissection, and arrhythmogenic right ventricular dysplasia (ARVD). The EKG can screen athletes for underlying cardiac conditions. CMR may provide a more comprehensive evaluation of athletes.

Purpose

This study evaluated a comprehensive 3 T CMR protocol in healthy intercollegiate athletes with an abnormal screening EKG.

Methods

CMR was performed on 21 intercollegiate athletes (12 men; 9 women) with EKG abnormalities from a screened cohort (N = 658). A whole-body 3 T MRI was used (Signa HDx, GE Healthcare, Inc.). The CMR protocol included: 1) cine imaging in LV 2, 3, and 4-chamber long axis planes as well as the short-axis plane from base to apex, using a breath-held steady-state free precession sequence (FOV = 33-35 cm, Thick = 8 mm, TR = 4.2 ms, TE = 1.9 ms, Flip Angle = 45°, Matrix = 224 × 224, 20 phases), 2) black-blood imaging in both axial and short-axis planes using a breath-held double-inversion recovery fast spin echo sequence (FOV = 28-34 cm, Thick = 5 mm, TR = 2 heartbeats, TE = 41 ms, Matrix = 256 × 256), and 3) coronary imaging at the level of the aortic root using a breath-held spiral gradient-echo sequence (FOV = 24 cm, Thick = 3 mm, TR = 1 heartbeat, TE = 5.8 ms, Flip Angle = 60°, 16 interleaves). LV and RV volume and function and LV wall thickness/mass were quantified using MASS software (MASS Analysis Plus Version 6.0, Leiden University) and compared to published normal ranges.

Results

The athletes were from 9 sports, and EKG abnormalities included ventricular hypertrophy (N = 7), abnormal Q waves (N = 7), ST depression (N = 4), T wave inversions in 3 or more leads (N = 2), low voltage (N = 1), and right atrial abnormality (N = 1). No evidence of HCM or ARVD was seen. All athletes had normal aortic root sizes with normal origin and course of their proximal coronary arteries. Male athletes had larger LV/RV volumes, larger aortic root sizes and LV mass but no difference in LV/RV ejection fraction. Compared to published adult ranges normalized to BSA (mean ± 2 SD), LV enlargement was present in 24% (2 M/3 F), RV enlargement in 38% (5 M/3 F), and increased LV mass in 52% (7 M/4 F), Table 1.

Conclusion

CMR provides a comprehensive evaluation of young athletes found to have abnormalities on EKG. While no HCM, anomalous coronaries, Marfan's or ARVD was identified, increased ventricular size or mass was present in the majority of athletes. Further prospective study of CMR in athletes with and without EKG abnormalities is warranted.

Table 1:

	Male	Female	p value
LVEDV (ml)	218.9 ± 37.5	149.3 ± 25.6	0.0001
LVESV (ml)	87.2 ± 23.5	56.0 ± 17.0	0.001
LVSV (ml)	131.7 ± 31.2	93.2 ± 13.8	0.001
LVEDV norm (ml/m2)	102.9 ± 12.7	87.2 ± 13.9	0.01
LVESV norm (ml/m2)	41.2 ± 11.7	32.6 ± 9.6	0.04
LVEF (%)	61.8 ± 6.6	62.2 ± 6.0	0.45
RVEDV (ml)	232.2 ± 28.7	167.1 ± 23.6	0.0001
RVESV (ml)	108.8 ± 23.3	75.2 ± 13.4	0.001
RVSV (ml)	123.6 ± 14.7	92.0 ± 15.2	0.0001
RVEDV norm (ml/m2)	109.6 ± 10.9	97.5 ± 11.7	0.01
RVESV norm (ml/m2)	51.3 ± 10.2	43.9 ± 7.3	0.04
RVEF (%)	54.7 ± 5.7	54.9 ± 4.8	0.46
SWTd (mm)	9.7 ± 1.2	8.8 ± 1.0	0.04
PWTd (mm)	9.8 ± 1.0	8.5 ± 0.8	0.004
LV mass dias (g)	175.8 ± 40.0	112.9 ± 14.1	0.0001
LV mass dias norm (g/m2)	82.8 ± 17.0	65.8 ± 6.0	0.005
Aorta Sinuses (mm)	32.6 ± 3.1	26.4 ± 3.4	0.0002
Aorta Sinuses Norm (mm/m2)	15.5 ± 1.7	15.5 ± 2.0	0.50