

## Letters

### Impact of the International Recommendations for Electrocardiographic Interpretation on Cardiovascular Screening in Young Athletes

Pre-participation cardiovascular screening of young athletes with electrocardiography (ECG) is practiced by several major sporting organizations. A primary argument against this practice is the workload and cost associated with secondary investigations due to the high number of abnormal ECGs. We have previously shown that ECG screening with the contemporary Seattle and refined criteria is associated with significant savings (1).

Since our original report, the international recommendations for ECG interpretation in athletes have been published to assist clinicians in distinguishing physiological adaptations in athletes from distinctly abnormal findings suggestive of underlying pathology (2). These consensus guidelines have yet to be validated in independent athlete cohorts. Therefore, we investigated the performance of the international recommendations in our cohort of young athletes.

Between 2011 and 2014, 4,925 previously un-screened athletes (85% male, 85% white; aged 14 to 35 years) from 26 different sporting disciplines were prospectively evaluated by cardiologists with a health questionnaire pertaining to personal and family history, physical examination, and a 12-lead ECG that was interpreted originally in accordance with the 2010 European Society of Cardiology (ESC) recommendations. The evaluations were a mandatory requirement of their respective sporting associations and were facilitated nationwide through the Cardiac Risk in the Young screening program in the United Kingdom. Athletes with positive screening evaluations were referred to hospitals in their geographical vicinity for secondary investigations to confirm or refute the diagnosis of cardiac disease. Data related to secondary investigations and the final diagnosis were obtained through communication with the club

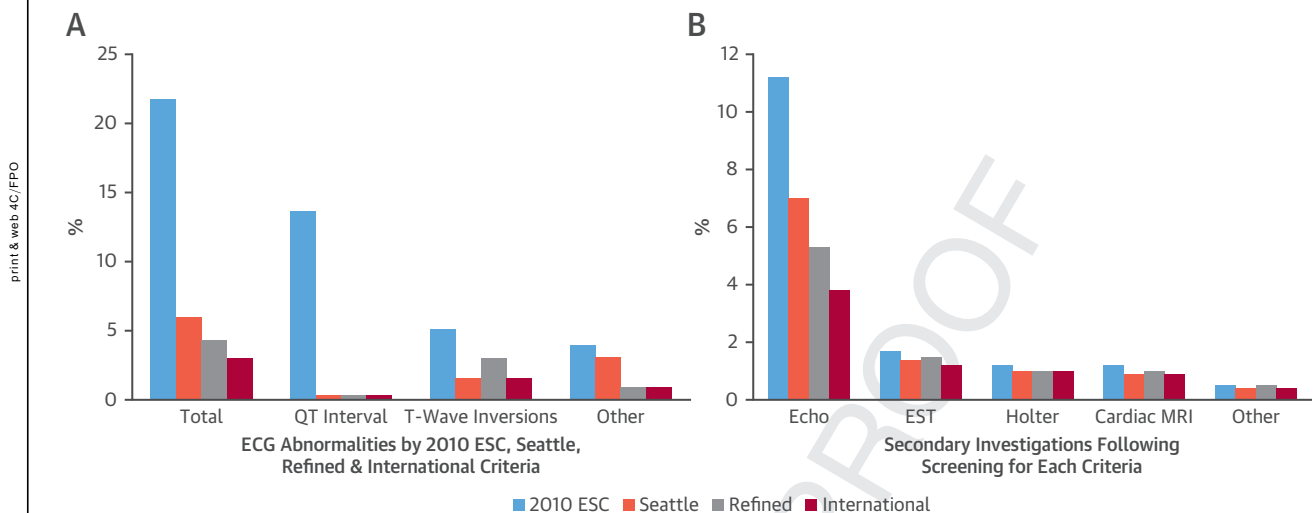
doctor using a questionnaire during 30 months (range: 6 to 54 months). The costs of secondary investigations were calculated based on the 2014/2015 U.K. National Health Service tariffs (1). The impact on cost after applying the international recommendations was evaluated retrospectively.

Proportions are presented as percentages and 95% confidence intervals (CIs). Group differences of proportions were tested with McNemar's test. The Essex 2 Research Ethics Committee granted ethical approval.

Seventy-nine athletes (1.6%; 95% CI: 1.3% to 2.0%) had an abnormal health questionnaire or physical examination. Application of the international recommendations resulted in 146 athletes (3.0%; 95% CI: 2.5% to 3.5%) being classified as having a positive ECG, which represented an 86%, 50%, and 30% relative reduction compared with the 2010 ESC, Seattle, and refined criteria, respectively (all 2-tail  $p < 0.0001$ ) (Figure 1A).

Inclusion of the ECG reported in accordance with the international recommendations for history and physical examination resulted in 3.8% (95% CI: 3.3% to 4.1%) of the cohort undergoing transthoracic echocardiography, 1.2% (95% CI: 0.9% to 1.5%) undergoing exercise stress testing, 1.0% (95% CI: 0.8% to 1.1%) undergoing Holter monitoring, 0.9% (95% CI: 0.7% to 1.2%) undergoing cardiac magnetic resonance imaging (MRI), and 0.4% (95% CI 0.3% to 0.7%) undergoing other tests to confirm or refute a diagnosis of cardiac disease. The figures equate to a 66% reduction in the number of echocardiograms, a 29% reduction in the number of exercise stress tests, a 17% reduction in Holter monitoring, and a 25% reduction in the number of cardiac MRI scans compared with the 2010 ESC recommendations (all 2-tail  $p < 0.0001$ ) (Figure 1B). Fifteen athletes (0.3% 95% CI: 0.2% to 0.5%) were diagnosed with serious cardiac diseases (hypertrophic cardiomyopathy:  $n = 6$ ; long QT syndrome:  $n = 3$ ; Wolff-Parkinson-White syndrome ECG pattern:  $n = 6$ ) after a secondary investigation after an abnormal ECG according to all 4 ECG criteria.

The overall cost of screening using the 2010 ESC recommendations was \$110 (95% CI: \$102 to \$122) per athlete and \$35,993 (95% CI: \$33,474 to \$39,896) per serious diagnosis. The Seattle and refined criteria reduced the cost to \$92 (95% CI: \$84 to \$103) and

**FIGURE 1 ECG Abnormalities and Secondary Investigations Following Pre-Participation Screening**

(A) Comparison of electrocardiographic (ECG) abnormalities and (B) secondary investigations following ECG screening with the 4 ECG interpretation criteria. Echo = echocardiography; ESC = European Cardiology Society; EST = exercise stress test; MRI = magnetic resonance imaging.

\$87 (95% CI: \$80 to \$94) per athlete screened and \$30,251 (95% CI: \$27,568 to \$33,912) and \$28,510 (95% CI: \$26,329 to \$32,123) per serious diagnosis, respectively. The international recommendations further reduced cost to \$80 (95% CI: \$74 to \$91) per athlete and \$26,405 (95% CI: \$24,392 to \$29,833) per serious diagnosis, representing a 27%, 13%, and 8% relative cost reduction compared with the 2010 ESC, Seattle, and refined criteria, respectively.

The study was limited in that we could not calculate the sensitivity or specificity of the international recommendations to detect disease because the secondary investigation was limited to athletes with positive screening evaluations. In addition, secondary investigations were performed at the discretion of attending cardiologists at the local hospitals and probably varied according to personal practice.

The international recommendations are associated with a significantly lower number of abnormal ECGs and result in an impressive reduction in workload and cost of screening without compromising the ability to detect athletes with serious cardiac disease. Prospective evaluation is required to understand the actual impact of this consensus document on testing, cost, and outcomes.

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<http://dx.doi.org/10.1016/j.jacc.2017.06.018>

Please note: Mr. Dhutia, Mr. Malhotra, and Dr. Finocchiaro were funded by research grants from Cardiac Risk in the Young. Dr. Sharma has been an applicant on previous grants from Cardiac Risk in the Young and British Heart Foundation to study athletes. All other authors have reported that they have no relationships relevant to the contents of this paper to disclose.

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