original article

Electrocardiogram screening for school children: a cross-sectional, population-based study

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Citation: Alakhfash AA, Al Mesned A, Al-Manea W, Al Qwaee A, Al-Hassnan ZN. Electrocardiogram screening for school children: a cross-sectional, population-based study. Ann Saudi Med 2025; 45(2): 69-78. DOI: 10.5144/0256-4947.2025.69

Received: November 8, 2024

Accepted: February 1, 2025

Published: April 3, 2025

Funding: King Abdulaziz City for Science and Technology 10-BIO1348-20

BACKGROUND: Identification of life-threatening arrhythmogenic disorders, which may present during infancy, childhood, or later stages, enables the early initiation of effective preventive therapies. Electrocardiogram (ECG) screening may detect conditions that elevate risk of sudden cardiac death (SCD) at an early stage.

OBJECTIVES: This study aims to assess the prevalence, clinical significance, and characteristics of ECG abnormalities in a large population of schoolchildren. It also aims to determine whether ECGs performed during childhood can aid in the early detection of conditions associated with the risk of SCD.

DESIGN: Population-based cross-sectional study

SETTING: A multicenter study conducted at King Faisal Specialist Hospital & Research Centre (KFSHRC) in Riyadh and Prince Sultan Cardiac Center-Qassim (PSCC-Q), Qassim, Saudi Arabia.

METHODS: The study analyzed 12-lead ECGs performed on elementary school students 6-15 years old in Buraidah, Qassim region, Saudi Arabia. ECGs were recorded and interpreted following international standards. Children with abnormal ECG results were referred for full pediatric cardiology evaluation.

MAIN OUTCOME MEASURES: Prevalence of normal and abnormal ECG findings, including long QT intervals

SAMPLE SIZE: 14 403 students

RESULTS: During the study period, ECGs were performed on 14 403 students (53.8% females). The mean age was 9.5±1.9 years, and the mean weight was 32.1±16.1 kg. Abnormal ECGs were identified in 468 students (3.3%), 271 of whom had complete clinical evaluation, including repeat ECG and echocardiography. The most common ECG abnormality was a prolonged QTc interval. The overall prevalence of abnormal ECG findings ranged from 0.7% to 2.04%, with long QTc intervals (460 msec or more) found in 0.4% to 1.6% of students.

CONCLUSIONS: Long QTc intervals (460 msec or more) were the most common ECG abnormality in school children, with an estimated prevalence of 0.4% to 1.6%. This study may serve as a model for large-scale, community-based, 12-lead ECG screening programs for children.

LIMITATIONS: Causality cannot be derived given the design, the potential for false positive and false-negative results, and the lack of genetic studies for children with prolonged QT intervals.

CONFLICT OF INTEREST: None.

Screening programs are designed to facilitate early detection and intervention for various diseases. The effectiveness of such programs depends largely on the quality of the screening tests employed. Numerous screening protocols are widely accepted for different age groups, including pulse oximetry screening for critical congenital heart disease (CHD), hypothyroidism testing for newborns, metabolic screening, developmental assessments, and screening for hemoglobinopathies, vision, and hearing issues.[1-3] In contrast, the value of electrocardiogram (ECG) screening in infants, children, and adolescents has been controversial.[4,5] Risk factors for sudden cardiac death (SCD), including inherited channelopathies, may be detectable through ECG screening. However, there is currently no comprehensive registry documenting SCD in neonates, infants, or children, as well as robust documentation of cardiovascular-related deaths and their causes. Some evidence suggests that channelopathies may contribute to sudden infant death syndrome (SIDS). Reports on the incidence of out-of-hospital non-traumatic cardiac arrest (OHCA) in young populations range from 0.6 to 8 per 100 000 person-years.[6-9] The early identification of life-threatening arrhythmogenic disorders through ECG screening therefore may allow for the timely initiation of preventive therapy, since it has been reported to offer satisfactory sensitivity and specificity in detecting such conditions.[10] This study aims to determine the prevalence, clinical significance, and characteristics of ECG abnormalities in a large population of schoolchildren in Qassim region, Saudi Arabia, and investigate the prevalence of inherited arrhythmias predisposing this population to sudden death. Lastly, the study aims to assess whether ECG screening during childhood contributes to the early identification of individuals at risk of cardiovascular morbidity and mortality, particularly in diseases where the prognosis may significantly improve with early intervention and adequate therapy.

MATERIALS AND METHODS

In this cross-sectional study, participants were recruited from a total of 566 elementary schools (268 for boys and 298 for girls) in Qassim region (350 Km north of Riyadh), Saudi Arabia. In 2009, the total number of male and female students in all 6 preliminary grades was 101 000, majority of whom (80%) are in urban areas. A core group of administrators, cardiologists, community volunteer nurses, and health care workers were recruited to conduct ECG screening for targeted school children. They underwent specialized training and quality review in performing pediatric ECGs, online transmission, and communication with the families. The study was conducted after obtaining ethical approval from the Research Advisory Council at King Faisal Specialist Hospital and Research Center (KFSHRC), Riyadh, Saudi Arabia, and permission from the regional directorate of the Ministry of Education. ECG Screening of a representative sample of school children in Buraidah city, Al-Qassim region was performed at study center 1 (Prince Sultan Cardiac Center-Qassim, PSCC-Q). After obtaining detailed consent from the legal guardians, simple clinical data and 12 lead ECGs were obtained, recorded, and sent electronically to the coordinating center (Pediatric Cardiology team at King Faisal Specialist Hospital and Research Centre, KFSHRC - Cardiac Center, study center 2) for analysis by trained pediatric cardiologists, according to international guidelines.[11] Obtained data was kept in a secure coded database for statistical analysis. In the case of abnormalities, the participant was called to the pediatric cardiology clinic at study center 1, where clinical assessment, physical examination, repeat ECG, and echocardiography were performed. The ECGs were evaluated by the local pediatric cardiologists at the study center 2. Any participant with confirmed ECG abnormalities was referred to a pediatric cardiologist/electrophysiologist and examined for genetic evaluation. The ECG was recorded by a trained technologist or registered nurse using a Philips Diagnostic ECG machine. Demographic data including age, gender, height, weight, and nationality were stored to a media drive. ECG and clinical data were transferred to study center 2 for subsequent analysis. Each ECG was identified by a unique identifier (Student Study Identifier) and recorded at a standard 25 mm/s and 10 mm/1 mV while the participant was supine and breathing quietly. ECGs were evaluated according to the commonly recommended ECG parameters 12, which included heart rate, rhythm, cardiac axis, P waves, pre-excitation, QRS and T wave morphology, and QT intervals. Additionally, signs of atrial enlargement, bundle branch block, ventricular hypertrophy, and Brugada-like patterns were assessed. **Figure 1** illustrates the flow algorithm of the research design and management of the ECGs obtained, and participants' follow-up. The QT interval measurement was initially identified using the automatic ECG report and was subsequently measured manually. The corrected QT interval (QTc) was calculated using Bazett's formula. A QTc interval of 450 to <470 ms in males and 460 to <480 ms in females was considered a borderline long QTc interval. A QTc interval equal to or more than 470 ms in males and equal to or more

than 480 ms in females was considered Long QTc. The criteria for a positive (abnormal) 12-lead ECG were based on the published recommendations (**Table 1**).[12] For participants with abnormal initial ECGs, a second ECG was repeated within one to two weeks in the pediatric cardiology clinic. The repeated ECGs were reviewed by both pediatric cardiologists and electrophysiologists at study center 2. Diagnosis and referral for further investigation were based on these results. Echocardiography was performed during clinical evaluation, and any abnormalities were documented. Genetic evaluation was recommended for students with significant findings. Statistical analysis was performed using SPSS version 25, with categorical variables expressed as frequencies (n) and percentages (%). Continuous variables were presented as means and standard deviations (SD).

RESULTS

Study population

During the study period, a total of 14403 ECGs were performed on elementary school students in Buraidah City, Qassim region. A total of 98 ECGs were excluded due to incorrect coding, unmatched names or contact details, leaving 14305 valid ECGs [6609 males (46.2%) and 7696 females (53.8%)]. The mean age of the students was 9.5 years (SD=1.9 years), with ages ranging from 6 to 15 years. The average weight was 32.12 kg (SD=16.1 kg), and the average height was 130.5 cm (SD=12.2 cm). **Figure 2** provides an overview of the ECG screening outcomes, including the results of repeat ECGs conducted in the clinic.

Prevalence of abnormal electrocardiography patterns

ECG abnormalities were identified in 468 participants (3.3%), with males and females almost equally affected [236 males (50.4%) and 232 females (49.6%)]. The vast majority of students (96.7%) had normal ECGs. Details of the ECG abnormalities are provided in **Table 1**. The most common ECG abnormalities were borderline QTc intervals, prolonged QTc intervals, left ventricular hypertrophy (LVH), incomplete right bundle branch block (IRBBB), and signs suggestive of Wolff-Parkinson-White (WPW) syndrome (**Tables 2 and 3**). Specifically, 88 participants had borderline QTc intervals, 85 males had a QTc exceeding 470 milliseconds, and 49 females had a QTc over 480 milliseconds. The overall prevalence of long QTc intervals was 0.94% (134 out of 14305). The prevalence of both borderline and prolonged QTc intervals was 1.6% (222 out of 14305). All participants

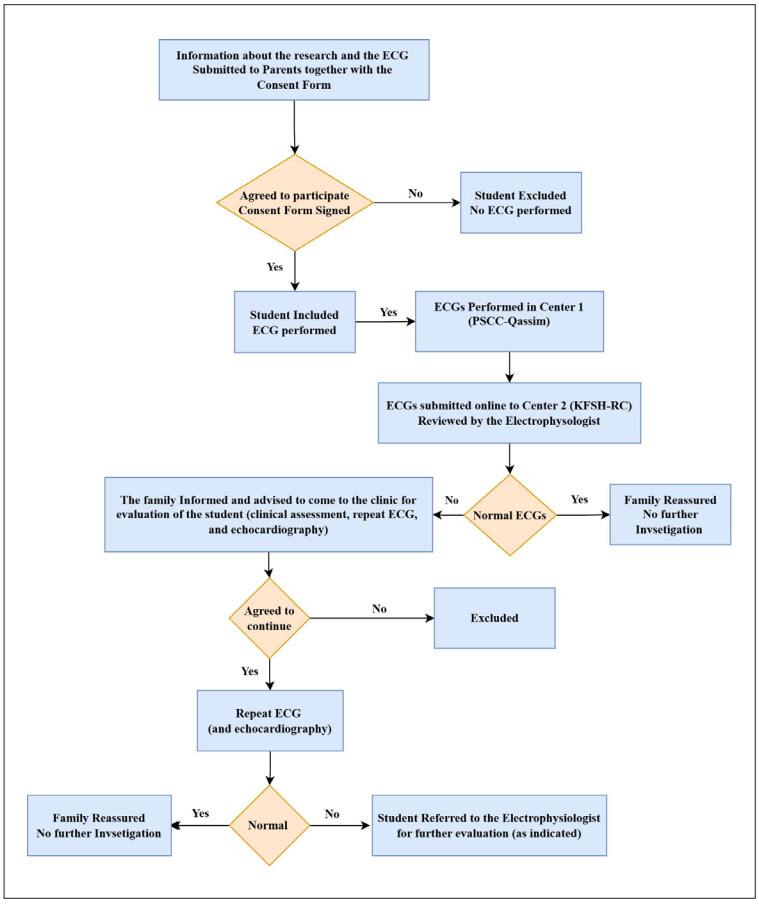

Figure 1. Flow algorithm of the research design and management of ECG screening and its results and follow-up.

with abnormal ECG results (n=468) were contacted for further evaluation at the Pediatric Cardiology Clinic (PSCC-Q), and only 271 participants [155 males (57.2%) and 116 females (42.8%)] underwent a full clinical assessment, including medical history, physical examination, repeat ECGs, and echocardiography. Repeat ECGs showed that 176 (65%) had normal results while 95 (35%) remained abnormal (**Tables 4 and 5**). The most common abnormalities were borderline and prolonged QTc intervals. Specifically, 46 participants were found to have borderline QTc intervals (450 to <470 ms in males and 460 to <480 ms in females), while 10 exhibited prolonged QTc intervals (≥470 ms in males and ≥480 ms in females). One participant was diagnosed with congenital complete heart block and remained under follow-up. One female participant was diagnosed with ectopic atrial tachycardia and exhibited reduced cardiac function, necessitating referral for electrophysiological (EP) study and subsequent ablation. WPW syndrome was detected in four participants. The

overall prevalence of abnormal ECG findings based on follow-up clinic evaluations, was 0.7% (95 out of 14305). However, if participants with abnormal ECGs and who did not attend the follow-up were included, the prevalence was 2.0% (292 out of 14305).

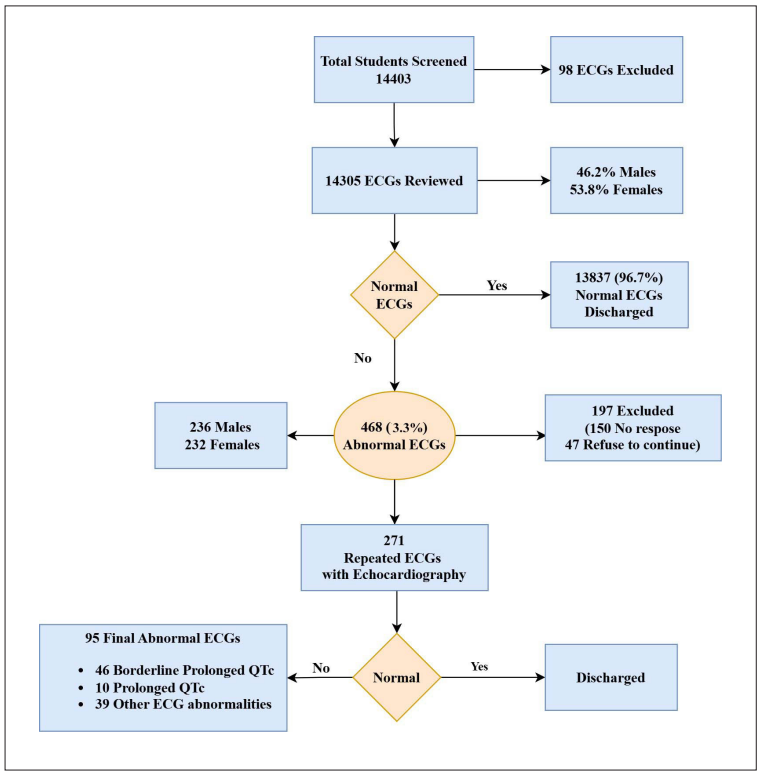

Figure 2. Flow algorithm of the overall results of primary ECG screening performed in the schools and the repeated ECGs in the clinic.

The prevalence of long QTc intervals (borderline and prolonged) was 0.4% (56 out of 14305; 25 males and 31 females). Echocardiographic findings included mitral valve prolapse (n=7), bicuspid aortic valve (n=3), patent ductus arteriosus (PDA) (n=3), and atrial septal defect (ASD) of secundum type (n=1) (**Table 6**). Participants with PDA and ASD were referred for cardiac interventions, including device closures (**Table 5**). No family history of cardiac events or sudden cardiac death (SCD) was noted in all participants evaluated in the clinic.

DISCUSSION

ECG is a valuable tool for assessing cardiac conduction and rhythm abnormalities, and it plays a crucial role in the pre-participation screening of athletes.[13-15] The primary goal of ECG screening is to facilitate the early detection of conditions that pose a risk for sudden cardiac death (SCD). However, there is a lack of comprehensive registries documenting SCD in neonates, infants, and children, including the expected or proven causes of such events and all deaths associated with the cardiovascular system. The causes of cardiac-related sudden death in the pediatric population are varied and complex,[6-9] making it essential to consider this heterogeneity when developing potential preventive strategies. A singular approach to screening may not adequately identify the diverse pathologies that can manifest in infants, children, and adolescents.[6,16] The etiology of SCD in pediatrics encompasses a broad spectrum, including structural heart diseases and arrhythmogenic disorders.

Table 1. Criteria for a positive 12-lead ECG.[12]

P wave	Left atrial enlargement: the negative portion of the P wave in lead V1≥0.1 mV and ≥0.04 s
	Right atrial enlargement: peaked P wave in leads II or V1 ≥0.2 mV in amplitude
QRS complex	Frontal plane axis deviation: right ≥ +120° or left –30 ° to –90 °
	Right Ventricular Hypertrophy: R in V1 >1.3 mV, S in V6 >0.4mV or, R in V1+S in V6 >1.7 mV
	Left Ventricular Hypertrophy: R in V6 >2.7 mV, S in V1 >2.6mV or, R in V6+S in V1 >4.7 mV
ST-segment, T-waves, and QT interval	ST-segment depression or T-wave flattening or inversion in two or more leads
	Prolongation of heart rate corrected QT interval .0.44 s in males and 0.46 sec. in females.
Rhythm and conduction abnormalities	Premature ventricular beats or more severe ventricular arrhythmias
	Supraventricular tachycardia, atrial flutter, or atrial fibrillation
	Short PR interval (0.12 s) with or without 'delta' wave
	Sinus Bradycardia with a resting heart rate of 40 beats/min
	First (PR >0.21 s), second or third-degree atrioventricular block
	Right or Left Bundle Branch Block

Table 2. ECG abnormalities in school-aged children based on the initial ECG performed in the schools.

ECG abnormality	Gender		n (%)
	Male	Female	
Borderline long QT	74	93	167 (36)
Left ventricular hypertrophy	50	24	74 (15.8)
Long QTc	25	35	60 (12.8)
Left axis deviation	9	7	16 (3.4)
Possible Right ventricular hypertrophy	8	8	16 (3.4)
Nonspecific T wave abnormality in inferior leads	10	4	14 (3)
Wolff-Parkinson-White	5	8	13 (2.8)
Incomplete right bundle branch block	7	5	12 (2.6)
1st degree AV block	8	2	10 (2.1)
ST abnormality	1	8	9 (1.9)
T wave inversion in inferior leads	4	4	8 (1.7)
Right atrial enlargement	1	6	7 (1.5)
Right bundle branch block	5	2	7 (1.5)
Biventricular hypertrophy	5	1	6 (1.3)
Premature ventricular complexes	2	4	6 (1.3)
Right ventricular hypertrophy	5	1	6 (1.3)
Left axis deviation; Right bundle branch block	2	2	4 (0.85)
Right ventricular hypertrophy	3	1	4 (0.85)
Sinus tachycardia	0	4	4 (0.85)
Short RP	2	2	4 (0.85)
Ectopic atrial rhythm	0	3	3 (0.64)
Right axis deviation	3	0	3 (0.64)
Complete heart block with Junctional esca[e rhythm	1	1	2 (0.43)
Left axis deviation; ST abnormality and T wave inversion	2	0	2 (0.43)
premature supraventricular complexes	1	1	2 (0.43)
Short PR	1	0	1 (0.21)
Abnormal QRS-T angle	0	1	1 (0.21)
Atrial tachycardia	0	1	1 (0.21)
Decreased left sided forces	0	1	1 (0.21)
Deep Q wave in lead V6	1	0	1 (0.21)
Left bundle branch block	0	1	1 (0.21)
Right ventricular hypertrophy	1	0	1 (0.21)
Right ventricular hypertrophy	0	1	1 (0.21)
Total	**236 (50.4%)**	**232 (46.6%)**	**468 (100)**

Data presented as frequencies (N) and percentages (%).

Table 3. Gender ECG diagnosis and QT corrected intervals cross-tabulation based on the initial ECG performed in the schools.

Gender	ECG diagnosis and QT corrected			Total
	Abnormal ECGs	Borderline QTc	Long QTc	
Male	114	37	85	236
Female	132	51	49	232
Total	**246**	**88**	**134**	**468**

Data presented as frequencies (N) and percentages (%).

Table 4. ECG abnormalities among students with repeated ECGs in the clinic (total of 271 students seen).

ECG findings	Gender		n (%)
	Male	Female	
Normal ECGs	109	67	176 (65)
Borderline long QTc	19	27	46 (17)
Long QTc	6	4	10 (3.7)
Sinus bradycardia	7	2	9 (3.3)
Incomplete Right Bundle Branch Block	4	4	8 (3.0)
Abnormal P wave axis	3	1	4 (1.5)
Left ventricular hypertrophy	1	2	3 (0.37)
Left axis deviation	2	0	2 (0.74)
Low voltage QRS complexes	0	2	2 (0.74)
Nonspecific ST-T wave changes	1	1	2 (0.74)
Short PR interval	1	1	2 (0.74)
Wolf-Parkinson-White syndrome	1	1	2 (0.74)
Complete heart block	1	0	1 (0.37)
RAD	0	1	1 (0.37)
Right atrial enlargement	0	1	1 (0.37)
SVT, ectopic atrial tachycardia	0	1	1 (0.37)
Sinus tachycardia	0	1	1 (0.37)
Total (%)	**155 (57.2)**	**116 (42.8)**	**271 (100)**

CHB: Complete heart block, EAT: Ectopic atrial tachycardia, ECG: Electrocardiograms (ECGs), I RBBB: Incomplete Right Bundle Branch Block, LAD: Left axis deviation, LVH: Left ventricular hypertrophy, QTc: corrected QT interval, RAD: Right axis deviation, RAE: Right atrial enlargement, SVT: Supraventricular tachycardia, WPW: Wolf Parkinson White syndrome.

Data presented as frequencies (N) and percentages (%).

Structural causes may involve cardiomyopathies, arrhythmogenic right ventricular cardiomyopathy, left ventricular non-compaction, myocarditis, congenital heart defects, and coronary artery disease. In many cases, a postmortem examination can reveal the cause of death. Moreover, early identification of life-threatening arrhythmogenic disorders is critical, as it may allow for timely initiation of effective preventive therapies.[10,17,18] The findings from this extensive population-based study provide valuable insights into the prevalence of ECG abnormalities among school-aged children in Qassim, Saudi Arabia. Our results showed that the prevalence of significantly abnormal ECGs is relatively low, ranging from 0.7% to 2.0%. The most frequently identified abnormality was the prolonged QTc interval, with significant implications for the early detection of arrhythmogenic disorders that may lead to SCD. Among the total ECGs analyzed, abnormal readings were found in 468 students (3.4%), with 271 being referred for further clinical evaluation. The predominant abnormality observed was an abnormal Long QTc interval. When calculating the incidence of abnormal ECGs based on those assessed in the clinic, the overall incidence was determined to be 0.7%, derived from 95 abnormal ECGs among the 271 students evaluated (95 out of 14305). However, the actual number of participants with abnormal ECGs might be higher, considering those who did not return for follow-up testing. If we subtract the 176 students with normal repeat ECGs from the original 468 students with abnormal initial ECGs, we estimate that the actual number of students with abnormal ECGs could be 292, resulting in an incidence of 2.04% (292 out of 14305). The overall incidence of long QTc intervals was found to be 0.4%, with 56 students exhibiting borderline or long QTc intervals among the 14305 evaluated (25 males and 31 females). Considering the QTc measurements from the initial ECGs, the incidence of long QTc intervals of 460 msec or more may range from 0.4% to 1.6%. Specifically, the incidence of long QTc intervals of 470 msec or more in males and 480 msec or

Table 5. Gender aECG diagnosis and QT corrected interval Cross-tabulation for students with repeated ECGs in the clinic (total of 271 students).

Gender	ECG diagnosis and QT corrected				Total
	Normal	Borderline Long QT	Abnormal ECG	Long QT	
Male	109	19	21	6	155
Female	67	27	18	4	116
Total	**176**	**46**	**39**	**10**	**271**

Data presented as frequencies (N) and percentages (%).

more in females could range from 0.07% to 0.94% when taking into account both clinic assessments and abnormal findings in the initial ECGs (**Tables 2 and 5**). While our data suggest a relatively low prevalence of clinically significant ECG abnormalities, we advocate for further studies to validate these findings and assess the cost-effectiveness of routine ECG screening in school-aged children. Our model of community-based screening may serve as a template for future research, particularly in evaluating its feasibility in various regions. For instance, the Italian neonatal screening program reported that, out of 33034 neonates, the incidence of long QTc >0.47 seconds was 0.07%. Of the 34 follow-up deaths recorded, 24 were due to sudden infant death syndrome (SIDS), with half of these cases exhibiting a QTc >0.44 seconds.[19,20] Approximately 2% to 10% of SIDS cases may be attributable to LQTS.[21,22] The prevalence of conditions that cause SCD varies by country, with estimates ranging between 0.2% and 0.7%.[22] ECG screening in school-aged and high school students may reveal that up to 2.5% have abnormal ECGs warranting further evaluation.[23,24] Primary arrhythmogenic disorders associated with SCD include familial long-QT syndrome (LQTS), Brugada syndrome (BrS), catecholaminergic polymorphic ventricular tachycardia (CPVT), short-QT syndrome, and idiopathic ventricular fibrillation (IVF). Notably, the causes of more than 50% of sudden arrhythmic deaths remain unidentified even after postmortem genetic testing.[17,25,26] When a family history of SCD in a young member is present, the diagnosis, management, and ongoing care of such families become challenging in clinical practice.[25] The inheritance pattern of cardiac genetic disorders in the general population is predominantly autosomal-dominant, occurring in nearly 95% of cases.[27] The HRS/EHRA consensus document outlines recommendations for managing surviving family members of individuals with unexplained sudden death following a negative postmortem examination.28 All relatives should undergo comprehensive histories, physical examinations, ECGs, and echocardiography. Additional investigations may include cardiac magnetic resonance (CMR) imaging for suspected arrhythmogenic right ventricular cardiomyopathy (ARVC), 24-hour ECG monitoring, signal-averaged ECG, and pharmacological challenge tests in cases of suspected Brugada syndrome. Up to 30% of families with sudden arrhythmic death syndrome (SADS) cases may have a potentially inherited cardiac disease, with LQTS being the most common.[29,30] Due to significant phenotypic variability, establishing a clear correlation between genotype and phenotype can be challenging. Genetic testing is essential for identifying at-risk family

Table 6. Echocardiographic findings among students seen in the clinic (total of 271 students).

Main echocardiographic findings	Gender		Total (%)
	Male	Female	
Normal	144	107	251 (92.6)
Mild mitral valve prolapse with trivial mitral regurge	1	6	7 (2.6)
Bicuspid aortic valve	3	0	3 (1.1)
Patent ductus arteriosus	3	0	3 (1.1)
Mild pulmonary stenosis	1	1	2 (0.7)
Atrial septal defect, secundum type	0	1	1 (0.4)
Left pulmonary artery stenosis	1	0	1 (0.4)
Mild dilatation of ascending aorta	1	0	1 (0.4)
Mild left ventricular non-compaction	0	1	1 (0.4)
Patent foramen ovale	1	0	1 (0.4)
Total (%)	**155**	**116**	**271**

Data presented as frequencies (N).

members and implementing preventive interventions. In a study conducted in Saudi Arabia involving families with LQTS, genetic sequencing of KCNQ, KCNH2, and SCN5A genes yielded positive results in 57.1% of families. Family screening identified a total of 123 individuals (66 males, 57 females) with positive genetic testing. Importantly, a normal QT interval in parents does not exclude the possibility of familial LQTS, as approximately 30% of cases may arise from de novo mutations in individuals with unaffected parents and no prior family history.[31] Most of these disorders can be diagnosed using a simple, non-invasive 12-lead ECG and can be effectively treated. Consequently, many organizations and societies recommend ECG screening for specific groups, including athletes and military recruits. Additionally, some have implemented population ECG screening in apparently healthy neonates to achieve similar objectives. However, concerns regarding the lack of expertise in interpreting neonatal and pediatric ECGs, as well as the cost-effectiveness of comprehensive ECG screening for all newborns and infants within National Health Services, remain significant barriers.[32,33] It is crucial that a single ECG must be put in the context of other clinical findings (e.g. family history, etc.). A normal ECG may be seen with multiple types of congenital heart defects and with the entire spectrum of arrhythmias. For those supporting routine neonatal ECG screening, the potential benefits of such a program might include (i) prevention and/or prevention of life-threatening arrhythmias in the affected infant; (ii) identification of at-risk additional family members; (iii) potential prevention of 'SIDS' or SCD; (iv) identification of other unexpected findings; other arrhythmias, or abnormal ECG suggestive of CHDs that might escape the routine clinical examination.[32] A significant challenge in implementing an ECG screening program for the pediatric population lies in determining who should interpret the ECGs. Pediatric ECGs and the phenotypic manifestations of many SCD-related diseases differ markedly from those in adults.[34] Therefore, it is essential for general pediatricians to receive training in interpreting pediatric ECGs and recognizing important pathological findings. An ideal screening test should accurately identify all individuals with the condition while yielding no false positives or negatives. However, it is widely recognized that neither the ECG nor a thorough history and physical examination can meet these criteria in isolation. Combining ECG assessments with medical history and physical examinations enhances overall sensitivity while maintaining low rates of false positives and false negatives (ranging from 2% to 16%).[35-39] A scientific statement from the American Heart Association and the American College of Cardiology addresses the conflicts and ethical considerations surrounding ECG screening for individuals aged 12 to 25. The consensus is that there is currently insufficient evidence to support universal ECG screening for asymptomatic young individuals who are not participating in competitive sports.[39] The QTc interval is known to vary with factors such as gender, age, and genotype. The ages of 12 to 14 represent a transitional period, during which clinicians must be particularly aware of the effects of gender and age on ECG findings and QTc intervals, especially at puberty's onset.[40] It is also essential to communicate the limitations of screening tests to the child's family, providing education regarding warning signs and symptoms that may precede a potential sudden cardiac event. Such discussions may provoke anxiety and concerns for both the individual and their family.[41] This study establishes a foundation for further research and could inform future initiatives aimed at the early detection of potentially fatal cardiac conditions in children.

Limitations

The study has several limitations. First, the study sample is not representative of the entire population and may be applicable only to the Qassim Region, Saudi Arabia. Second, causality cannot be derived given the cross-sectional nature of the study. Third, there is a lack of genetic studies, as the primary objective of the study was to estimate the incidence of conduction abnormalities via a school-based ECG screening, and genetic analysis is not readily available in such a setting. Fourth, false-positive test ECG results remained unresolved, and false-negative test results are unknown in this study, with an unknown prevalence of structural heart disease in children with normal ECGs. Fifth, no data is available for any family history of a cardiac event in screened students. Sixth, no reported ECG findings suggestive of Brugada syndrome and other channelopathies (apart from LQTS) were observed in this population. Finally, a complete follow-up is not available till now.

CONCLUSION

The prevalence of abnormal ECG patterns is low (0.7% to 2.0%) in a large population of school children in Qassim, Saudi Arabia. The study can serve as a model for larger-scale community-based epidemiologic research, which is essential before recommending the implementation of a universal pediatric 12-lead ECG screening program.

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