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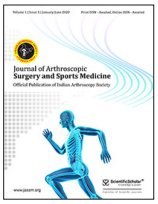

Original Article

Assessment of cardiovascular risk among school athletes: A retrospective cross-sectional study

Yakupiti Himan Shashidara De Silva[1], Sanka Theekshana Thebuwanarachchi[1], Dimuthu C. Weerasuriya[2], Sampath Gunawardena[3], Omega Lokuyaddage De Silva[4], Hapuarachchige Maheshika Dilrukshi Perera[5], Wewelwala Hewage Harsha Mendis[6], Amaranath Karunanayake[3]

[1]Sports Medicine Unit, National Hospital Galle, Karapitiya, Galle, [2]Department of Pediatrics, Lady Ridgeway Hospital, Colombo, [3]Department of Physiology, Faculty of Medicine, University of Ruhuna, Galle, [4]Department of Emergency Medicine, National Hospital of Sri Lanka, Colombo, [5]Department of Physiotherapy, Sri Lanka Foundation Institute, Center for Excellence, Padanam Mawatha, Torrington place, Colombo, [6]Department of Surgery, National Hospital, Galle, Sri Lanka.

ABSTRACT

Objectives: Globally, undiagnosed cardiovascular anomalies are the primary cause of sudden cardiac deaths among school athletes. In Sri Lanka, data on this subject remain scarce. Recent fatalities involving adolescent athletes have highlighted the need for preventive measures to be introduced by the country's healthcare sector. The aims and objectives of the study are to determine the prevalence and contributing factors for cardiovascular pathologies found in school athletes as well as the associated cardiovascular risks of competing in other major competitive sports.

Materials and Methods: A retrospective cross-sectional study was conducted at a sports medicine clinic in a tertiary care hospital, focusing on school athletes aged 10-19 years undergoing medical clearance for endurance sports. The study spanned 18 months, from January 1, 2022, to June 30, 2023, with a computed sample size of 784 athletes. Preliminary testing led to adjustments in the data collection sheet. Secondary data were retrieved by sports medicine physicians from archived pre-participation health clearance questionnaires.

Results: Among the participants, 118 individuals (15.1%) were aged 10-12 years, 164 (20.9%) were 13-15 years, and 502 (64%) were 16-19 years. The prevalence of electrocardiogram (ECG) abnormalities was estimated at 5.6%. The relative risk of detecting an ECG abnormality in the 10-12 age group compared to those aged 13 years and above was 6.773 (confidence interval [CI] 3.868-11.859), with an odds ratio of 8.247 (CI 4.385-15.509). Similarly, comparing the 16-19 age group (n = 502) to the combined 10-15 age groups (n = 282) revealed a relative risk of 5.340 (CI 2.742-10.401) and an odds ratio of 5.916 (CI 2.940-11.903). It can be concluded that the younger participants have a relatively higher incidence of ECG abnormalities compared to older age groups. The study found a 3% prevalence of cardiovascular anomalies among adolescent athletes in Sri Lanka. The mitral valve prolapses are the most common followed by mitral stenosis, ventricular septal defect, and the least being aortic stenosis.

Conclusion: Screening athletes with a thorough medical history and detailed clinical examination effectively uncovers hidden cardiovascular conditions and serves as a reliable method to identify potential risks. Adding an ECG improves the sensitivity of detecting rare or asymptomatic issues, while the selective use of 2-D echocardiography further enhances diagnostic accuracy.

Keywords: Cardiovascular risk, Endurance sports, School athletes, Sudden death, Sport medicine

INTRODUCTION

Undetected cardiovascular abnormalities have been recognized as a leading cause of sudden cardiac death (SCD) in young athletes participating in sports.[1-6] The primary goal of pre-participation health evaluations (PPEs) is to identify cardiovascular conditions that could increase a player's risk of adverse events during sports activities. Although less commonly associated with SCDs, the sports medical fitness assessments aim at diagnosing adolescents with previously undiagnosed structural cardiac abnormalities, such as mitral valve prolapse (MVP), atrial septal defects (ASDs), coarctation of aorta, ventricular septal defects (VSD), and aortic stenosis (AS) and may be identified during sports medical fitness assessments.[6]

Athletes may have underlying conditions that present no obvious symptoms and can only be identified through thorough cardiovascular evaluation. Examples include hypertrophic cardiomyopathy, arrhythmogenic right

***Corresponding author:** Yakupiti Himan Shashidara De Silva, Sports Medicine Unit, National Hospital, Karapitiya, Galle, Sri Lanka. drhiman1975@gmail.com

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ventricular cardiomyopathy, congenital coronary artery anomalies, and channelopathies. These conditions often remain asymptomatic until a life-threatening arrhythmia occurs.[1] However, in some cases, these conditions can be identified through thorough cardiovascular evaluation.[6,7] Three online databases were explored: PubMed, the Cochrane Database, and the Open Access Journal of Sports Medicine. The search was conducted using the keywords "Cardiovascular abnormalities." The search was conducted using the keywords "Cardiovascular abnormalities. The search was conducted using the keywords "Cardiovascular abnormalities" and "school athlete," "school athlete." A total of 341 articles were found on this topic, with 15 deemed relevant for use. A total of 341 articles were found on this topic, with 15 deemed relevant for use. According to Baggish *et al*. (2010), incorporating an electrocardiogram (ECG) alongside patient history and clinical examination increases the cumulative sensitivity of pre-participation cardiovascular assessments. Nevertheless, this approach also results in a higher incidence of false positives under the latest ECG interpretation guidelines.[8] In contrast, Price *et al*. (2014) concluded that modern ECG interpretation standards result in a low false-positive rate, while also affirming that ECG enhances pre-participation screening (PPS) by improving the detection of arrhythmogenic and structural cardiovascular conditions associated with sudden cardiac death. Although routine echocardiography can identify other clinically significant cardiac abnormalities, its role in PPS remains uncertain.[9]

Sri Lankan situation

At present, Sri Lanka lacks a comprehensive database for cardiovascular abnormalities or sudden deaths among young athletes. However, numerous deaths have been reported in this population, particularly during endurance sports. Public concern about this health issue grew significantly following four consecutive deaths during school marathon races in January 2013. Between 2013 and 2024, a total of 14 sudden deaths were recorded during endurance events. Sadly, nearly all of these individuals had not undergone any cardiovascular risk assessments.[10]

Structural cardiac abnormalities such as ASD, VSD, and rheumatic valvular conditions like MVP are occasionally identified when athletes visit sports medicine clinics for pre-participation medical clearance. Although no official statistics have been published, heat stroke is believed to be a leading trigger of fatal cardiac arrhythmias, contributing to unexpected fatalities among young endurance athletes in Sri Lanka. Other cardiac causes, including myocarditis, hypertrophic cardiomyopathy, and arrhythmogenic right ventricular cardiomyopathy, are also significant contributors. In addition, commotio cordis, a sudden non-penetrative impact to the chest, can induce fatal arrhythmias, resulting in the death of a young athlete. The occurrences of sudden deaths among young athletes during sporting events since 2013 have prompted governing bodies to focus on implementing proper PPE assessments for all athletes before engaging in endurance sports. To battle against such sudden athletic deaths, on 8th of April 2015, the Ministry of Health launched a comprehensive PPE and pre-event program to screen all due athletes. Through the Ministry of Health, the government has issued a circular declaring the mandatory PPE screening, the (H-1246) clearance certificate by the government circular.[10-14]

Justification

Adolescents participating in endurance sports with undetected cardiovascular risks face potentially life-threatening situations. Many of these deaths could be prevented through comprehensive pre-participation assessments and medical clearance implemented nationwide. To address this, the Ministry of Health in Sri Lanka introduced an assessment tool (H-1246) in 2015 to reduce sudden athletic deaths in selected endurance and contact-collision sports.[11-13] However, data on cardiovascular risk factors in Sri Lankan athletes remain unpublished and poorly understood.

To address this gap, a pilot study will be conducted at a Sports Medicine clinic in the Teaching Hospital, Galle. This study aims to identify cardiovascular risks in adolescent school athletes participating in endurance sports. The findings will serve as a foundation for further research in sports medicine, contributing to the enhancement of existing preventive strategies or the development of new measures to mitigate these risks.

Objectives

General objective

The general objective of the study is to identify cardiovascular risks and their associated factors in adolescent school athletes participating in selected endurance sports during pre-participation assessments at the sports medicine clinic of a tertiary care hospital in Sri Lanka.

Specific objectives

1. To outline the clinical domain of cardiovascular anomalies identified in adolescent school athletes screened at a sports and exercise medicine clinic in a tertiary care hospital in Sri Lanka.
2. To evaluate cardiovascular risk factors among school athletes assessed at a sports medicine clinic of a tertiary care hospital in Sri Lanka.

MATERIALS AND METHODS

Study design

This is a retrospective cohort study.

Setting

The study was carried out at the Sports Medicine Unit of National Hospital Karapitiya, Galle, Sri Lanka, from January 1, 2022 to June 30, 2023.

Data collection method

The research utilized archived clinic records of athletes who visited the Sports Medicine Unit at Teaching Hospital Karapitiya. Risk assessment involves reviewing medical history, conducting physical examinations, and performing basic medical investigations when necessary.[10,15]

Trained sports medicine physicians identified adolescent school endurance athletes with cardiovascular risks that could impact their participation in endurance sports during the medical clearance process. In accordance with the protocol and guidelines set by the Sports Medicine Development Committee of the Ministry of Health in Sri Lanka, only authorized medical officers or consultants in sports medicine are allowed to issue the PPE clearance certificate (H-1246). Therefore, the questionnaires kept in the clinic were filled out by these authorized professionals, who affixed their signatures and official stamps onto the documents.

Data collecting instrument

Further, all athletes seeking the H-1246 PPE clearance certificate must submit the standardized application form along with an ECG in advance. The application form is designed as a comprehensive medical history questionnaire and also allows space for a medical officer to document the clinical examination findings, investigation results, referrals made to any other medical specialties, endurance test results, diagnosis, and final inferences of the athlete's cardiovascular fitness level. Those completed questionnaires should be signed and stamped by the medical officer and also be kept for a minimum of 1 year. The relevant data for the research were extracted from those questionnaire forms, which were archived in the clinic record room and then transferred to the data extraction sheets as secondary data [Supplementary material]. The study utilized the collected data to identify the prevalence of cardiovascular risks and the factors linked to these risks among adolescent school athletes involved in endurance sports.

Participants

A representative group of 784 athletes who visited the clinic requesting pre-participation medical clearance, the (H-1246) clearance certificate between the 1st of January 2022 and June 30th of 2023, over a period of 18 months, were selected.

Inclusion criteria

Adolescent school endurance athletes aged between 10 and 19 years.

Taking part in a sport with a mandatory PPE screening, the (H-1246) clearance certificate by the government circulars by the Ministries of Health and Education includes running 1500 m and or above running, swimming 400 m and or above, martial arts, boxing, cadeting, rugby, soccer, race walking, cycling, hiking, and any other sport when an athlete is having a significant health issue.[10]

Exclusion criteria

Non-schooling adolescent athletes.

School adolescent endurance athletes requesting the (H-1246) clearance certificate for any sport other than the mandatory government-designated sporting events mentioned above. The rationale for focusing on school athletes stems from the study's objective to produce data that are directly relevant to the school setting. This approach facilitates the development and implementation of targeted injury prevention programs within schools. Moreover, the structured and organized nature of school sports programs ensures greater consistency and control in data collection while providing easier access to participants through the school system. In contrast, non-school adolescent athletes often engage in more varied and less structured sports environments.

Variables

Analysis was done on age, gender, sport, ECG analysis, and cardiovascular examination findings.

Data sources/management

Experienced sports medicine physicians and a pediatric cardiologist meticulously handled the data obtained from the clinic records.

Bias

The risk was minimal as sports physicians extracted data retrospectively from standard sources and filled gaps by contacting athletes when necessary.

Study size

Simple random sampling was used.

The sample size was calculated based on an anticipated prevalence of abnormalities at 15%, referencing a study in the USA by Price *et al*., 2014.[9]

The sample size was calculated using the following formula: Lowanga and Lameshow, 1991, and considering the anticipated prevalence as 15%.[16]

(*z=1.96, **P=0.15, ***d=0.025)

$$n = \frac{z^2\ p\ (1\text{-}p)}{d^2}$$

$$n = \frac{(1.96 \times 1.96) \times 0.15\,(1\text{-}0.15)}{(0.025 \times 0.025)}$$

$$n = \frac{0.48904}{0.000625}$$

n = 783.7

Data from 784 students were analyzed.

n = Number of participants (sample size), *z = Level of confidence (level of significance - 0.05), **d = absolute precision, ***P = estimated proportion of individuals in the sample with the characteristics of interest.

Statistical method

The data analysis was conducted using the Statistical Package for the Social Sciences software, version 25. Descriptive statistics were applied to present the basic sociodemographic information, while cross-tabulation was utilized to compare various groups of athletes. As all data were directly obtained from fully completed, archived questionnaires, the study did not encounter any confounding variables, missing data, or loss to follow-up. In cases requiring additional clarification, patients could be contacted using the mobile number or school postal address provided on the questionnaires.

RESULTS

Participants

About 1117 eligible questionnaires have been archived in the clinic record room for the period of analysis. About 784 questionnaires were randomly selected and retroactively analyzed.

Descriptive data

Based on the study sample, as presented in Table 1, male marathon participants accounted for 63.3% (497), while females made up 36.7% (287). This highlights a greater inclination among male adolescent athletes to participate in marathons compared to their female counterparts. The higher incidence of fatal events among male athletes has been attributed to their greater participation in competitive sports, coupled with more rigorous training regimens and higher levels of athletic performance compared to females.

Table 1: Frequency analysis - gender.

Gender	Frequency	Percentage
Male	497	63.3
Female	287	36.7
Total	784	100

As indicated by the study sample in Table 2, marathon participation was comparatively higher among athletes aged 16-19 years. This trend could be attributed to athletes in this age group having more established training routines, greater experience, and increased confidence in competing in endurance events.

Table 2: Frequency analysis - age.

Age category	Frequency	Percentage
10-12 years	118	15.1
13-15 years	164	20.9
16-19 years	502	64
Total	784	100

Outcome data

Based on the analysis of Table 3, the prevalence of cardiovascular abnormalities was determined to be 3% (24 cases). The most frequently identified condition was mitral valve prolapse, accounting for 1.4% (11 cases). Other detected abnormalities included mitral stenosis (MS) at 0.2% (2 cases), VSD at 1.2% (9 cases), and AS at 0.2% (2 cases).

Table 3: Frequency analysis - cardiovascular (CVS) abnormality detected.

Type of CVS abnormality	Frequency	Percentage
Mitral valve prolapse	11	1.4
Mitral stenosis	2	0.2
Ventricular septal defect	9	1.2
Aortic stenosis	2	0.2
None	760	97
Total	784	100

A notable finding during pre-participation examinations is the presence of cardiac murmurs. As shown in Table 4, the prevalence of heart murmurs within the sample is 2.8% (22 cases).

Table 4: Frequency analysis - heart murmur.

Heart murmur	Frequency	Percentage
Heart murmur present	22	2.8
Heart murmur not present	762	97.2
Total	784	100

Analyzing the ECG [Table 5] is crucial in PPE examinations. The prevalence of detected electrocardiographic abnormalities was 5.6% (44 cases). The addition of a 12-lead ECG notably improves the sensitivity of the screening process in identifying cardiac conditions that increase the risk of sudden deaths while engaged in physical activities. Maron, 2005, stated that up to 95% of individuals with hypertrophic obstructive cardiomyopathy (HOCM) - the leading cause of instant cardiac demise among adolescent athletes - exhibit abnormal electrocardiographic findings.[17] Similarly, according to Corrado *et al*., 1988, ECG abnormalities have been frequently reported in many athletes who succumbed to arrhythmogenic right ventricular dysplasia.[18]

Table 5: Frequency analysis - electrocardiogram (ECG) abnormality.

ECG abnormality	Frequency	Percentage
ECG abnormality found	44	5.6
ECG abnormality not found	740	94.6
Total	784	100.0

From the analysis of Table 6, it can be inferred that the most frequently observed ECG abnormality was the right bundle

branch block (RBBB), accounting for 2.8% (22 cases). RBBB is generally considered a benign finding in young athletes, often reflecting physiological cardiac remodeling due to regular, intense physical activity. Other abnormalities included T-wave inversion in individuals over 16 years of age at 1.7% (14 cases). T-wave inversion in this age group has clinical significance since it may warrant further evaluation to rule out underlying structural or functional cardiac abnormalities, particularly when found in specific leads or associated with clinical symptoms. Further, ectopic beats at 0.5% (4 cases) and right ventricular hypertrophy (RVH) also at 0.5% (4 cases) were detected. While ectopic beats are relatively common and often benign in athletes, RVH requires careful assessment to differentiate physiological adaptations from pathological conditions such as pulmonary hypertension or congenital heart disease.

Table 6: Frequency analysis - type of electrocardiogram (ECG) abnormality.

Type of ECG abnormality	Frequency	Percentage
Right bundle branch block	22	2.8
Ectopic beats	4	0.5
T Inversion	14	1.7
Right ventricular hypertrophy	4	0.5
None	740	94.5
Total	784	100

Running events exceeding 1500 m were found to have the highest prevalence of cardiovascular and/or ECG abnormalities, accounting for 42% (28 cases) [Table 7]. Other sports with notable prevalence included swimming events over 400 m at 18% (12 cases), martial arts at 15% (10 cases), and cycling/hiking at 7.5% (5 cases), from a total of 66 detected cardiovascular and/or ECG abnormalities.

Table 7: Frequency analysis - cardiovascular and/or electrocardiogram abnormality detected in main sports.

Main sports	Frequency	Percentage
Running (>1500 m)	28	41.1
Swim (>400 m)	12	17.6
Martial arts	10	14.7
Cycling/hiking	5	7.3
Rugby/soccer	5	7.3
Cadeting	6	8.8
Race walking	0	0
Other	2	2.9
Total	68	100

Table 8 illustrates the cross-tabulation analysis of age versus the detection of abnormal ECG findings with the measures of association. The prevalence of abnormal ECGs was approximately 3% in the 10-12-year age group, while the ≥13-year age group had a prevalence of 2.55%. Similarly, the 10-15-year age group demonstrated a prevalence of 4.20%, whereas the ≥16-year age group showed a lower prevalence of 1.40% for abnormal ECGs.

DISCUSSION

Key results

Participation in sports among school athletes has notably decreased in recent years, largely due to the unforeseen sudden cardiac deaths of adolescent school athletes. These catastrophic events have had a significant effect on sports participation, leading many parents to hesitate in permitting their children to take part in endurance competitions. Without a proper PPS system, young athletes engaging in endurance sports face a heightened risk of career-ending outcomes. A scientific evaluation of cardiovascular risk factors through comprehensive pre-participation clinical assessments is therefore essential to prevent sudden cardiac deaths during events such as marathons.

This research, conducted at the Sports Medicine Clinic of the Teaching Hospital Karapitiya in Sri Lanka, identified a 3% prevalence of cardiovascular abnormalities among school athletes. A total of 68 cardiovascular irregularities were documented, including 24 cases of valvular heart disease and 44 ECG abnormalities across various sports. In addition, 11 physiological murmurs were observed. Out of the 24 valvular defects, 22 were detected through meticulous auscultation of murmurs, while the remaining two were confirmed using echocardiography.

The most common abnormality was mitral valve prolapse (1.4%, 11 cases). Other detected conditions included MS (0.2%, 2 cases), VSD (1.2%, 9 cases), and AS (0.2%, 2 cases).

There were 118 (15.1%) individuals in the age category of 10-12 years, 164 (20.9%) in the age category of 13-15 years, and 502 (64%) in the age category of 15-19 years. There were 24 participants with ECG abnormalities in the age category of 10-12 years, while the other two categories combined (i.e., ≥13 years of age) had 20 participants (i.e., a relative risk of 6.773 (confidence interval [CI] 3.868-11.859) for having an ECG abnormality in the age group of 10-12 years compared to the age group of ≥13 years). The odds ratio was 8.247 (CI of 4.385-15.509).

Similarly, when the ≥16-year age group (n = 502) was compared with the other two age groups combined (i.e., 10-15 years, n = 282), there were 11 ECG abnormalities and 33 ECG abnormalities, respectively. This gives a relative risk of 5.340 (CI 2.742-10.401) for showing ECG abnormality in the age group of 10-15 years compared to ≥16-year age group. The odds ratio between the same groups was 5.916 (CI 2.940-11.903).

A notable feature is that the age group 10-12 has a higher relative risk of an abnormal ECG finding compared to other age groups. This could have happened because of the overall smaller number of athletes requesting fitness medicals.

Table 8: Cross tabulation of Age – abnormal electrocardiogram (ECG)

		Abnormal ECG			Measures of association	
Age groups	**Age range**	**Yes Count (%)**	**No Count (%)**	**Total Count (%)**	**Odd ratio (Confidence interval)**	**Relative risk (Confidence interval)**
Age group 1	10-12 Years	24 (3.06%)	94 (11.98%)	118 (15.05%)	8.247 (4.385-15.509)	6.773 (3.86-11.85)
	≥13 years	20 (2.55%)	646 (50.64%)	666 (84.94%)		
Age group 2	10-15 years	33 (4.20%)	250 (31.88%)	282 (35.96%)	5.916 (2.94-11.90)	5.340 (2.74-10.40)
	≥16-year	11 (1.40%)	491 (62.62%)	502 (64.03%)		

Analysis of past literature, including the work of De Noronha *et al*. 2009,[7] and the researcher's personal experience highlight three critical factors that substantially elevate the predisposition to heart conditions:

1. A significant familial history of cardiovascular disease
2. The existence of additional coronary risk factors
3. Symptoms that strongly indicate the presence of heart disease.

The main drawback is the lack of similar studies conducted in Sri Lanka or globally that directly align with the specific population and focus of our research. This absence of comparable studies underscores the novelty of our work and its potential to fill a critical gap in the existing literature.

While global studies frequently report a higher prevalence of cardiovascular abnormalities (ranging from 5% to 10% depending on the population, types of sports being considered, and screening methods), the lower prevalence in Sri Lanka may reflect differences in screening protocols rather than actual incidence. The reliance on basic diagnostic methods, such as physical examinations and selective use of ECG, contrasts with more resource-intensive approaches seen in high-income countries, where echocardiography and advanced imaging are often employed.

The observed prevalence in Sri Lanka also highlights a narrower focus on endurance sports compared to global studies that often evaluate a wider array of athletic disciplines. For example, contact sports such as American football and rugby, which dominate studies in North America, carry their unique cardiovascular risks due to the intense physical strain and potential for trauma. In contrast, the predominance of running in Sri Lanka's athletic profile provides insights into how specific sports influence cardiovascular risks.

One major similarity lies in the age-related findings. Both global and Sri Lankan studies indicate that younger athletes, particularly those in early adolescence, exhibit higher rates of ECG abnormalities. This underscores the importance of initiating cardiovascular screening early in an athlete's career to ensure timely identification and management of potential risks.

Differences also emerge in the resources and infrastructure available for cardiovascular evaluations. High-income countries often implement more comprehensive PPE protocols, including access to portable ECG devices, advanced imaging technologies, and specialized personnel. In contrast, Sri Lanka's resource limitations mean that screenings are less comprehensive, potentially leading to under-diagnosis of certain conditions.

Recommendation

The findings of this retrospective study align closely with those of other research conducted on the subject. Considering the evidence, the following recommendations are proposed:

Targeted screening

School athletes should undergo a thorough PPS to identify cardiovascular risks. The American Heart Association (AHA) highlights the significance of identifying a history of high systemic blood pressure, known heart conditions among blood relatives, and the finding of a cardiac murmur. These factors are essential in raising concern or detecting cardiovascular diseases that may pose a risk to athletes. Athletes presenting such evidence should be directed for further evaluations, investigations, and testing.

Age-specific screening

The AHA has recommended 12 key pre-screening elements, including detailed medical histories, followed by a thorough physical examination.[19] Therefore, all competitive school athletes aged 12 years and above participating in marathons should be subjected to a comprehensive pre-participation examination.

ECG evaluation

The screening process should incorporate a 12-lead ECG evaluated by a knowledgeable sports medical doctor. The ECG has the capability to detect or alert to the presence of serious cardiovascular anomalies such as hypertrophic obstructive cardiomyopathy (HOCM), dilated and other forms of cardiomyopathies, arrhythmogenic right ventricular cardiomyopathy/dysplasia (ARVC/D), channelopathies such as Bragada syndrome, long QT and short QT syndromes, Lenore disease, and wolf-Parkinson-white syndrome (WPW). Collectively, the conditions accounted for above contribute to as much as 60% of sudden athletic deaths among competitive adolescent athletes.[20]

Further testing for positive ECGs

Athletes with positive ECG findings should be referred to a cardiologist for additional testing. Initial non-invasive tests may include echocardiography, 24-h ambulatory Holter monitoring, and exercise testing. In uncertain cases, invasive testing such as contrast ventriculography, coronary angiography, endomyocardial biopsy, or electrophysiological studies may be required to confirm or rule out heart disease.

Disqualification for high-risk cases

According to the recommendations of the Bethesda conference, athletes diagnosed with cardiovascular conditions associated with a high overall risk of sudden death during physical activities should refrain from such risky competitive sports.

Suggestions for future research

To further prevent sports-related fatalities, future research should focus on understanding the underlying causes and mechanisms of sudden death in athletes, with an emphasis on improving screening strategies.

Environmental factors

In tropical countries, environmental conditions such as high heat and humidity pose a significant risk for heat stroke, a life-threatening condition often encountered during marathons. Research should be conducted to assess risk factors associated with heat stroke in marathon runners.

Echocardiography utilization

Echocardiography, being a non-invasive and widely accessible method, can improve the accuracy of screenings by identifying cardiovascular conditions associated with sudden cardiac death in adolescent marathon runners. Further studies should evaluate its role in improving the PPS process.

Limitations and strength

Limitations include getting the ECG for all mandatory sports before PPE. Government hospitals prioritize ECG testing for patients over testing for athletes. The primary strength of the study lies in its analysis of a larger cohort of athletes in many different age groups in several different kinds of endurance sports. There could be the researchers' bias while interpreting the ECG**.** Some of the pathological ECG changes might not appear at the time of test. The history given by the athlete and the filling of the questionnaire may have false information.

Selection bias

Our study's retrospective nature and reliance on data from a specific clinic population may have introduced selection bias. The participants included in the study are athletes who sought care at our clinic, which may not fully represent the broader population of young athletes in Sri Lanka. Athletes who did not seek medical care or attended other facilities might have different injury profiles, leading to potential underrepresentation or overrepresentation of certain conditions. The cohort in the age group 10-12 years was comparatively less, thus leading to a significantly higher relative risk and odds ratio.

Information bias

The study relied on existing medical records, which may have varying levels of completeness and accuracy. This reliance poses the risk of information bias, as inconsistencies in documentation could affect the quality of data used for analysis. Furthermore, retrospective data collection limits our ability to verify the accuracy of reported variables and introduces the possibility of misclassification errors.

Generalizability

Our findings may not be generalizable to all young athletes in Sri Lanka, particularly those outside the schooling athlete population or those participating in informal sports settings. The study population was confined to individuals who participated in organized sports within schools and sought care at a tertiary-level sports medicine clinic, limiting the applicability of our results to other groups.

We recognize the importance of these limitations and their potential impact on the study's findings. To address these concerns, future research should consider prospective study designs, include broader and more diverse populations, and implement standardized data collection methods. We will update the limitations section of our manuscript to reflect these points comprehensively.

CONCLUSION

The study identified a 3% prevalence of cardiovascular abnormalities among school athletes, with Mitral Valve Prolapse being the most frequently observed condition.

ECG abnormalities were estimated at 5.6%, with RBBB being the most common, accounting for 2.8%. It can be concluded that the younger participants have a relatively higher incidence of ECG abnormalities compared to older age groups.

It is recommended that school athletes undergo comprehensive PPSs to detect cardiovascular risks. The results of this retrospective study are consistent with findings from similar research. In addition, echocardiography, as a non-invasive and readily accessible diagnostic tool, shows significant potential for improving the precision of PPE screenings.

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Author contributions: YHSD and STT: Conceptualized and designed the study, ensuring its scientific rigor and relevance; DCW

and SG: Actively involved in data collection, statistical analysis, and initial result interpretation; OLS and HMDP: Contributed to the comprehensive interpretation of findings and took the lead in drafting the manuscript; WHHM and AK: Provided insightful critical revisions, enhancing the manuscript's clarity and impact, and granted final approval for submission. All authors thoroughly reviewed the final draft, ensuring accuracy and integrity, and collectively took responsibility for the content, agreeing to be accountable for all aspects of the research and its presentation.

Ethical approval: The research/study was approved by the Institutional Review Board at the ethical review committee of the faculty of medicine, University of Ruhuna, number 2019/P/002 (14.02.2019), dated July 18, 20119.

Declaration of patient consent: Patient's consent is not required as there are no patients in this study.

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REFERENCES

1. Ljungqvist A, Jenoure P, Engebretsen L, Alonso JM, Bahr R, Clough A, *et al*. The International Olympic Committee (IOC): Consensus statement on periodic health evaluation of elite athletes March 2009. Br J Sports Med 2009;43:631-43.
2. IOC Medical Commission. International Olympic Committee: Sudden cardiovascular death in sports: Lausanne recommendations: Preparticipation cardiovascular screening. Available from: https://stillmed.olympics.com/media/documents/athletes/medical-scientific/consensus-statements/2004_sudden-cardiovascular-death-sport.pdf [Last accessed on 2004 Dec 10].
3. Corrado D, Pelliccia A, Bjørnstad HH, Vanhees L, Biffi A, Borjesson M, *et al*. Cardiovascular pre-participation screening of young competitive athletes for prevention of sudden death: Proposal for a common European protocol: consensus statement of the Study Group of Sport Cardiology of the Working Group of Cardiac Rehabilitation and Exercise Physiology and the Working Group of Myocardial and Pericardial Diseases of the European Society of Cardiology. Eur Heart J 2005;26:516-24.
4. Billea K, Figueiras D, Schamasch P, Kappenberger L, Brennerc JI, Meijboom FJ, *et al*. The Lausanne recommendations: Sudden cardiac death in athletes. Available from: https://serval.unil.ch/resource/serval: bib_9867ce795f48.p001/ref.pdf [Last accessed on 2024 Dec 09].
5. Maron BJ, Epstein SE, Roberts WC. Causes of sudden death in competitive athletes. J Am Coll Cardiol 1986;7:204-14.
6. Maron BJ, Thompson PD, Puffer JC, McGrew CA, Strong WB, Douglas PS, *et al*. Cardiovascular preparticipation screening of competitive athletes: A statement for Health Professionals from the Sudden Death Committee (Clinical Cardiology) and Congenital Cardiac Defects Committee (cardiovascular disease in the Young), American Heart Association. Circulation 1996;94:850-6.
7. De Noronha SV, Sharma S, Papadakis M, Desai S, Whyte G, Sheppard MN. Aetiology of sudden cardiac death in athletes in the United Kingdom: A pathological study. Heart 2009;95:1409-14.
8. Baggish AL, Hutter AM Jr., Wang F, Yared K, Weiner RB, Kupperman E, *et al*. Cardiovascular screening in college athletes with and without electrocardiography: A cross-sectional study. Ann Intern Med 2010;152:269-75.
9. Price DE, McWilliams A, Asif IM, Martin A, Elliott SD, Dulin M, *et al*. Electrocardiography-inclusive screening strategies for detection of cardiovascular abnormalities in high school athletes. Heart Rhythm 2014;11:442-9.
10. National hospital Galle, sports medicine unit. Available from: http://sportmedicinegallelk.org/english/images/files/the_national_traning_program_2023-2024.pdf [Last accessed on 2024 Dec 09].
11. Ministry of Health, Nutrition and Indigenous Medicine-Sports Medicine Development Committee. 2015-Guideline manual for pre-participation and pre-event medical examination. Vol. 1. 2015. p. 1-29
12. Ministry of Health, Nutrition and Indigenous Medicine - Department of Health/Services/DDGMS11.Sports Medicine Development Committee. 2018-Guideline manual for issuing pre-Participation (PPE)/pre-event (PEE) medical certificates. Vol. 2. 2018. p. 2-89.
13. Weerasuriya D. Pre-participation screening of athletes to prevent sudden cardiac deaths (SCD): Cardiac abnormalities Ministry of Health, Nutrition and Indigenous Medicine - Department of Health Services/DDGMS11. Sports Medicine Development Committee. Vol. 2. 2018. p. 1-27.
14. Ministry of Health, Nutrition and Indigenous Medicine - Department of Health/Services/DDGMS11.Sports Medicine Development Committee. 2023-Guideline manual for issuing pre-participation (PPE)/pre-event (PEE) medical certificates. Available from: https://www.health.gov.lk/wp-content/uploads/2024/01/sports-medicine-guideline-manual-book.pdf [Last accessed on 2024 Dec 09].
15. 8th IOC Course on Cardiovascular evaluation of Olympic athletes, Rome, Italy; 2018. Available from: http://ioc-preventionconference.org/?page_id=482 [Last accessed on 2024 Dec 09].
16. Lemeshow S, Lwanga SK. Sample size determination in health studies: A practical manual. Geneva: World Health Organization; 1991. Available from: https://iris.who.int/bitstream/handle/10665/40062/9241544058_%28p1-p22%29.pdf [Last accessed on 2024 Dec 09].
17. Maron BJ, Ackerman MJ, Nishimura RA, Pyeritz RE, Towbin JA, Udelson JE. Task Force 4: HCM and other cardiomyopathies, mitral valve prolapse, myocarditis, and Marfan syndrome. J Am Coll Cardiol 2005;45:1340-5.
18. Corrado D, Basso C, Shiavon M, Thiene G. Screening for hypertrophic cardiomyopathy in young athletes. N Engl J Med 1998;339:364-9.
19. Recommendations and Considerations related to preparticipation screening for cardiovascular abnormalities in competitive athletes: 2007 update: A Scientific statement from the American Heart Association Council on nutrition, physical activity, and metabolism: Endorsed by the American College of Cardiology Foundation. Available from: https://doi.org/10.1161/CIRCULATIONAHA.107.181423.
20. Prescott E. Cardiovascular pre-participation screening of young competitive athletes for prevention of sudden death: proposal for a common European protocol. Eur Heart J 2006;27:2904-5.

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