



## Short Communication

# Association between electrocardiographic and echocardiographic right ventricular hypertrophy in a military cohort in Taiwan: The CHIEF study<sup>☆</sup>



## ECG criteria for RVH

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## ABSTRACT

We compared electrocardiographic and echocardiographic right ventricular hypertrophy (RVH) in 264 military members in Taiwan. The correlations of the Myers et al. and Sokolow-Lyon criteria with RV wall thickness were low ( $r < 0.1$ ). Our data supported the American guidance that RVH voltage criteria violations should not receive further echocardiographic investigation.

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## 1. Introduction

The European Society of Cardiology (ESC) in 2010 recommended that athletes with electrocardiographic (ECG) right ventricular hypertrophy (RVH) should receive further investigation to exclude pathologic right ventricular dilatation or hypertrophy.<sup>1</sup> However, the American Heart Association (AHA) guideline in 2014 did not support the ESC suggestion to use routine ECG screening for athletes since there were high false positive rates as comparing ECG-RVH with cardiac imaging findings.<sup>2</sup> Most of the ECG studies were examined for the White athletes and some for the Black athletes, but there were very few ECG studies regarding the Asian athlete populations. Therefore we aimed to investigate the association between ECG-RVH and echocardiographic RVH in a military cohort with regularly rigorous exercise training in Taiwan.

## 2. Methods

In the cardiorespiratory fitness and hospitalization events in armed forces (CHIEF) study,<sup>3</sup> we included 264 subjects undergoing both an ECG and an echocardiography at a hospital-affiliated medical clinic. The Sokolow-Lyon criterion-based RVH was defined as a composite of amplitudes (R voltage of V1 + S voltage of V5 or V6) > 10.5 mm,<sup>4</sup> and the Myers et al. criterion-based RVH was defined as (1) R/S ratio of V1 > 1 or (2) R/S ratio of V5 or V6 < 1 or (3) R voltage of V1 > 6 mm.<sup>5</sup> Two-dimensional echocardiographic anterior right ventricular wall thickness (RVWT) was measured by the leading edge-to-leading-edge method at the onset of the QRS complex of end diastole from the parasternal long-axis window. Echocardiographic RVH was defined as anterior RVWT > 5.5 mm,<sup>6</sup> the 95th percentile in our cohort.

Pearson's correlation coefficient ( $r$ ) was used to determine the degree of correlation between each ECG criterion and RVWT, and compared by the Fisher's  $z$  test. The sensitivity and specificity of each ECG criterion for echocardiographic RVH were compared. A two-tailed value of  $p < 0.05$  was considered significant. All analyses were performed using SAS version 9.1 (SAS Institute, Cary, NC).

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**Table 1**  
Baseline Characteristics of Electrocardiographic Measurements and Echocardiographic Parameters in the Military Population.

Variables	Military Participants (n = 264)
Age (years)	27.3 ± 6.5
Sex, male (%)	242 (91.7)
Height (cm)	171.1 ± 6.0
Weight (kg)	73.6 ± 12.4
Waist circumference(cm)	84.2 ± 10.0
Current smoker, n (%)	105 (39.8)
Body mass index (kg/m <sup>2</sup> )	25.1 ± 3.9
Underweight (<18.5) (%)	8 (3.0)
Normal (18.5–24.9) (%)	139 (52.7)
Overweight (25–29.9) (%)	93 (35.2)
Obesity (≥30) (%)	24 (9.1)
Body surface area (m <sup>2</sup> )	1.8 ± 0.18
Systolic blood pressure (mm Hg)	122.2 ± 16.3
Diastolic blood pressure (mm Hg)	73.8 ± 12.1
Heart rate (beats/min)	65.7 ± 11.5
R/S (V1)	0.48 ± 0.52
R/S (V5 or 6) minimum	8.9 ± 8.6
R (V1) (mm)	3.0 ± 1.9
Sokolow-Lyon RVH (mm)	5.4 ± 3.1
R(V1) + S(V5 or 6) maximum	
RVWT (mm)	4.30 ± 0.74
Prevalence of RVH	
RVWT >5.5 mm, n (%)	12 (4.55)

Abbreviations: RVH, right ventricular hypertrophy; RVWT, right ventricular wall thickness.

**Table 2**  
Pearson Correlation Coefficient (R) of Electrocardiographic Criteria With Anterior Right Ventricular Wall Thickness in the Military Population.

ECG criteria	RVWT	
	R	p-value
R/S (V1)	0.079	0.21
R/S (V5, 6) minimum	0.020	0.78
R (V1) (mm)	0.0053	0.93
Sokolow-Lyon RVH (mm)	0.090	0.15
R(V1)+S(V5 or 6) maximum		

Abbreviations: ECG, electrocardiographic; RVH, right ventricular hypertrophy; RVWT, right ventricular wall thickness.

### 3. Results

Table 1 shows the baseline characteristics of the military cohort. Table 2 shows that both the Myers et al. and Sokolow-Lyon ECG voltage criteria were not correlated with echocardiographic anterior RVTW ( $r=0.0053-0.090$ ). Table 3 reveals that the prevalence of ECG-RVH was generally low (0–0.76%) and so was the sensitivity of each ECG criterion for RVH (0–16.7%). In contrast, most of the specificities were greater than 90%. The positive predictive value was estimated from 0 to 7.7%. However, the negative predictive values were all greater than 94%.

**Table 3**  
The Prevalence, Sensitivity, Specificity, and Predictive Values of Each Electrocardiographic Criterion for Echocardiographic Right Ventricular Hypertrophy.

ECG Criteria	Prevalence(%)	Sensitivity(%)	Specificity(%)	PPV(%)	NPV(%)
RVWT >5.5 mm	4.55				
R/S (V1) >1	0.38	8.3	93.7	5.9	95.6
R/S (V5 or 6) minimum <1	0.76	16.7	71.0	2.7	94.7
R (V1) >6 mm	0	0	95.6	0	95.3
Sokolow-Lyon RVH >10.5 mm	0.38	7.1	94.8	7.7	95.6

Abbreviations: ECG, electrocardiography; NPV, negative predictive value; PPV, positive predictive value; RVH, right ventricular hypertrophy; RVWT, right ventricular wall thickness.

### 4. Discussion

The ECG criteria were not sensitive to identify echocardiographic RVH and the positive predictive values were low. In contrast, both the specificity and negative predictive values of each ECG criterion for echocardiographic RVH were high in our military cohort. To our best knowledge, high specificity/negative predictive values and low sensitivity/positive predictive values are common features for non-gold standard diagnostic tests utilized in a cohort of low pre-test probability of disease.

We acknowledged that the low prevalence of ECG-based RVH is not only present in our overall 4,080 military participants in Taiwan but also in a large sample of 2,533 Caucasian athletes (0.9% and 2.0% respectively).<sup>3,7</sup> Similarly, ECG-based RVH may not be commonly coexisted with other right ventricular pathologies. Zaidi et al. revealed that the prevalence of the Sokolow-Lyon ECG-RVH in patients with arrhythmogenic right ventricular cardiomyopathy (ARVD) was only 1.5%. Accordingly, the sensitivity and positive predictive value of the ECG based-RVH for ARVD was also estimated less than 1.5%.<sup>8</sup>

Although it is a simple estimate of RVH by using RVWT >5.5 mm in young- to-middle aged adults, the echocardiographic quantitative assessment of RV mass has been difficult due to the complex RV anatomy.<sup>9</sup> In the Multi-Ethnic Study of Atherosclerosis (MESA), RV mass was precisely measured by cardiac magnetic resonance (CMR) imaging and the results were in line with the findings in several echocardiographic studies that low sensitivity/positive predictive values and high specificity/negative predictive values of the Myers et al. and Sokolow-Lyon ECG criteria for the CMR defined RVH in a middle- to-old aged multi-ethnic population free of clinical cardiovascular disease.<sup>10</sup>

In conclusion, our data supported the American guidance that RVH voltage criteria violations should not prompt further echocardiographic investigation among military members in Taiwan.

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