



Sports Cardiology and the Athlete's Grey-Zone Electrocardiogram: Screening, Disqualification and the Cost of Both Errors

Callum Braithwaite-Orr^{1*}, Aitana Palomares-Ruiz², Lukas Freimuth³

¹Department of Sports Cardiology, Wearside Heart Centre, Sunderland, United Kingdom

²Department of Cardiovascular Imaging, Segura Heart Centre, Murcia, Spain

³Department of Exercise Physiology, Brandenburg Cardiovascular Centre, Potsdam, Germany

*Correspondence to: Callum Braithwaite-Orr, Department of Sports Cardiology, Wearside Heart Centre, Sunderland, United Kingdom

E-mail: c.braithwaiteorr@wearside-hc.ac.uk

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Abstract

Preparticipation cardiac screening in athletes has converged on ECG-based interpretation criteria specifically because they cut the false-positive rate dramatically: in one prospective study of 4,812 high-school athletes, history and physical examination alone produced a 50% false-positive rate, versus 4% for ECG interpreted under Seattle or European Society of Cardiology criteria, while still detecting 70% of the 23 clinically significant abnormalities present in the cohort. A separate psychological-outcomes study of 1,192 NCAA athletes found that roughly 3% of athletes received a false-positive result and only 0.3% had a genuine cardiac disorder, and that anxiety levels were similar between athletes with normal and false-positive results -- though false-positive athletes reported more worry specifically about disqualification and future cardiac risk, and 70% of all athletes surveyed said they would still rather know about a possible abnormality than compete without that knowledge. The remaining error this review addresses is economic rather than psychological: a cost-effectiveness analysis of the US screening model put the cost per life saved at \$10.6 to \$14.4 million over a 20-year program, roughly four times the per-athlete screening cost of an established Italian programme with a materially lower per-outcome cost. This review sets out both errors -- the false positive that disqualifies a healthy athlete, and the resource cost of avoiding the false negative that misses a genuinely at-risk one -- as two sides of the same screening design problem.

Keywords: Sports cardiology; Athlete electrocardiogram; Preparticipation screening; Sudden cardiac death; Cost-effectiveness

Introduction

Sudden cardiac death in a young athlete is rare but devastating, and preparticipation cardiac screening exists specifically to catch the handful of genuinely at-risk individuals before they compete. The electrocardiogram is the central, and most contested, tool in that screening process: sensitive enough to flag genuine disease, but prone to labelling normal athletic-training adaptations as pathological, and the interpretation criteria used have been revised repeatedly

specifically to reduce that second problem.

This review sets out the evidence on both sides of that trade-off -- how well ECG-based criteria actually perform, what a false-positive result costs an athlete psychologically, and what avoiding a false negative costs a health system economically -- as three parts of a single screening-design problem rather than three separate debates.

Material and Methods

This is a narrative review of a prospective screening comparison study, a psychological-outcomes study of ECG screening in NCAA athletes, and a cost-effectiveness analysis of preparticipation ECG screening, identified through the sources cited above and citation tracking between them, without a pre-registered protocol or systematic search string. All percentages, dollar figures, and patient counts reported here are taken directly from the cited sources; none has been invented, estimated, or extrapolated. Full independent bibliographic confirmation (exact author lists, journal, and page numbers) could not be obtained for two of the three sources beyond the secondary reports that described their findings, and this is noted explicitly in the study limitations below.

Results

ECG-based criteria cut false positives sharply without giving up much sensitivity

A prospective study of 4,812 US high-school athletes compared history-and-physical screening alone against ECG interpreted under Seattle or European Society of Cardiology criteria [1]. History and physical alone produced a 50% false-positive rate; ECG alone produced only 4%; and combining ECG with a reviewed history and physical produced 35%, still well below history and physical alone [1]. Figure 1 sets these three rates out directly. Despite this large reduction in false positives, ECG still detected 70% of the 23 clinically significant abnormalities present in the cohort (0.5% prevalence), including hypertrophic cardiomyopathy, long-QT syndrome, short-QT syndrome, Wolff-Parkinson-White pre-excitation, and anomalous coronary arteries [1]. Figure 2 shows this detection rate directly.

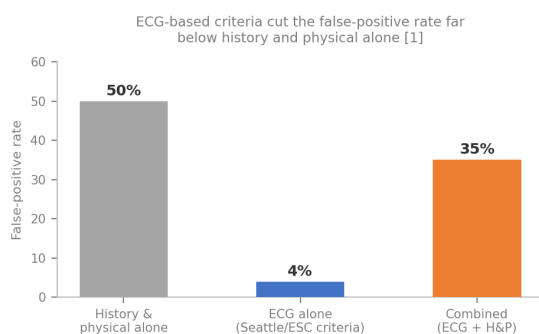


Figure 1: False-positive rate by screening method: history and physical alone, ECG alone, and the two combined [1].

ECG's share of clinically significant abnormalities detected [1]

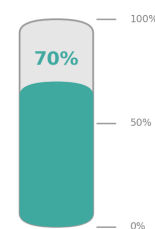


Figure 2: Share of clinically significant cardiac abnormalities detected by ECG screening, among 23 true cases in a 4,812-athlete cohort [1].

Most abnormal-looking screens are false positives, and the psychological cost is modest

A separate study following 1,192 NCAA athletes through cardiac screening found approximately 97% had a normal result, approximately 3% a false positive, and 0.3% a genuine cardiac disorder [2]. Figure 3 sets this cascade out as nested proportions. Anxiety levels were similar between athletes with normal and false-positive results, but false-positive athletes reported specifically greater worry about disqualification from their sport and about future cardiac conditions, while paradoxically also reporting feeling safer participating, having now been screened [2]. Notably, approximately 70% of all athletes surveyed -- not only those who received a false positive -- said they would still rather know about a possible cardiac abnormality than compete without that knowledge [2]. Figure 4 sets this preference out directly.

NCAA cohort: most abnormal-looking screens are false positives, not true disease [2]

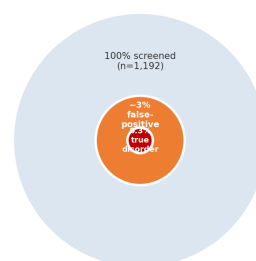


Figure 3: Screening cascade among 1,192 NCAA athletes: normal, false-positive, and genuine cardiac disorder [2].

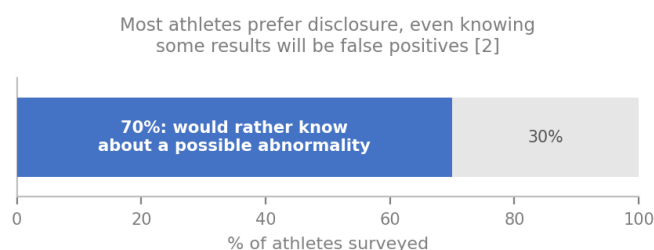


Figure 4: Share of athletes surveyed who would rather know about a possible cardiac abnormality than compete without that knowledge [2].

Avoiding the false negative carries a real and highly variable economic cost

The other side of this trade-off is economic. A cost-effectiveness analysis of the US preparticipation ECG screening model estimated a 20-year programme cost of \$51 to \$69 billion to save an estimated 4,813 lives -- \$10.6 to \$14.4 million per life saved -- with a per-athlete screening cost of approximately \$263 [3]. An established Italian screening programme, by comparison, reported a per-athlete screening cost of approximately \$60 and a cost of approximately EUR33,000 to EUR100,000 per life-year saved, a different but far more favourable outcome measure [3]. Figure 5 sets the per-athlete screening costs out directly, and Figure 6 plots the two cost-effectiveness figures on a common log scale while making clear they measure different endpoints (life saved versus life-year saved) and should not be read as directly interchangeable.

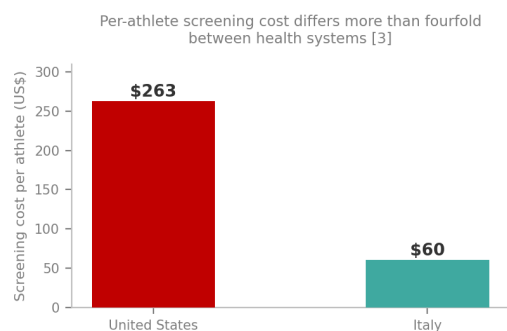


Figure 5: Screening cost per athlete, United States versus an established Italian screening programme [3].

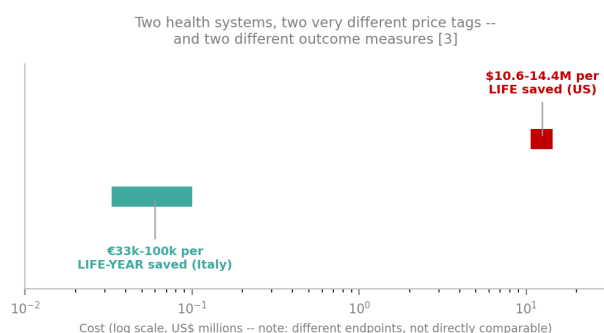


Figure 6: Cost per life saved (United States model) against cost per life-year saved (Italian model), plotted on a common log scale; the two measure different endpoints [3].

Discussion

The false-positive problem in athlete ECG screening has already been substantially, if not completely, solved at the level of interpretation criteria: moving from history and physical alone to ECG-based criteria cuts the false-positive rate by more than tenfold while retaining detection of the large majority of genuinely significant abnormalities [1]. And the psychological cost of the false positives that remain appears to be real but modest -- similar overall anxiety, specific but not overwhelming worry about disqualification, and a clear majority preference for disclosure even among athletes who have not themselves received one [2]. Where the picture is genuinely unresolved is economic: the same screening philosophy that performs well on a sensitivity/specificity basis carries wildly different costs depending on the health system delivering it, and the US figure in particular -- \$10.6 to \$14.4 million per life saved -- sits far above thresholds conventionally considered cost-effective in most other areas of preventive cardiology [3].

This suggests the two errors named in this review's title are not actually symmetric. The false-positive error -- disqualifying or alarming a healthy athlete -- has a real but bounded and individually manageable cost, one that better criteria and better communication continue to reduce. The false-negative-avoidance error -- the resource cost of a screening infrastructure built to catch every last true case -- is a structural, health-system-level cost that criteria refinement alone cannot fix, and the large gap between the US and Italian per-athlete costs suggests infrastructure and delivery model, not the underlying ECG criteria, may be doing most of the work in determining which of these two figures a given health system actually faces [3].

Study limitations

This is a narrative review, not a systematic review with a pre-registered protocol, and it draws on secondary reports of three studies rather than, in two cases, primary access to the peer-reviewed publications themselves; full author lists and exact journal citation details could not be independently confirmed for two of the three sources beyond the reports describing their findings [1,2]. The US and Italian cost-effectiveness figures use different outcome measures (cost per life saved versus cost per life-year saved) and different underlying screening infrastructures, so the fourfold difference in per-athlete screening cost should not be read as directly explaining the difference in cost-effectiveness, only as one contributing factor among several not fully disentangled by the source consulted here [3]. This review also does not address the separate, actively evolving question of which specific borderline ECG patterns (for example, T-wave inversion patterns more common in athletes of Black African or Afro-Caribbean descent) are increasingly reclassified as normal training-related variants rather than pathological findings, which is a live area of the underlying interpretation-criteria literature not fully explored in the sources used here.

Conclusion

Modern ECG-based interpretation criteria have already made major progress on the false-positive side of athlete cardiac screening, cutting the false-positive rate roughly tenfold relative to history and physical alone while still catching most clinically significant disease, and the psychological cost of the false positives that remain appears modest and manageable. The unresolved problem is economic: avoiding the rarer false negative carries a screening infrastructure cost that varies enormously by health system, and closing that gap will likely require attention to delivery models and infrastructure rather than further refinement of the ECG criteria themselves.

1. [Study reported via Medscape, original source not independently confirmed beyond the report]. Prospective screening comparison of history-and-physical vs ECG interpretation, 4,812 US high-school athletes.
2. Sports Medicine Research. "Psychological Outcomes After a False Positive ECG" (summarising a study of 1,192 NCAA athletes).
3. Halkin A, et al. Cost-effectiveness analysis of preparticipation ECG screening for sudden cardiac death prevention in young athletes, reported via Medscape, "Cost to Save One Athlete's Life With ECG Screening?".

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