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The False-Positive Burden and Diagnostic Blind Spot of Resting Cardiac Evaluations in Youth Athletes: A Systematic Review and Meta-Analysis

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ADMINISTRATIVE INFORMATION

Support - Grant university.

Review Stage at time of this submission - Data extraction.

Conflicts of interest - None declared.

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Amendments - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 29 March 2026 and was last updated on 29 March 2026.

INTRODUCTION

Review question / Objective What is the comparative diagnostic yield of continuous exertional telemetry versus standard resting cardiac evaluations (ECG, echocardiography) for identifying arrhythmogenic substrates in pediatric and adolescent athletes, and what is the rate of false-positive sports restrictions generated by resting evaluations?

Condition being studied Sudden cardiac death (SCD) risk stratification, exercise-induced arrhythmias (e.g., Catecholaminergic Polymorphic Ventricular Tachycardia [CPVT], Arrhythmogenic Right Ventricular Cardiomyopathy [ARVC], concealed non-ischaemic left-ventricular fibrosis), and sports cardiology screening (pre-participation and return-to-play evaluation) in pediatric and adolescent athletes.

METHODS

Search strategy A systematic literature search was conducted in MEDLINE (via PubMed), Embase, and the Cochrane Central Register of Controlled Trials (CENTRAL) from inception to March 2026. The search strategy was designed for high precision, employing specific clinical terminology to target studies directly relevant to exertional cardiac monitoring in youth athletes. The Boolean strategy combined terms for the population, intervention, and outcomes. Keywords included: ("Pediatric" OR "Adolescent" OR "Youth") AND ("Athlete" OR "Sports") AND ("Exertional Telemetry" OR "Ambulatory ECG" OR "Holter" OR "Continuous Monitoring") AND ("Resting ECG" OR "Echocardiogram" OR "Screening") AND ("False Positive" OR "Diagnostic Yield" OR "Arrhythmia" OR "Sudden Cardiac Death"). No language restrictions were applied.

Participant or population Inclusion: Pediatric and adolescent athletes aged 21 years or younger.
Exclusion: Adult or masters athletes (cohorts with a mean age above 21 years); non-athletic pediatric populations.

Intervention Continuous medical-grade exertional telemetry (ambulatory ECG, sports Holter monitoring) performed during sport-specific dynamic exercise or maximal physical exertion. Only devices with formal regulatory diagnostic approval (FDA/CE mark) were eligible.

Comparator Standard resting cardiovascular evaluations, primarily resting 12-lead electrocardiogram (ECG) and/or resting echocardiography, performed in a static, supine position.

Study designs to be included Observational cohort studies, cross-sectional studies, and case series reporting quantitative diagnostic yield (with extractable numerator and denominator). Randomised controlled trials were eligible but none were identified. Single case reports without an extractable denominator, narrative reviews, editorials, letters, and conference abstracts without sufficient methodological detail were excluded.

Eligibility criteria Inclusion: (1) Pediatric and adolescent athletes aged 21 years or younger; (2) studies reporting quantitative data on either the false-positive rate of standard resting cardiac evaluations (resting 12-lead ECG and/or echocardiography) or the diagnostic yield of continuous medical-grade exertional telemetry (ambulatory ECG, sports Holter monitoring) during dynamic exercise; (3) medical-grade monitoring devices with formal regulatory diagnostic approval (FDA/CE mark).

Exclusion: (1) Adult or masters athlete cohorts (mean age >21 years); (2) non-athletic pediatric populations; (3) studies using consumer-grade fitness wearables lacking regulatory diagnostic approval; (4) studies evaluating resting ECG parameters without an exertional monitoring component or without reporting false-positive outcomes; (5) narrative reviews, editorials, and single case reports without extractable denominators.

Information sources MEDLINE (via PubMed), Embase, and the Cochrane Central Register of Controlled Trials (CENTRAL). Reference lists of included studies and relevant systematic reviews were hand-searched to identify additional eligible publications.

Main outcome(s) 1. The pooled proportion of false-positive findings and unnecessary sports restrictions generated by standard resting cardiac evaluations, stratified into ECG-criteria false positives and clinical-disease false positives.
2. The incremental diagnostic yield of continuous exertional telemetry, defined as the absolute number of life-threatening arrhythmogenic substrates (e.g., CPVT, ARVC, concealed non-ischaemic left-ventricular fibrosis) uniquely detected during exertional monitoring that were missed by baseline resting evaluations.

Quality assessment / Risk of bias analysis Methodological quality and risk of bias for each included observational study will be independently assessed by two reviewers using the Newcastle-Ottawa Scale (NOS), adapted for cross-sectional studies where applicable. Studies will be evaluated across three domains: (1) selection of participants, (2) comparability of cohorts, and (3) ascertainment of outcomes. Each study will be assigned a total NOS score and classified as low risk (7–9 stars), moderate risk (4–6 stars), or high risk (0–3 stars). Disagreements will be resolved by consensus or adjudication by a third reviewer. Results will be presented in a summary table and used to inform sensitivity analyses.

Strategy of data synthesis Meta-analysis will be performed using a random-effects model (DerSimonian-Laird) to account for clinical and methodological heterogeneity across pediatric cohorts. Pooled proportions with 95% confidence intervals will be calculated for primary outcomes. Statistical heterogeneity will be quantified using the I-squared statistic (I^2 > 50% indicating substantial heterogeneity). Publication bias will be assessed via funnel plot inspection and Egger's regression test.Meta-analysis was performed using a random-effects model (DerSimonian-Laird) to account for clinical and methodological heterogeneity across pediatric cohorts. Pooled proportions with 95% confidence intervals were calculated for primary outcomes. Statistical heterogeneity was quantified using the I-squared statistic (I^2 > 50% indicating substantial heterogeneity). Publication bias was assessed via funnel plot inspection and Egger's regression test.

Subgroup analysis Subgroup analyses will stratify diagnostic yield and false-positive burden by clinical indication for testing: (1) mass screening cohorts, (2) symptomatic/referral cohorts, and (3) post-clearance/return-to-play cohorts. Meta-

regression will be performed against mean cohort age to evaluate the impact of physiological Athlete's Heart remodelling on false-positive rates.Subgroup analyses stratified diagnostic yield and false-positive burden by clinical indication: (1) mass screening cohorts, (2) symptomatic/referral cohorts, and (3) post-clearance/return-to-play cohorts. Meta-regression was performed against mean cohort age to evaluate the impact of physiological Athlete's Heart remodelling on false-positive rates.

Sensitivity analysis Leave-one-out sensitivity analysis will be conducted to evaluate the robustness of pooled estimates and identify whether any single large-scale study disproportionately influences the overall effect size. An additional sensitivity analysis will exclude studies classified as high risk of bias on the Newcastle-Ottawa Scale.Leave-one-out sensitivity analysis was conducted to evaluate the robustness of pooled estimates and identify whether any single large-scale study disproportionately influenced the overall effect size.

Language restriction None.

Country(ies) involved Poland.

Keywords Pediatric sports cardiology; Exertional telemetry; Resting ECG; Sudden cardiac death; False positive; Return-to-play; Arrhythmia; Athlete's Heart.

Contributions of each author

Author 1 - Filip Bossowski - Conceived the study, designed the search strategy, performed data extraction, conducted the meta-analysis, writing – original draft and revised the manuscript.
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