Meta-Analysis of the Effectiveness of Screening History and Physical vs ECG in Detecting Conditions Associated with Sudden Cardiac Death in Young Athletes Over the Past 5 Years

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Introduction

Sudden cardiac death (SCD) in young athletes is a devastating event that may be preventable by effective pre-participation screening; however, there is no universal screening method for the conditions associated with SCD. The American Heart Association (AHA) and the Association for European Paediatric Cardiology (AEPC) both recommend a screening history and physical exam (H&P) be performed. AEPC guidelines also recommend a 12-lead ECG be performed before clearing an athlete to play. We sought to conduct a meta-analysis of the literature between 2015 and 2020 to compare the value of H&P to that of a 12-lead ECG as a screening tool for true cardiac disease.

Methods

Data Sources– A systematic search of MEDLINE, EMBASE, and PubMed was conducted for studies published between January 1st, 2015 and June 30th, 2020 for original research articles investigating the ability of various screening procedures to identify true cardiac disease.

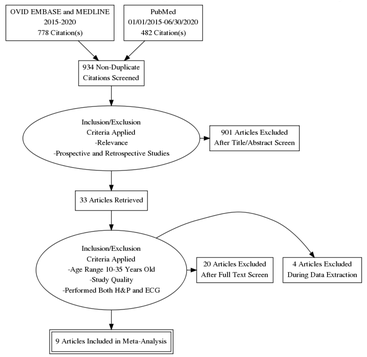

Fig. 1- PRISMA Diagram of Study Selection Process

Inclusion Criteria-

- Published in English
- Prospective and retrospective studies
- Athletes 10 – 35 years of age
- Use of both ECG and H&P in screening for cardiac disease

Data Extraction- Data were extracted by one author (NKG) and then reviewed by another (AH) for accuracy. Four studies were excluded after data extraction had begun due to some categories used in our analysis not being reported.

Statistical Methods- For each study, the association of ECG with true cardiac diagnoses and the association of H&P with true cardiac diagnoses were quantified as odds ratios. Meta-analysis of log odds ratios using a random-effects model with restricted maximum likelihood estimation was conducted with the MAJOR module in jamovi (https://www.**jamovi**.org), based on the metafor package in R (Viechtbauer, Journal of Statistical Software, 36:3, 2010).

Results

Nine studies were identified for use in our meta-analysis. There were 28,011 patients included in our meta-analysis from 7 countries. Their ages ranged from 11 to 35 years old, with 21,574 (77%) patients specified as male. 12,415 patients identified as Caucasian, 1,963 patients identified as Black, and 430 identified as Asian/Pacific Islander. A further 1,160 identified as other/mixed race, and 11,882 patients did not identify their race.

Author	Journal	Year	Country of Origin	# of Athletes Screened	Age Range(y), (mean) or [median] Age	Males, n (%)
Malhotra et al	New England Journal of Medicine	2018	United Kingdom	11,168	15-17 (16.4)	10,581 (95)
Drezner et al	Journal of the American College of Cardiology	2015	United States	790	17-25 (18)	444 (56)
McClean et al	Heart	2019	Qatar	1,304	11-18 (15.1)	1,304 (100)
Grazioli et al	European Journal of Preventative Cardiology	2017	Spain	1,650	12-18 (15.09)	986 (60)
Conway et al	Clinical Journal of Sports Medicine	2020	United States	1,686	16-25 [18]	993 (59)
Drezner et al	American Journal of Cardiology	2016	United States	5,258	18-25 (20.1)	2,892 (55)
McKinney et al	Canadian Journal of Cardiology	2017	Canada	714	12-35	Not Specified
Dhutia et al	Journal of the American College of Cardiology	2016	United Kingdom	4,925	14-35 (19.9)	4,068 (83)
Tischer et al	Scandinavian Journal of Medicine and Science in Sports	2015	Denmark	516	13-35 (21.58)	306 (59)
Total			7 Countries	28,011	11-35	21,574 (77)

Table 1- Study Characteristics and Baselines

Category (Abbr.)	Condition	# of Diagnoses
Arrhythmia, Other (A)	Atrial Fibrillation	1
Arrhythmia, Other (A)	Premature Ventricular Contraction (PVC) Frequent	1
Arrhythmia, Other (A)	Sustained Ventricular Tachycardia	1
Cardiomyopathy (CM)	Arrhythmogenic Right Ventricular Cardiomyopathy	5
Cardiomyopathy (CM)	Dilated Cardiomyopathy	2
Cardiomyopathy (CM)	Hypertrophic Cardiomyopathy	19
Cardiomyopathy (CM)	Left Ventricular Non-Compaction	2
Cardiomyopathy (CM)	Myocarditis	3
Coronary Anomaly (CA)	Anomalous Origin of Left Coronary Artery	1
Coronary Anomaly (CA)	Coronary Artery Anomaly	3
Coronary Anomaly (CA)	Congenital Coronary AV Fistula	1
Long QT (LQT)	Long QT Syndrome	8
Other	Aneurism with Aortic Root Dilation	1
Other	Aortic Coarctation	1
Other	Atrial Septum Defect	4
Other	Bicuspid Aortic Valve	7
Other	Dextrocardia	1
Other	Mitral Valve Prolapse	2
Other	Patent Foramen Ovale	2
Other	RV Compression from Pectus Excavatum	1
Sudden Cardiac Death, Unspecified Etiology (SCD)	Sudden Cardiac Death, Unspecified Etiology	2
Supraventricular Tachycardia (SVT)	Supraventricular Tachycardia	2
Wolff-Parkinson-White Syndrome (WPW)	Wolff-Parkinson-White Syndrome	57
	Total	127

Table 2- True cardiac conditions found across 9 studies. All are associated with SCD except for Other. Abbreviations are used as data labels in Fig. 2.

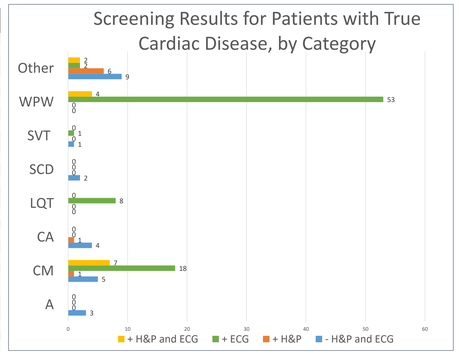

Fig. 2- Bar graph showing the screening results for each of the categories of conditions listed in Table 2.

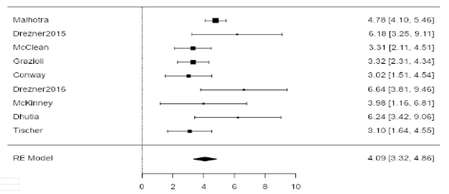

Fig. 3- Forest plot showing the results of 9 studies examining the association between ECG and true cardiac disease: the log odds ratio with corresponding 95% confidence intervals in each individual study and the overall log odds ratio estimate based on a random-effects model.

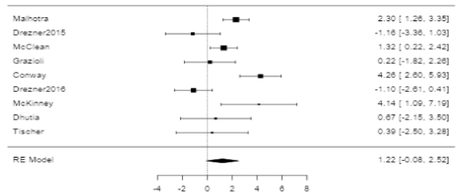

Fig. 4- Forest plot showing the results of 9 studies examining the association between H&P and true cardiac disease. For details, see legend to Fig. 3.

Association of ECG with true cardiac disease- The random-effects model applied to the 9 studies, which showed moderate heterogeneity (I^2=55%), yielded a statistically significant (Z=10.4, p<0.001) back-transformed odds ratio of 60 (95% confidence limits: 28 to 130).

Association of H&P with true cardiac disease- The random-effects model applied to the 9 studies, which showed high heterogeneity (I^2=79%), yielded a back-transformed odds ratio of 3.4 (95% confidence limits: 0.92 to 12) that was not statistically significant at the 5% level (Z=1.84, p=0.066).

Discussion

We sought to compare how identification of cardiac disease in young athletes compared using H&P vs. a 12-lead ECG. Our results revealed that the odds of identifying true cardiac disease were statistically significant when utilizing ECG, whereas the association between H&P and identifying cardiac disease had no statistical significance. The ECG screening was particularly effective at identifying WPW, long QT syndrome, and cardiomyopathies, all of which are known conditions associated with increased risk for SCD. Coronary anomalies and other structural defects, which are also SCD-associated, were not able to be found by ECG. When considering the clinical significance of this study, limitations exist. Reading ECG's is not a standardized process, and variations among providers leaves room for error. In addition, screening large numbers of athletes with ECG's requires a large amount of time and medical resources, which may be overwhelming in many medical markets. This reality becomes even more apparent when considering that of the 28,011 athletes included, only 110 (0.04%), were able to be identified as having true cardiac disease associated with potential SCD. Future research would ideally look at ECG and H&P together as screening tools and address costs to evaluate the feasibility as well as effectiveness of a screening protocol.

Conclusions

The odds of identifying cardiac disease in young athletes is higher and statistically significant (odds ratio of 60; p<0.001) when utilizing ECG, as compared with H&P (odds ratio of 3.4; p=0.066), which was not a statistically significant method of identifying cardiac disease. We conclude that a 12-lead ECG as a screening tool improves the odds of identifying true cardiac disease in young athletes; however, the absolute numbers of identifying true positive patients is very low when compared to the overall population. Utilization of an ECG for screening of young athletes is labor intensive and costly, but our results suggest that it could be a more effective tool than a traditional H&P in the right setting with sufficient resources and adequate medical support.